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CLIMATE CHANGE

HANDBOOK OF THE ANTHROPOCENE
IN LATIN AMERICA III

CALAS
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Eleonora Rohland, Virginia García Acosta, Anthony Goebel McDermott, Javier Taks (eds.)
Climate Change – Handbook of the Anthropocene in Latin America III

The Anthropocene as Multiple Crisis: Perspectives from Latin America

Editorial

The aim of the six-volume Handbook **The Anthropocene as Multiple Crisis: Perspectives from Latin America** is, first, to think about the Anthropocene from a particular region of the Global South. Thus, this Handbook offers a platform to discuss the multiple "anthropocenic" socio-environmental crises from a specifically Latin American point of view, without losing sight of their global and planetary dimensions. The second objective is to systematize, from the perspective of Latin American social sciences and humanities, the multifaceted environmental crises that reached and crossed the planetary boundaries of the earth-systems and led to the new geological time of the Anthropocene. In doing so, we generate an empirical basis for the genealogy of the Anthropocene in an unprecedented global region with key regional and historical differentiations.
The series is edited by Olaf Kaltmeier, Eleonora Rohland, Gerardo Cham and Susana Herrera Lima.

Eleonora Rohland is a professor for entangled history in the Americas at Universität Bielefeld, Germany. She has been a principal investigator in the Collaborative Research Center "Practices of Comparing: Ordering and Changing the World" and co-coordinator of the research group "Coping with Environmental Crises" at the Center for Advanced Latin American Studies (CALAS). Her current research focuses on environmental history and the Anthropocene.
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Eleonora Rohland, Virginia García Acosta, Anthony Goebel McDermott, Javier Taks (eds.)

Climate Change – Handbook of the Anthropocene in Latin America III

[transcript]

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Acknowledgements

This Handbook series on "The Anthropocene as Multiple Crisis: Latin-American Perspectives" is the outcome of the Laboratory of Knowledge on multiple ecological crises of the Maria Sibylla Merian Center for Advanced Latin American Studies, CALAS.

As editors of the series, we would like to pay tribute to the hard work and patience of our authors, who were fundamental to the existence of this publication project consisting of six thematic volumes on the Anthropocene from Latin American perspectives. Such a monumental work on the Anthropocene – covering diverse historical epochs and all regions of Latin America and the Caribbean – is only possible with the support of the international academic community. More than eighty-eight reviewers from eighteen countries contributed their expertise and sharp criticism, motivating the improvement of each chapter. All these reviewers constitute our Academic Advisory Board. Furthermore, all chapters were collectively reviewed in editorial conferences by the editors of the other volumes of this series.

Under the direction of Olaf Kaltmeier, we set up an editorial office at Bielefeld University. The general coordination of this editorial office was in the hands of Luisa Raquel Ellermeier. Luisa, Omar Sierra Cháves, and Eric Rummelhoff organized the editorial process and proofread, translated, and revised all chapters. Rafael García Roncalla and Vinicius Aureliano Bellotto dos Santos were responsible for formatting the texts, while Raoul Manuel Palm was responsible for supporting revisions and final formatting. Ann-Kathrin Volmer and Nadine Pollvogt organized the editorial conferences in the CALAS headquarters in Guadalajara, Buenos Aires, Quito, and San José de Costa Rica. They all did an outstanding job in making this Handbook a reality.

Special thanks go to our publisher, Bielefeld University Press (BiUP), who supported this project with great enthusiasm right from the start. Sabrina Diab-Helmer clarified all organizational aspects of publishing, and Vera Breitner and Gero Wierichs handled the editorial details, attending to all our extra requests. Bielefeld University has generously supported the open-access publication.

The series also stands out with its aesthetic design. Fernando Efrén Sandoval Herrera has created a work of art for each of the volumes. Using these pieces, Leon Che Ernst Pöhler from BiUP has designed memorable book covers.

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General Introduction

Source: Fernando Efrén Sandoval Herrera (2021)

The Anthropocene as Multiple Crisis

Latin American Perspectives on Climate Change[1]

Olaf Kaltmeier, Eleonora Rohland, Gerardo Gutiérrez Cham, Susana Herrera Lima, Antoine Acker, León Enrique Ávila Romero, Juan Arturo Camacho Becerra, Virginia García Acosta, Anthony Goebel McDermott, Ricardo Gutiérrez, Regina Horta Duarte, Cecilia Ibarra, María Fernanda López Sandoval, Sofía Mendoza Bohne, José Augusto Pádua, Elissa Rashkin, Heidi Scott, Javier Taks, Helge Wendt, Adrián Gustavo Zarrilli

The Anthropocene is probably one of the most disruptive concepts in contemporary science. It has the intellectual power to question ideas previously thought to be obvious, such as the modern-Western separation between nature and culture, because Earth's history no longer follows only natural laws but is shaped by the history of human societies. Conversely, these histories can no longer be understood without the inescapable consideration of planetary systems and their boundaries. Beyond its impact on academia, the emergence of the Anthropocene concept is a historical-political event, as it marks the global need not only to rethink but also to fundamentally remake the relationship between humanity and nature.

The concept of the Anthropocene has gained strength in the global public arena over the past twenty years and has been hotly discussed by the social sciences and the humanities for the past decade. The word was coined in 2000 by the Dutch atmospheric chemist Paul Crutzen and the U.S. American biologist Eugen Stoermer at a conference in Cuernavaca, Mexico. Both scientists observed the profound changes that human beings had caused to the environment. Based on this, they attempted to express the global reach of the great anthropogenic changes with the new term. Thus, the Anthropocene emerges as a new geological era in which humans introduce unprecedented amounts of CO_2 into the atmosphere through the massive use of fossil fuels. In addition, another major anthropocenic problem has been the large-

1 This introduction aims to provide the reader with an overview of the conceptual and organizational principles of this six-volume handbook on the Anthropocene in Latin America. To improve readability, we have dispensed with the usual academic references. In each article, the reader will find a detailed and individualized bibliography.

scale extraction of non-renewable resources. Other processes by which human beings have come to change all spheres of the planet include plastic pollution, nuclear waste, ocean acidification, the extinction of species, the fossil energy regime, the depletion of water sources, and the massive use of agrochemicals and pesticides. All of this constitutes the multiple crisis of the Anthropocene.

Given the above, it is clear that the Anthropocene is more than just a new fashionable term to refer to climate change as it has been widely, yet incorrectly, understood through the media. Nor is it simply a new concept useful for comprehensively addressing known environmental problems, although these issues obviously play an important role in its understanding. The novelty of the perspective that led to the coining of the term "Anthropocene" is fostered by the technological and informational possibilities of Earth system sciences to collect and process data like never before since the 1990s. In this way, it was possible to make visible the alterations, or rather the anthropogenic damage, in all the systems of the planet.

This is not the place to present all facets of the reflections on the concept of the Anthropocene carried out in the social sciences and the humanities. For our purposes, it is sufficient to refer to debates that offer novel perspectives to understand the historical singularities of Latin America in the Anthropocene. In this regard, discussions have recently resumed and continued about the Anthropocene and its derivatives such as the Capitalocene, Plantationocene, Chtulucene, Necrocene, etc.

In this context, the Latin American debate is particularly useful when it comes to relating multiple environmental crises to various sociocultural crises related to capitalism, coloniality, and racism. Here, approaches to environmental justice, the ecology of the poor, Latin American environmental history, nineteenth and twentieth century Latin American critical thought, and the approaches developed by Indigenous, Afro-descendant, peasant, and/or feminist movements and communities become relevant. An example of this from the Andean region is the concept of *Buen Vivir* (Good Living), *sumak kawsay*, based on the idea of the need for a turning point, *pachakutic*, according to which the poor governance and immoral leadership of global neoliberal capitalism with its colonial foundations must be substantially overcome.

Planetary thinking in the Anthropocene can and should be approached differently depending on the places of enunciation embedded in different constellations of power. In this regard, our concern is to broaden the debate, which so far has been largely carried out predominantly in the Global North by the natural and Earth sciences, to include a perspective from Latin America rooted in critical humanities and social sciences.

The aim of this six-volume handbook, *The Anthropocene as Multiple Crisis: Perspectives from Latin America,* published by the Maria Sibylla Merian Center for Advanced Latin American Studies (CALAS), is, first of all, to think about the Anthropocene from a particular region of the Global South. In this way, this handbook offers a platform for discussing the multiple "anthropocenic" socioenvironmental crises and their possible solutions from a specifically Latin American point of view, without losing sight of their global and planetary dimension. The second objective is to systematize, from the perspective of Latin American social sciences and humanities, the multifaceted environmental crises that have met and crossed the planetary boundaries of Earth systems and led to the new geological time of the Anthropocene. With this, we have produced an unprecedented empirical basis for the Anthropocene's complex genealogy in a specific region of the world – in this case, Latin America – with key regional and historical differentiations.

Thus, our perspective combines the already mentioned planetary dimension with a perspective that takes into account the local and regional specificity of ecosystems and socioenvironmental relationships in Latin America. The humanities and social sciences pose different questions in relation to the new geohistorical temporal layer of the Anthropocene. This task is by no means trivial. Rather, it is a multifaceted search process in which the initial assumptions of the definition of the Anthropocene in the Earth sciences are questioned, corrected, completed, and expanded. This starts with historical classification. The question of whether there is an epoch called the Anthropocene, and also of when it begins, was initially addressed by the Anthropocene Working Group (AWG) of the International Commission on Stratigraphy and was weighed according to geological considerations.

Based on the geological and socioecological evidence, 1950 has been proposed to be the year of the "Great Acceleration" despite the first defenders of the Anthropocene having proposed previous historical periods, such as the Industrial Revolution or the invention of the steam engine by James Watt in 1769. Reference may be made here to the smoking chimneys of Manchester factories. But precisely this origin narrative, based on the historical experience of the West, is criticized from a Latin American perspective. Manchester's industrial dynamics relied on the supply of cotton for textile production or sugar as a source of calories for the labor force. Both resources were produced in new plantation systems on the Atlantic coasts of America based on the introduction of neobiota and the labor of enslaved people forcibly brought from Africa. Equally worth mentioning is the mega-mining that emerged during the European colonization of Latin America, symbolically expressed in the system of Potosí, the silver mining center in present-day Bolivia. The silver mined there laid the foundations for the capitalist development and subsequent industrialization of Western Europe. Thus, mega-mining and plantation economies do not constitute mere gradual changes in human use of the environment but rather mark a fundamental and planetary rupture in the social metabolism, that is, in the management, use, and exploitation of natural resources.

Recognizing the deepest historical roots of the Industrial Revolution leads us to reconstruct a genealogy of the Anthropocene in which it cannot be separated from coloniality, the rise of the capitalist world system, and racial capitalism. Thus, 1492, the year of European contact with the Caribbean and the Americas, is a turning point in world history and represents a fundamental rupture for the Indigenous peoples and cultures of America. Along with the conscious and unconscious introduction of new plant and animal species, European pathogens arrived in America, together with the colonial violence against Indigenous peoples, a massive number of fatalities, and the consequent cultural ruptures. Ninety percent of the Indigenous population died as a result of the conquest, either through direct violence, the destruction of their living conditions, or the introduction of new germs. It was one of the greatest genocides in history, wiping out 10 percent of the world's population. The abandonment of a large part of the agricultural area and the subsequent spontaneous reforestation caused a drop in global temperature at the beginning of the seventeenth century, coinciding with the beginning of the Little Ice Age – responsible for extreme atmospheric events on the planet.

In biological terms, the Columbian Exchange was so fundamental that biologists set 1492 as the milestone for the categorization of neophytic plants, distinguishing them from plants established in biomes (archaeophytes). With the Columbian Exchange of species, a homogenization of flora and fauna took place between the American continent, Africa, and Eurasia.

The criticism of European/Western capitalism as a driver of the Anthropocene goes hand in hand with a radical critique of European/Western modernity and the recognition that the Anthropocene puts an abrupt end to the European teleological notions of development, progress, and civilization. We stress the criticism of the leveling effect of the Anthropocene concept in the way that it has been coined by the natural sciences, insofar as it implies that the human species is responsible for the great transformations of the environment to which the concept refers. The danger of this approach is to ignore not only the sociohistorical differences between the Global North and the Global South but also the differences between different ethnic and "racial" groups (even if we acknowledge the fact that there are no biological races), as well as those between social classes within the respective regions of the world, especially in terms of consumption patterns or even cosmological representations.

Not all human societies have a predatory approach to the non-human environment, nor do all humans have the same ecological footprint. Perceiving human beings as a single species that destroys ecological environments ignores asymmetric power relationships and how they influence interactions and practices between human beings and the environment. Some voices from the humanities, however, are beginning to question the absolute rejection of the species category. They advocate the cultivation of a dual perspective that addresses not only the asymmetries of power that fracture human experiences and histories but also the geobiological history of the planet, where the human species constitutes a minority life form, despite having undoubtedly become a geological force with a profound impact on the entire planet.

In this sense, the notion of the Anthropocene requires us to question precisely the gap between the scientific idea of a single planetary system, the universe, and the multiverse of forms of existence and life on Earth. Despite recognizing and stressing the need for planetary thinking, this handbook highlights the current disconnect between global quantifications of systemic limits and the political and social realities historically constructed in the territory. This is where the handbook revisits the concept of planetary boundaries, approaching it from the social sciences and the humanities. In other words, while Earth system sciences conceive of the planetary from a satellite's point of view, we will get closer to the ground without completely losing our planetary perspective. We will reduce the spatial scale to the regional and local while also adding temporal depth, which we will then attempt to reconnect with the planetary perspective. This approach is necessary if we want to investigate the impact that different regions had on the acceleration or slowdown of the planetary rise of the Anthropocene during different historical conjunctures. It is also relevant for keeping the focus on the extremely unequal socioenvironmental dynamics of the Latin American Anthropocene, where European/white settlers "naturalized" Indigenous and Afro-descendant peoples as exploitable resources.

On the other hand, the Anthropocene's genealogy is invariably constituted as a history of conflicts and crises, having developed in Latin America from the beginning of the Conquest to the present day in a very violent way. However, those who were subject to such violence should by no means be understood only as passive victims. In this particular region, there have always been creative social responses to overcome multiple socioecological crises. From our perspective, these approaches are an integral part of a genealogy that cannot be conceptualized solely as a linear history of decline.

Through these debates between the editors of the handbook, we identified the most important thematic axes for understanding the Anthropocene's genealogy. We enter into a critical dialogue around the general approaches of a planetary Anthropocene, expressed, for example, in the debate on planetary boundaries and the historical and contemporary experiences and reflections proposed by the social sciences and Latin American environmental humanities. Faced with the continuous conjunctures of colonization from the Conquest to current extractive practices, the importance of deforestation, and the dynamics of the technosphere's advance, especially in urban zones, we identify **land use** as a paradigmatic theme for understanding the Anthropocene from Latin America. For this reason, we dedicate the first volume of the series to this topic. Within this theme, we are interested, firstly, in aspects of environmental change associated with different forms of land use, such as planting, ranching, livestock, or the large-scale clearcutting of forests for infrastructure projects. In addition, we are especially interested in the interconnection with extremely unequal and sometimes violent social processes and crises that originate from these aggressive land uses.

Biodiversity is another central aspect of the Anthropocene discussion. Latin America and the Caribbean are home to 40 percent of the world's biological diversity and seven of the world's 25 biodiversity hotspots, including six of the 17 megadiverse countries and the second-largest reef system on the planet. This region also has Indigenous forms of management, as well as a long history of preservation that is threatened by dynamics of commodification and dispossession. For this reason, a volume is dedicated precisely to biodiversity.

A research project on the Anthropocene, such as the one we present here, must necessarily pose questions related to **climate change** without reducing it exclusively to the global variation of the Earth's climate due to natural causes. The Anthropocene has caused unprecedented changes in this regard in Latin America, often linked to social conflicts and demands for environmental justice. On the other hand, the issue of **water** is inevitably related to climate change and raises important questions on issues such as human consumption and pollution. This vital resource has generated numerous socioenvironmental conflicts during the Anthropocene. Therefore, two volumes in this series are dedicated to climate change and water, respectively.

Due to its importance since the beginning of the conquest, we dedicate a volume to **mining and energy,** which addresses mining extractivism from the silver of Potosí to the lithium of the Altiplanos' salt flats. Mining is inextricably intertwined with the energy sector and its various regimes. Both are linked to specific social processes and structures, in particular, the extreme exploitation of labor leading to slavery, as well as the displacement of Indigenous populations in favor of the use of fossil, or even renewable, energy. These tensions and contradictions comprise the focus of our volume on the subject.

In the discourse on the Anthropocene in the humanities and social sciences, the visual and artistic representation of the concept has occupied a special place, as the question of what images we use to narrate the Anthropocene emerged quite early on. For this reason, we are dedicating a special volume to the **visual representations** of the Anthropocene's genealogy.

In a complex project such as this handbook series of the Anthropocene from Latin America, it seems appropriate to provide guidelines to facilitate reading for all kinds of audiences. The handbook is neither a simple edited volume nor a compendium. Rather, it is organized according to a conceptual matrix in order to understand and address the Anthropocene's genealogy from Latin America. Therefore, all volumes have the same basic structure. Each is structured by a temporal axis divided into three historical periods: the colonial era, the middle of the nineteenth century to 1950, and 1950 to the present day. In turn, each of these respective periods is preceded by a general historical introduction to the topic. This allows for a contextualization from a broad Latin American perspective, making it easier for the reader to navigate the general debates. After this contextual introduction, the main entries follow. These entries synthetically discuss the Anthropocene's genealogy with respect to the volume's theme in large regions of Latin America. From the south to the north of the Latin American continent, the reader will find for each of the three historical periods five descriptive and analytical chapters of about 10,000 words, including a coherent bibliography, on the Southern Cone, the Andes, the Amazon, Mesoamerica, and the Caribbean. To depict the structure of the handbook's matrix in more detail, we first present a concise characterization of the three relevant periods, placing special emphasis on the phases of intensification and acceleration of anthropocenic dynamics. Secondly, we present the regions of Latin America and the Caribbean that will help us to analyze anthropocenic dynamics beyond the methodological nationalism that still predominates in the social sciences. And thirdly, we explore the different elements and variables that are covered in this volume on climate change.

Periods of the Anthropocene's Genealogy in Latin America

Since its proposal in 2000 by Paul Crutzen and Eugene Stoermer, the Anthropocene has now begun the process of being ratified as a new geological epoch in Earth's history. Although the Anthropocene Working Group, a subgroup of the International Commission on Stratigraphy, is interdisciplinary, the argument for the ratification and acceptance of a new epoch is purely geological. In other words, for the Commission to recognize the Anthropocene, it needs, first and foremost, stratigraphic evidence of such planetary human influence on all natural systems. That is to say, it looks for a marker, the so-called "golden spike," in the natural record of soil and rock layers, as well as the atmosphere. Evidence from Earth system science and human history points to a post-World War II marker in the 1950s. In 2023, the Anthropocene Working Group (AWG) proposed Lake Crawford, in Canada, as the Golden Spike, given that the radioactive fallout from the atomic bomb tests of the 1950s and other anthropogenic changes in the environment are especially marked here. Although this proposal has not been accepted by the Geologists of the Subcommission on Quaternary Stratigraphy in 2024, it coincides with the beginning of a phase that members of the AWG and associated researchers have dubbed "The Great Acceleration." This time reference, from 1950 to the present, is included as the last of three axes that we have identified as relevant to a specifically Latin American perspective on the genealogy of the Anthropocene. However, we argue that to understand the process that led to the geological definition of the Anthropocene, it is necessary to grasp dynamics and processes prior to the 1950s.

From a Latin American perspective, we propose tracing the Anthropocene's genealogy to the European Conquest of the American continent starting in 1492 with the Columbian Exchange, the plantation system, and mega-mining. Thus, the colonial era in Latin America is understood as the phase of intensification of important features in the genealogy of the planetary Anthropocene. A second phase begins with the end of the colonial empire and the processes of independence in America. In addition to profound political changes, this phase encompasses an accelerating moment for the historical construction of the Anthropocene, especially from the 1860s to the world economic crisis of 1929. Finally, we include in a *sui generis* manner the Anthropocene phase from 1950 to the present day. Within this phase, it is possible to detect an intensification of anthropocenic factors in Latin America, especially since the 1960s with the Green Revolution and oil exploitation, as well as the eighties with neoliberal policies that accelerated extractive economies and mass consumption.

Colonial Period

1492, the year of European contact with the Caribbean and the Americas, marks a turning point in world history. For the Indigenous peoples and cultures of America, it represents a fundamental rupture and even the end of their worlds. From the perspective of the European conquerors, the so-called "New World" emerges, altering the existing medieval vision of the world. For the first time, the imagination of a global "single world" arises. At the same time, the conquest and colonization of the Americas become the starting point for the formation of a capitalist world system.

In this way, 1492 marks a milestone in environmental history. An intercontinental exchange of biota begins that fundamentally changes both the "Old" and the "New World." Plants from America, such as potatoes, tomatoes, or corn, leave their mark on European cultures and become national foods. At the same time, cane sugar makes its way into Europe and provides the energy reserves for the subsequent Industrial Revolution. The Americas today are hard to imagine without the biota introduced by European colonizers, from bananas, citrus fruits, and coffee to chickens, cows, pigs, sheep, and horses.

In 1492, a large-scale socioenvironmental transformation began, from landscapes characterized by Indigenous land use to Europeanized ones. From this abrupt alteration arises the accumulation of extractive capital. It is important to recognize that, clearly, the Caribbean and American environment was not only extensively modified by Europeans, but also by the numerous and diverse Indigenous populations that inhabited both continents, as well as the Caribbean archipelago for millennia before. Our argument for 1492 as a turning point is one of scale and intensification. In other words, with the arrival of European contact, specific practices of exploitation and extractivism that were unprecedented on the continent became widespread. In fact, the introduction of new species favored the conquest of Indigenous populations, as well as the domination of vast rural areas of the American territory.

One of the "anthropocenic" processes of the colonial phase was the massive reforestation that occurred after the genocides of Indigenous populations as a result of pathogens and European violence. The natural scientists who have modeled this process argue that the disuse of cleared agricultural space led to a large-scale regrowth of forest cover – a massive carbon sink – which, in turn, tangibly cooled the climate around 1610. This theory is known as the Orbis Spike Hypothesis and has also been suggested as the beginning of the Anthropocene. This is a highly controversial topic in climate science, given that this period is also associated with the beginning of the Little Ice Age, but it raises important questions about the relationship between human societies and the Earth system. In any case, the continuity of the colonial process reversed this environmental dynamic, producing extensive deforestation.

On the other hand, the colonial era left as a legacy the development of the plantation system that some academics have called the Plantationocene. In the plantations, systematic techniques of overexploitation of nature were developed, connected also to the excessive exploitation of subaltern labor, that is, Indigenous and African slavery. Human muscle strength (African or Indigenous) was violently exploited as energy to power these plantation machines, thus connecting to the energy history of the Anthropocene's formation and to the process of building European modernity from the margins. The plantation system became an epicenter of confluence between early capitalism and racism, becoming part of the Anthropocene's genealogy. Starting in the last years of the eighteenth century, this process of colonial occupation was decisive in abolishing the natural limits of the solar energy economy in the imaginary of modern capitalism, opening the way for the unrestrained and unlimited expansion of extractive frontiers. This made overexploitation of the land a fundamental characteristic not only of the Americas and Europe but of the global capitalist system.

From the Mid-Nineteenth Century to 1950

During the nineteenth century, the industrial model developed in the European eighteenth century was consolidated. Although the Latin American countries that were becoming independent sought their own ways to carry out social, political, and economic transformations, such transformations were part of global and international struggles of an accelerated imperialism and nationalism. Political and economic changes brought about social transformations in the forms of production, the management of natural resources, and the dimensions of exploitation, accelerating towards the end of the nineteenth century. Although the break with the colonial model was gradual, the oligarchies acquired greater power through the Latin American independence processes, dividing and distributing capital together with the territories of production and the complicity of the landowners.

Nationalism, represented in forms of development, also fragmented territories and the uses of natural resources. New geographical and naturalistic explorations and a new conquest of the environment marked the beginning of the nineteenth century. This century is also considered the era of the second globalization, entailing the consolidation of unequal ecological exchange. There is talk of a second Columbian Exchange related to a global metabolic fracture. Based on this logic, exchange networks were consolidated. This involved not only the exchange of raw materials for industrialized goods, but also the trade of difficult or impossible to replace goods – such as energy, soil nutrients, and biodiversity – for rapidly replenished goods, such as industrial products.

The period between the 1860s and the world economic crisis of 1929 served as a phase of economic liberalization and modernization associated with a new integration of the region into world capitalist structures and a strong reinforcement of extractive economic sectors. Within the framework of the handbook, it can be understood as a phase of intensification and acceleration of the Anthropocene, comparable only to the metabolic rift of the Conquest. With the exception of a few regions, the predominant agricultural model was the exploitation of vast *haciendas* and plantations. In addition, this period is characterized by a process of internal colonization and land grabbing in peripheral regions, referred to by some historians as the Second Conquest. The extraction of raw materials such as rubber, henequen, and mate gave rise to new estates (*latifundios*), export-oriented elites, the establishment of feudalized forms of labor exploitation, and the rapid destruction of natural landscapes.

State formation played a crucial role in the structure of the nineteenth century, marking the definition of new forms of land use and outlining enclave economies in various regions of Latin America. This process was strengthened by new technologies such as steam, electricity, and the subsequent modern means of transport derived from these technological innovations. In the economic transformation of independent Latin American countries, foreign capital investment played a key role, both in the exploitation of agricultural land and in mining. Foreign companies from the United States, Great Britain, France, and Germany accelerated economic and political transformations, directly impacting land exploitation.

With regard to land tenure, the transformation of properties contributed to the displacement of Indigenous communities and the cooptation of others who had been exploited under conditions of semi-slavery in the hacienda system. This phenomenon was observed in different regions of Mexico, the Andes, and the *estancias* (ranches) of the Southern Cone. In Caribbean countries, independence came late and led to new dictatorships at the beginning of the twentieth century. Demographic growth went out of control in some regions, leading to a separation and even segregation between the rural and urban worlds. The motto of "Progress and Order" regulated business and daily life in the nineteenth century. This included hygiene and control measures conducive to new forms of segregation and inequality, which in turn had negative impacts, both on Indigenous communities and on increasingly urbanized populations. It should be noted that at the end of the nineteenth century, the first responses emerged to mitigate anthropocenic effects.

Conservationism was consolidated with the creation of natural protected areas in several countries. The biotic flow began to be controlled – albeit under a reductionist conception of conservation spaces – either as untouchable and unaltered areas, intended as pristine or as reservoirs of exploitable resources in the future.

From 1950 to Present

The period from the mid-twentieth century to the present is known, from an anthropocenic perspective, as the Great Acceleration. It is a period marked by the accelerated consumption of natural resources, raising serious questions about the viability of the Earth system. This phenomenon is the result of important transformations in the world economic system, including the exponential growth of gross domestic product (GDP), population growth, increasing urbanization, energy production and consumption, and the use of fossil-based fertilizers, among other variables.

All of these large-scale socioeconomic transformations have drastic effects on the components of the planetary system beyond the expected natural variations. In the context of Latin America, these changes are reflected in the modification of the phosphorus and nitrogen cycle, which has resulted in the eutrophication of rivers and soil degradation due to industrial agriculture. In addition, an alteration has been observed in the carbon cycle with the loss of sinks due to deforestation and a dangerous increase in carbon dioxide and methane emissions from agricultural sources. Also, changes have been registered in the hydrological cycle with more frequent extreme events of droughts and floods and greater impacts due to the vulnerability of productive systems and urban habitats. Furthermore, there has been an increasing demand for water reservoirs for irrigation and hydroelectricity. Another relevant impact is the simplification of ecosystems and agroecosystems, which has led to a generalized loss of biodiversity.

Since the mid-twentieth century, Latin American governments and elites have assumed changing roles in driving their nations' development models and schemes. In the first stage, coinciding with developmental theory, production and consumption were oriented towards the "catch up," the theory of rapidly reaching the progress and well-being of Euro-Atlantic societies. During this period, local elites and governments adopted a planning approach to the future, with a programmed increase in the scale and pace of production. The import substitution model was implemented, allowing some countries in the region to satisfy the domestic market and to industrialize moderately: Brazil, Argentina, and Mexico being the most prominent. The Economic Commission for Latin America (ECLAC) was created in 1948, and the dependency theory was developed, which allowed the region's situation of marginalization to be explained from a structuralist perspective.

Towards the end of the 1990s, with the wave of neoliberal policies across Latin America, the role of the state was consolidated as a facilitator and intermediary for private transnational capital. Under this scheme of welfare political control, companies were able to freely access natural resources and territories through mechanisms such as public-private partnerships. In parallel, selective integration into the world market based on the exploitation of natural resources encouraged agroindustry and extractivism, such as mining, agroforestry, or fishing. With the new millennium, progressive or neo-developmental governments spread throughout the region. Although they assumed greater roles of state control and planning, these governments facilitated the arrival of global capital mainly oriented to the production and export of raw materials associated with the commodity boom, aimed at increasing the public budget allocated to social policies. Despite their differences, all these models have had in common the primary target of economic growth as the governing axis of the economy, as well as public policies aimed at strengthening the economic bases of the Great Acceleration.

In this period of acceleration, an increase in the rate of extraction of natural resources for the world market has been seen, giving rise to what are known as old and new extractivisms that include the mining, agriculture, forestry, fishing, and urban sectors. In addition, there has been a new Green Revolution characterized by the use of monocultures based on transgenics, the massive use of harmful agrochemicals, and intensive water consumption. Large areas of the region have also been deforested for the expansion of the agricultural frontier, leading to a further significant loss of biodiversity.

Another crucial aspect of the Great Acceleration has been the need to increase the production and diversification of energy sources. In Latin America, there has been an early use of hydroelectric energy, creating profound environmental impacts, both in the flow of rivers and in the production of greenhouse gases that have contributed to global warming. Widespread rural and urban electrification processes have been favored. However, hydrocarbon extraction has also played an important role. New frontiers of oil exploitation, whether offshore (the Brazilian coast and the Gulf of Mexico) or in the Amazon rainforest (particularly in Peru and Ecuador), have helped to increase the supply of fossil fuels in the global market and to delay the international energy transition. In fact, the accelerated integration into global markets has led to the advancement of production frontiers towards non-anthropized areas, causing significant impacts on natural ecosystems and local communities. In addition, there has been a growing presence of financial capital and fictitious economies, characterized by cycles of financial crisis. During this period, internal, regional, and international migration has taken on a new dimension in terms of quantity and quality. In particular, regional migration has intensified due to greater obstacles blocking movement to the countries of the North, although there are still migratory flows to those regions. On the other hand, water management has been oriented towards intensive extraction, both in the industrial and agricultural spheres, generating significant pollution of the region's main hydrographic basins.

Anthropogenic climate change and natural climate variability are also prominent phenomena during the Great Acceleration. The Latin American region is one of the largest terrestrial carbon sinks, in part due to the existence of biomes with less anthropogenic transformation, such as the Amazon, the Mayan Jungle, and Patagonia. Greenhouse gas emissions, however, have not been kept below the sinks. Meanwhile, the increase in the scale of agroindustrial and urban enterprises has produced a continuous increase in waste generation and pollution. During the Great Acceleration, an increase in economic and social inequality has been observed in Latin America, which has meant that different social groups have different levels of destructive capacity. A significant change has been the relative loss of the state's monopoly on the use of force, leading to the emergence of organized crime groups that are involved in the processes of production and environmental predation, controlling territories in both rural and urban areas. At the same time, Latin America has witnessed the rise of resistance movements and proposals for local alternatives, especially around feminism and environmentalism.

Technological changes and transformations in communications have been profound and extensive during this period. Satellization and fiber optics have revolutionized communication media, allowing for a diversity of messages and greater appropriation of the media by subalternized movements and organizations. Nevertheless, there has also been a concentration in the distribution of cultural messages, posing challenges in terms of the democratization of information and culture.

In conclusion, the Great Acceleration has been a period of intense socioeconomic and environmental changes in Latin America. The accelerated consumption of natural resources, development models oriented to economic growth, extractivism, water management, anthropogenic climate change, inequality, and migration are some of the key aspects that define this stage. Latin America faces significant challenges in achieving a sustainable development that guarantees the preservation of its natural resources and the well-being of future generations.

Anthropocene Regions in Latin America

Regarding space, the handbook combines the perspective of planetary boundaries with a regional approach that takes into account the local and regional specificity of climates, ecosystems, and socioenvironmental relationships. The operationalization of this regional approach for the handbook project poses a complicated task. In macro-regional terms, the handbook is limited to what today corresponds to Latin America, including South America, Central America, Mexico, and the Caribbean. However, given the wide variety of climates and ecosystems in this vast region, we have proposed to define smaller and, at times, even larger areas. To this end, we do not want to rely solely on the geopolitical units of nation-states – important entities for the political regulation of the environment. Often, such territorial divisions ignore natural boundaries, while, at the same time, climate extremes tend to disregard human-created national borders. Finally, from a heuristic standpoint, we chose to define five areas that we consider suit what we would like to show in the six handbooks and that, according to our approach, are characterized by a certain ecological and cultural coherence without national borders. From south to north, these regions are as follows: the Southern Cone, the Andes, the Amazon, Mesoamerica, and the Caribbean.

Southern Cone

The Southern Cone can be defined in a combined manner. In biophysical terms, its hydrographic network, which corresponds to the Rio de la Plata Basin, stands out. In geopolitical terms, it is defined by historical processes that determine flows of people and material wealth. While still taken into account, these flows transcend the national borders of neighboring states. From a political-administrative point of view, the definition of the Southern Cone has varied. In the colonial past, the delimitation of the viceroyalty of the Rio de La Plata and the Jesuit-Guarani territory outlined a region. The Southern Cone would encompass Uruguay, Argentina, Chile, Paraguay, southern Brazil, and even the southeastern tip of Bolivia, forming a region with common structures in a heterogeneous scenario. More recently, the Southern Cone acquired geopolitical meaning in the seventies, as well as a commercial and customs significance with the creation of Mercosur in the nineties.

In the colonial period, the region was an important corridor that linked the silver mines of Potosí to the Atlantic. Much of the territory of the Southern Cone had not yet been conquered and controlled by the Spanish Crown but was kept in the hands of various Indigenous peoples. The southern part of the region, especially, was controlled by the Mapuche, whom the Spanish Crown could not conquer. During the colonial period, the relationship between Indigenous peoples – particularly the Guaraní in south-eastern Bolivia, southern Brazil, northern Argentina, and Paraguay – was fundamental for inter-ethnic relations and landscape transformations, especially due to the Jesuit presence until their expulsion at the end of the eighteenth century.

This geopolitical situation changed dramatically in the second half of the nineteenth century. We can speak in the Southern Cone of a Second Conquest, which found its highest expression in the bilateral Chilean-Argentine military campaign against the Mapuche people in the 1860s.

Figure 1: Anthropocene Regions in Latin America

Source: Own elaboration.

Parallel to this violent grabbing of Indigenous territories, a massive process of European immigration took place. In the middle of the nineteenth century, the Southern Cone states received a large number of settlers of European origin. In fact, the Brazilian Southeast, especially the megalopolis and the interior of São Paulo and even Rio de Janeiro, can be integrated into the Southern Cone due to its similar characteristics in terms of economic structures and the important role played by European migrations in its overall human composition. Colonial and neocolonial ambitions to create "Neo-Europes" are reflected in many city names, urban landscapes, dietary habits, and agricultural practices in the Brazilian Southeast. From a European perspective, mass immigration was a biopolitical solution for the rural population, impoverished and made redundant by industrialization.

The environmental characteristics of the Southern Cone region vary widely due to its extensive territory and geographical diversity. The region is home to a great diversity of ecosystems, including subtropical rainforests, temperate forests, steppes, grasslands, wetlands, deserts, and glaciers. On this backdrop of complexity, heterogeneity, and abundance of natural resources, there are some structuring features of the territory that provide it with identity. A very important one is the presence of its three main rivers: Paraná (4,352 km), Paraguay (2,459 km), and Uruguay (1,600 km), which make up the Río de la Plata basin. These rivers are among the largest in the world, while the Rio de la Plata estuary is the widest in the world.

The La Plata Basin, the central part of the Southern Cone, integrates a large part of the territory of Brazil, Argentina, and Uruguay, as well as all the territory of Paraguay. In this vast territorial expanse, various biomes or ecoregions converge, each with very distinctive characteristics. Some have already undergone severe transformation or degradation, while others are on the path to degradation: the Paranaense Forest, the Pantanal, the Chaco, the Iberá Wetlands, the Pampas Grassland, the Delta, etc. All these are unique ecosystems globally and hold significant ecological value. One of the largest wetland systems in the world is also in its territory, including the recharge and discharge areas of the Guaraní aquifer.

Historically, the colonization of the interior took place mainly through the Paraná, Paraguay, and Uruguay rivers. These also form the transportation routes that today connect the region to the world market. Large quantities of soybeans, cereals, meat, and iron ore are shipped here.

But it is not only the La Plata Basin that gives the Southern Cone its identity. In turn, a second integrating pillar of the region is the presence of the Andes, as an axis that structures a specific space and a fundamental part of the territory. Chile to the west and the Andean regions of Argentina and Bolivia to the east create a socioenvironmental-cultural framework of notable specificities. In the case of the Southern Cone, the southern Andes, with their two sub-regions, are key. First, the arid Andes – from the north of the Chilean-Argentine border (Cerro Tres Cruces) to the Pino Hachado Pass in northern Patagonia – stand out for their aridity and their great heights, such as Mount Aconcagua (6960 m MSL). The Atacama Desert is an ecosystem characterized by its extreme drought, with precipitation not exceeding 18 mm per year. It is a subregion with intense geopolitical and socioenvironmental conflicts in which, as a result of productive activities, considerable changes have been observed in the natural environment, related to mining activities, such as large-scale copper and lithium mining. These metals have become emblematic of the new mining impetus in the triangle of deposits formed by Chile, Bolivia, and Argentina. In this region, there are also a series of socioenvironmental problems, which can be interpreted as the result of human-induced alterations to the natural environment that have affected the population. The second sub-region is the Patagonian Andes, extending south of the Pino Hachado Pass with the Patagonian Andean forest. In southern Argentina and Chile. we find Patagonia, which extends from the Colorado River in Argentina to the Strait of Magellan in Chile, covering approximately 1,043,076 km^2 in total. The strait, as a natural inter-oceanic passage, saw great commercial activity until the inauguration of the Panama Canal at the beginning of the twentieth century. Another view of this region is from the fragmented and insular coastal edge connected to Antarctica, with a population attentive to maintaining sovereignty flags.

Faced with the vastness of resources, the notion of dispute has been present in the various territories of the Southern Cone, from Gran Chaco to Patagonia and the Southern Andes, the land where colonists exercised sovereignty by eradicating the aborigines. The genocide of the original peoples was accompanied by the destruction of the ecosystems in which they lived. Further west, in Chilean territory, another dispute: the resistance of the Mapuche people to the advance of the Chilean army from the north and the colonists from the south. This conflict remained active for much of the nineteenth century and does not seem to be fully resolved. Conflicts over Indigenous territories are still active and are exacerbated by interest in mining areas, the southern sea for salmon farming, or the rivers for hydroelectricity, among other resources.

The Southern Cone has been blessed with an enormous variety of flora and fauna and extensive ecosystems. However, rapid population growth, industrial expansion, mining, agriculture, forestry, and large-scale hydraulic engineering projects have caused great territorial deterioration and strong socioenvironmental conflicts throughout history. This history is indicative not only of the abundance of natural resources and the natural productivity, goods, and services provided by these ecosystems but also of the tensions, imbalances, and conflicts that their exploitation has caused throughout their historical development. In conclusion, the Southern Cone presents itself as a region rich in biogeographic and cultural diversity, marked also by significant environmental and socioeconomic challenges. The sustainable management of its natural resources, the preservation of its unique ecosystems, and equity in the access and use of these resources are key elements for a future development that guarantees the prosperity of the region and the well-being of its inhabitants. A deep understanding of the region's environmental and social history is essential to address current challenges and build a more sustainable future for the Southern Cone.

Andes

The Andes region encompasses the countries crossed by the Andes Mountains, located in the tropical zone of South America, between 11° North and 27° South latitudes. In administrative terms, it includes the south of Venezuela, Colombia, Ecuador, Peru, and Bolivia, as well as the tropical parts of the Argentine and Chilean extreme north. From a natural point of view, the region has common elements in relief, altitude, and climatic behavior, but with significant variations. While the northern areas of the Andes experience two rainy and two dry seasons, the central Andes are characterized by only one rainy and one dry season.

The Andes Mountains are divided into two main mountain ranges: the Cordillera Negra in the west and the Cordillera Blanca in the east. These are connected by transverse mountain ranges and their valleys, as well as by the elevated lands of the *páramo* in the north and those of the Altiplano, a wide plateau that reaches its largest extent in Bolivia. The great elevational variation of the Andean region, which ranges from sea level to heights of more than six thousand meters, creates several altitudinal floors with different ecological characteristics. The climatic influence of the El Niño-phenomenon and the Humboldt marine current, which circulate along the Pacific coast, also translates into climatic diversity along the latitudinal gradient. These features range from very humid ecoregions on the North Pacific coast, such as the Colombian Chocó, to desert ecoregions on the Peruvian coast.

The Andes are home to several ecoregions that are internationally recognized as biodiversity hotspots. In fact, the region constitutes a complex mosaic of more than 130 ecosystems, including *páramos*, *punas*, and Andean valleys, with high levels of biodiversity. The tropical Andes are a leading region in endemism worldwide, with an estimated rate of more than 50 percent in plant species and more than 70 percent in fish and amphibians. Thus, it is the region with the greatest diversity of amphibians in the world, with around 980 species, 670 of those endemic.

When we refer to the Andes, we mean three diverse geographic zones that comprise the Pacific coast, the Andes, and the Amazonian foothills. The region's diverse ecologies have been used and shaped by humans for more than 14,000 years. The formation of complex human societies based on agriculture dates back approximately one thousand years before the Inca expansion in the fifteenth century. On the coast, the construction of monumental structures and urban centers in several valleys of the central and northern coast of Peru, such as the Supe Valley, cannot be comprehended without taking into account the maritime resources provided by the Humboldt Current, especially the rich fishery. The key characteristics of Andean societies, such as the specialization of social roles, the emergence of formal belief systems, the increase in food production, and technologies for systematic data recording, are evident more than a thousand years before the Incas began their imperial expansion in the fifteenth century.

Over the millennia, Andean societies in the mountain range have employed diverse strategies and technologies to survive and thrive in a challenging physical environment. These strategies include the construction of irrigation systems and terraces, innovations that enabled the spatial and seasonal expansion of agriculture. They also facilitated the proliferation of species suitable for agriculture, such as corn and potato varieties, as well as the domestication of camelids. In addition, Andean societies promoted demographic expansion, especially in the mountain range. These technologies were complemented by the emergence of dispersed settlement patterns, allowing communities to take advantage of a wide range of ecological zones at different altitudes, with their diverse available resources. Although these strategies fostered the self-sufficiency of many communities, the Incan imperial expansion introduced a policy of integration evidenced in the construction of an extensive road network, as well as in the relocation of ethnic groups, and the storage and distribution of food, textiles, and other goods.

From the imperial scale to the level of the *ayllus* – the basic social units in Andean communities – existing physical infrastructure and organizational practices formed the initial basis of colonial society after the invasion of the Spanish conquerors. However, the prolonged turbulence of the conquest, aggravated by epidemics and depopulation processes, caused the deterioration of road, irrigation, and cultivation systems in many areas of the Andean territories.

On the other hand, the viceregal policy of introducing large-scale mining manifested itself dramatically in silver mining in Potosí, an industry that emerged as the epicenter of large continuous movements of forced and free Indigenous workers, as well as goods. This restructured communities in the surrounding provinces and, among other environmental effects, led to deforestation. The appearance of mega-mining during the colonial regime marked an acceleration point in the Anthropocene, with its collateral effects of excessive land and water use, deforestation, and pollution.

Mainly in the northern Andes and the eastern foothills, the colonial exploitation of gold deposits, which often relied on enslaved Afro-descendant workers, accompanied silver mining. Whereas the extraction of precious metals was crucial during the colonial era, the second half of this period witnessed economic diversification in many parts of the Andes. Although the wars of independence in the nineteenth century brought about political and social changes, the exploitation of primary resources remained the main economic base of the new Andean republics. In Bolivia and Peru, the decline of mining during the wars was followed by a process of recovery and transformation, driven by foreign investment, industrialization in the Global North, and the introduction of machinery powered by steam and electricity in many mining sites. Overall, trends toward intensification and expansion of mining operations have continued into the twenty-first century in response to growing global demand for a variety of metallic and non-metallic minerals.

In all the countries of the region, the rise of the oil industry, especially during the last five decades, represents a parallel intensification process in the extraction of subsoil resources. The mining, oil, and gas industries, dominated in many cases by transnational corporations, have been responsible both for severe ecological degradation in many areas of operation and for the production of socioenvironmental conflicts. At the same time, agricultural industrialization has had diverse impacts on the Andean region since the second half of the nineteenth century. These include cacao plantations in Ecuador, coffee plantations in Colombia, cotton and sugarcane plantations in Peru, and the unrestrained exploitation of seabird guano off the Peruvian coast, followed later by nitrates, to promote the development of intensive agricultural systems in the North, especially in Great Britain and the United States. This transfer of resources marks a profound metabolic rupture in Andean ecosystems.

The agrarian reforms of the 1960s and 1970s mainly caused a modernization of the agrarian structure, including the introduction of the agrochemical packages of the Green Revolution. With the implementation of neoliberal policies that began in the 1980s, the orientation towards exports intensified, giving rise to new agroindustries, such as the expansion of African oil palm, especially in Colombia and Ecuador. This was alongside the more traditional monocultures of coffee and bananas, which have produced a great deal of deforestation.

In the coastal valleys of Peru, the industrial-scale cultivation of a variety of agricultural products for external markets contributes to the worsening of the water deficit faced by many communities. Local or regional conflicts over water and other vital resources are intertwined with the impact of anthropogenic climate change at the trans-Andean level, driving, among other things, the retreat of Andean glaciers.

Despite a long history of colonialism and its profound legacies, many Indigenous and Afro-descendant communities have succeeded in defending and rebuilding high degrees of cultural and territorial autonomy. Nowadays, especially in Ecuador, Bolivia, and southern Colombia, Indigenous movements constitute a considerable political force, sometimes manifesting as resistance to extractive projects or as new forms of care for the natural environment. These forms of care are also expressed in the concept of Buen Vivir.

Although all the countries of the Andean region defined themselves as multicultural or even plurinational in the 1990s and countries such as Ecuador and Bolivia incorporated rights of nature into their constitutions, extractivism deepened. Today, the various socioenvironmental conflicts in the Anthropocene era are at the center of fundamental debates about the future of the Andean region. These conflicts are also manifested on a global scale, as seen in the Bolivian-Chilean-Argentine highlands, which is becoming a new pole of rare earth metals extraction, especially lithium, to support the Green Deal and the CO_2-neutral industries and transportation of the Global North.

Amazon

The Amazon is a region defined by its belonging or proximity to the Amazon River basin, which crosses nine nation-states: Brazil, Colombia, Peru, Bolivia, Ecuador, Venezuela, and the three Guianas. Each of these nations has different trajectories in their relationship with the forest, both quantitatively and qualitatively. In Brazil, the Amazon is connected to the Cerrado and the Northeast through a history of migration since the end of the nineteenth century, linked to activities such as rubber extraction, mining, livestock farming, and logging. The Amazon has also been a supposed ecological paradise to which the victims of drought and the inequalities of the plantation system were encouraged to flee and settle. In the north, the Amazon River system is connected to the Orinoco, the third largest river in Latin America. Across the Atlantic, the Orinoco River system was an important entry point for extractive economic activities in the Amazon, such as the exploitation of rubber, the felling of native trees, livestock farming, and mining. Being a difficult-to-access area for the European colonizer, the otherness of Amazonian nature has been the source of numerous myths and cultural representations that have served to justify its exploitation or conservation, given that it is the largest rainforest reserve on the planet with a great diversity of biomes.

Although the concept of the Amazon has served to exemplify the notion of nature in its most "pristine" state, it is actually a historically constructed concept. At the beginning of colonization, it was not spoken of as a totality. Rather, it was established sociohistorically in the mid-nineteenth century, as until then, the Amazon only referred to the river and the river system associated with it. European knowledge of the area was gradually recorded in the cartography of the sixteenth and seventeenth centuries, showing imaginaries built on the idea of an exotic and exuberant Eden, as threatening as it was paradisiacal.

Despite the predominant image of a "virgin" jungle, the Amazon region is cultural. It has been transformed by humans for around 10,000 years. Indigenous and certain mestizo populations are important actors, even though forest biodiversity is the result of millions of years of evolutionary processes prior to human presence. During the colonial period, among European and Creole travelers and settlers, the predominant idea was that of a "green hell," the scene of the great drama of man against a wild and unhealthy nature full of dangers arising from its flora, fauna, climate, and human groups, associated above all with the idea of the cannibal. Over the centuries, various projects coexisted or alternated such as the conquest of the jungle, its exploitation, or its occupation, later moving to a conservation discourse framed by the idea of the region as a global natural heritage beyond the protection managed by specific political entities.

In the countries of the Amazon, this region has generally not been a geopolitical center, but rather a territory in a certain limbo, considered to be a reserve for the future. The predominance of national structures as determinants of public policies, whether of colonization, exploitation, or conservation, does not take into account the fact that non-human forms of life and many human populations do not always live according to the assumptions of Western structures. Animals, plants, and rivers experience and renew their existence through cycles and movements that do not consider borders. However, the actions that each nation does or does not implement in the jungle may determine whether the life of these beings on its borders is viable. Both official policies and the demands of social movements are becoming important in the continuous construction of a territory in which the Anthropocene – apparently less visible here than in more urbanized places – is constantly maintained as a structuring principle. This is evidenced by the numerous interventions carried out in the Amazon since the first half of the twentieth century. From that point on, an increasingly extractive economy with varying intensities broke out. In addition to the extraction of natural resources, the expansion of nation-states entailed the occupation of land for agriculture and livestock, as well as the development of large infrastructure projects. By the 1970s, there was already flagrant harassment of the jungle, marked by the invasion of the territory. There were slight variations in the implementation of the occupation projects according to the historical processes of each country.

In many Amazonian areas, the second half of the century was also characterized by the incursion of religious missions, first Catholic and then Protestant, whose presence had strong impacts on the organization of the native peoples, both in the management of resources and in their relations with the environment. In the twenty-first century, the growing political role of evangelical churches and their representatives has been supportive of right-wing factions with little willingness to stop environmental devastation. Instead, they have come into open conflict with environmental and land defense movements. The case of Brazil during the administration of Jair Bolsonaro, when the destruction of the Amazon rainforest increased alarmingly, exemplifies this alignment of forces and the threat it poses to the region. Given the key role of the Amazon in global ecology, the ease with which governments, ultimately transitory, are able to trigger environmental crises that impact their countries and the entire planet is worrying.

In contrast to this bleak landscape, several projects emerge that amalgamate multi- and transdisciplinary perspectives with the purpose of recovering or generating ways of inhabiting the Amazon in a sustainable manner. Although the region has become a testing ground for a new Green Economy, the weight of extractive capitalism, represented by mining and oil exploitation, among others, remains overwhelming. In addition, harmful practices such as clear-cutting, livestock farming, and other archaic predatory economic forms persist.

It is worth noting, however, a change in approach that considers biodiversity not only in terms of biological diversity and physical environment, such as waters and soils, but also in relation to sociodiversity. The latter is perceived as an element that must necessarily be integrated into conservation actions. In this context, non-dualistic thinking acquires relevance when reflecting on the Anthropocene, stressing the need to not separate nature and culture. Instead of erecting visions based on the ancient myth of a "virgin" jungle in which the human being is simply a hindrance – an idea that has been used more to displace Indigenous and peasant communities than to curb large-scale exploitation –, one must consider that the challenge lies in building conditions favorable to ecological balance. Indigenous and traditional worldviews, revitalized by current generations, offer ways to rethink the relationship between the human and natural worlds.

Mesoamerica

We propose to include the Central American Isthmus and Mexico in a new notion that we call Greater Mesoamerica. The conceptualization of Mesoamerica, presented by Paul Kirchhoff in 1960 and originally published in 1943, has been very useful because of its specificity, making it possible to distinguish a given area in geographical and cultural terms. Mesoamerica has solved problems associated with unclear concepts, such as Middle-America, used in the handbooks of the 1960s, whose translation into Spanish was never clear. In addition, it geologically identifies Mexico as part of North America, while also being part of Latin America. However, Kirchhoff's definition omits northern Mexico and part of southern Central America, leading us to propose a more inclusive notion.

In this volume, we will consider Greater Mesoamerica the geographical and socioenvironmental space that encompasses the entire Mexican territory, the five Central American nations that formed the Captaincy General of Guatemala (Guatemala, Honduras, El Salvador, Nicaragua, and Costa Rica), as well as the present-day Belize and Panama. Greater Mesoamerica, as we conceive it here, does not intend to analytically homogenize the biocultural diversity that characterizes this region; rather, we start from the premise that, despite this diversity, historical processes have taken place that present parallels in the field of socioenvironmental relations, differentiating it from other Latin American territories.

In ecological and socioenvironmental terms, the subregions of Mexico and the Central American Isthmus have peculiarities and interrelationships that we must highlight. Mexico is a megadiverse country thanks to its geographical position, connecting North America with Central America, and its strategic location between two oceans: the Pacific and the Atlantic. This allows for the conjunction of nearctic and neotropic vegetation in that territory. Mexico ranks first in terms of reptile diversity in the world. Half of the country is desert, and more than 50 percent of its national surface has a rugged topography with hills and mountains. Most of the territory experiences severe droughts, and the availability of water is mainly in the south-southeast.

This is clearly a geographical Vavilov center, defined as the place of origin of domesticated plant species of great economic importance. Led by corn, the dietary basis of the region, these species include chili, tomato, pumpkin, cacao, amaranth, and others that form part of the world's food heritage. Mexico has more than 20 biocultural regions, where language and culture are combined with natural biological species, generating broad and diverse knowledge systems. Mexican cuisine, in recognition of this biocultural richness, has been declared an Intangible Cultural Heritage by UNESCO. However, this wealth is under threat and requires urgent protection measures.

Central America stands out as the only region in the world with both an intercontinental and an interoceanic position. This isthmus links North America with South America, separating the Pacific Ocean from the Caribbean Sea. It extends from Tehuantepec in southern Mexico to the Atrato Valley in northeastern Colombia. Formed 3 to 4 million years ago in the Pliocene, the isthmus has been a bridge for North-South movement for about 10 to 12 thousand years. Its unique location gives it a variety of contrasting landscapes, including mountain ranges, intermountain valleys (altiplano), hillsides, and coasts. The region is characterized by its climatic diversity. Tropical and subtropical climates predominate, but microclimates abound.

There is a great contrast between the mountainous areas – composed of hills, mountains, volcanoes, and plateaus – and the slopes. This climatic diversity is reflected in the region's natural richness. Its diverse life zones host forests that range from the very humid, humid, and rainy to the dry. The isthmic condition of Central America explains the presence of flora and fauna from North and South America. Until Nicaragua, the vegetation is nearctic, and from the south of Costa Rica, the vegetation becomes neotropic. The combination of species in these regions explains the vast biodiversity of this subregion.

Greater Mesoamerica clearly covers a period that precedes the beginning of the genealogy of the Anthropocene, which, from this project's perspective, stems largely from the European invasion. However, we will limit the period of study in these handbooks starting with the considered territories' conquest, that is, the colonial period, based on the logic of the intensification of exploitation processes. Therefore, the concept of Mesoamerica present in the contributions of these handbooks must be understood from a broad geographical, cultural, and socioenvironmental sense, as stated above. It is, then, an operational concept that does not ignore the diffuse and subtle nature of inter- and intraregional divisions, nor does it ignore the socially constructed nature of any spatial delimitation, especially – although not exclusively – when it comes to socioenvironmental relations.

Caribbean

The Caribbean, whose core was delineated by different groups of various-sized islands, is characterized by the territorial interaction between these insular and maritime spaces, as well as the surrounding coastal areas in the Gulf of Mexico. This is known as the Circum-Caribbean, and we include it in our conception of what we call the Greater Caribbean, which also includes the Atlantic coast of northern Latin America with Colombia, Venezuela, and the Guianas. It was the first region "discovered" by Christopher Columbus. The island of Hispaniola (currently the Dominican Republic and Haiti), in particular, became the geopolitical epicenter of the Spanish and other European powers. It was called "the gateway to the Americas," at least until the mainland (*Tierra Firme*) – with more promise – was discovered and began to be conquered.

From the perspective of the Anthropocene's genealogy, the Caribbean is a particularly vulnerable region in relation to climate change in historical times, i.e., the colonial imaginaries of "primitive climate engineering," and also to anthropogenic climate change since the Great Acceleration. First, the Caribbean archipelago has been especially exposed to weather extremes such as hurricanes, droughts, and extreme rainfall, as well as to geological extremes such as volcanic eruptions. Second, these small island ecosystems were extremely sensitive to disturbances, such as large-scale deforestation undertaken by colonizers to create sugar plantations.

The Caribbean is a point of confluence between various geographical areas of the American continent, located in the middle part of the continent in much of the Atlantic Ocean. This has allowed large territories of the Caribbean to become gateways, both by sea and by land, for the migrations of people from European countries and the American continent itself. In addition, the Caribbean was the first region in the Americas to experience migrations of flora and fauna, especially with the arrival of Spanish inhabitants who introduced new livestock species and various agricultural products. The anthropogenic change caused by the European arrival was, to a large extent, related to the introduction of pathogens, causing the massive death of Indigenous populations and the abandonment of land cultivation in different Caribbean regions.

It is no accident that, until today, the Caribbean is recognized globally as a large tropical and mountainous area contrasted with coastal activities. It brings together vast territories with a wealth of terrestrial and maritime biodiversity that, for centuries, have been a meeting point for migrants from Europe, America, Asia, and Africa. The migratory diasporas to and from the Caribbean had such intense periods that we can say the region has provided conditions for complex and conflicting *mestizaje*.

After European colonization and the beginning of the transatlantic slave trade, the extractive plantation industries, which exploited the labor of large numbers of enslaved Africans, gave rise to highly stratified and socially vulnerable societies in this geographically fragile environment of small islands. From this perspective, there are numerous analogies and a shared history of forced migration, racial stratification, and systematic ecological exploitation as in the Brazilian Northeast. Both regions, of roughly the same demographic size, are fundamental nexuses of the Afro-Atlantic world and constitute spaces of ecological circulation that are paradigmatic for the colonial plantation system, in addition to its enduring legacy in the creation of the Anthropocene. The northernmost part of Northeastern Brazil, that is, states such as Ceará and Rio Grande do Norte, are sometimes included in classifications of the Caribbean.

During the colonial period, the Caribbean was one of the most important markets for people exploited by the international slave trade, financed by European economic powers. To a large extent, current migrations from the Caribbean are due to very complex processes of the anthropocenic degradation of territories and popular settlements, as well as to the violent penetration of criminal groups that have forced large sectors of the civilian population to take refuge in neighboring countries or seek migratory routes to the United States.

Since the conquest, violence and political instability shape the Caribbean region. At the end of the eighteenth century, Haiti was the epicenter of the first major revolt of people freeing themselves from the yoke of slavery in America. Since then, the conditions of slavery and labor exploitation have been intolerable for large sectors of the civilian population. However, at the same time, the Caribbean has been a space of great transformation and anthropocenic resilience, despite extractivist policies focused on land use changes, the exploitation of aquifers, the introduction of non-endemic fauna and flora, the extraction of oil, clandestine logging of forests, and the extraction of minerals. Countries such as Cuba, Haiti, Barbados, and the Bahamas are just a few examples of nations that have experienced dramatic transformations with great effects on their inhabitants due to the extractive policies implemented from colonial periods until today.

In anthropocenic terms, Indigenous and Afro-descendant communities have been especially affected due to the occupation of their ancestral territories and the implementation of industrial-scale monocultures. Paradigmatic examples of this are bananas, cacao, and coffee, products with great global demand that are grown using labor under precarious conditions, often equivalent to slavery. Another manifestation of anthropocenic devastation in the Caribbean is sugarcane, which has resulted in extensive deforestation to grow tubers imported from the Philippines, depleting water reserves due to intensive water use.

In addition, the mining of precious metals such as gold and silver has been a significant factor of anthropocenic devastation. Land use and the pollution of rivers with toxic substances, such as mercury and cyanide, have seriously affected the natural environment. Copper mining since the nineteenth century and nickel mining in the twentieth century have had a global impact and have wreaked havoc on diverse ecosystems. These activities have also profoundly transformed the region's cultural forms and traditions.

In short, the Anthropocene has had a significant impact on the Caribbean region, especially from the nineteenth century to the present, due to abusive and uncontrolled extractive policies in populations that have suffered a long history of systematic impunity, corruption, government abuses, discrimination, and endemic racism. In addition, the phenomenon of mass tourism in the twentieth century has affected the natural resources and biodiversity of jungles, mountains, and beaches through the international sale of land and property to European and North American foreigners. Finally, we wish to emphasize that, given the historical legacy of colonialism, slavery, and continued economic dependence on European powers – even after political independence – together with anthropogenic climate change, these small island states remain vulnerable. However, creative regional solutions are emerging to address the climate crisis, especially in the form of specifically and innovatively structured disaster insurance programs.

Climate Change

This volume of the CALAS Handbooks series focuses on one of the core issues of the Anthropocene in Latin America: Climate Change. As a starting point, it must be acknowledged that the conceptualization of Climate Change itself faces a challenge, particularly with regard to the time period covered in the six volumes of this series. In analyzing the genealogy of the Anthropocene in the Americas from 1492 onwards, it is imperative to differentiate between natural climate variability and anthropogenic climate change over the proposed epochs. Furthermore, the question arises of how "climate" or its variability and "climate change" have manifested and been perceived by local societies in different regions of Latin America. How have these societies been transformed by Climate Change over the extended period of time covered in this volume?

Given the challenging time frame, as well as the intertwining between social and "natural" factors, which are shared by all six CALAS Handbooks, it is important to note that before the mid- to late nineteenth century, no standardized and measured "climate data" was available for Latin America. In other words, much of the early genealogy of the Anthropocene in this volume is based on climate history, in part by reconstructing climate extremes from past written sources and natural proxy data. This results in qualitative studies that explore the impact of climate variability on colonial societies and the effects of human intervention in nature. The qualitative nature of these studies is also applicable to the remainder of this volume. Consequently, this volume will not provide numerical data on changing climates. Instead, it presents narratives that illustrate socio-environmental entanglement, thereby facilitating a more profound comprehension of both contemporary and historical climatic changes.

In order to understand the nature of the data utilized and produced by this volume, it is imperative to acknowledge the terminological challenge posed by the term "climate." Historically, in European and colonial contexts, the concept of "climate" was understood as a geographical term, closely associated with the notion of latitude. This perspective contrasts with the contemporary understanding of climate as the average weather conditions (precipitation and temperature) in a specific region. Analogous to the notion of the "El Dorado" in the context of land use (Volume I of the Handbooks series), the climate, and the tropical climate in particular, offered Europeans the promise of abundant and cash crops and, more ominously, exploitable human labor. This labor would relieve Europeans of the arduous labor of their production and harvest. In other words, Africans were forcibly deported to and indigenous people displaced within the Americas to perform these tasks. By tracing how climate was historically imagined within the colonial worldview, this volume – especially the contributions on land use and biodiversity – can be more fully situated, while also bringing the colonial past into conversation with contemporary debates on restitution and reparations.

At the conceptual level, the inquiries presented in this volume encompass a dialectical perspective on the human-nature relationship. On the one hand, climate and climatic extremes emerge as conditioning factors of societies, encompassing the pre-colonial, colonial, and post-colonial periods. On the other hand, through various cultural practices and historical processes, humans turn into climate transformers, particularly through transformations in land-use associated with agriculture, extractive mining, and deforestation, as well as shifts in energy use and urbanization patterns.

An examination of climate and Climate Change during the "Proto-Anthropocene" – this phase of slow accumulation of anthropocenic processes preceding the Great Acceleration – thus entails, in the first instance, an exploration of how Latin American societies have interacted and adapted to specific environments, as well as how colonial societies, often fractured, were able to react to the frequent climatic extremes that threatened colonial livelihoods and food regimes.

The volume will explore how societies coped with and made sense of droughts, hurricanes, and floods, both sudden-impact and slow-impact over the long term. It is important to note that these natural hazards are increasingly influenced by global phenomena, which are part of climate variability itself (such as El Niño – ENSO – or hurricanes). However, these phenomena are also undergoing changes in their effects, and the damage they cause is magnified due to anthropogenic climate change. Finally, it is imperative to explore the coping strategies employed by these societies in the face of climatic anomalies during the Little Ice Age (LIA). Studies, particularly those focused on the Mexican context, have demonstrated that these anomalies led to agrarian transitions, floods, prolonged droughts, epidemics, epizootics, and recurrent agrarian crises, which in turn resulted in destabilized human health and elevated mortality rates. This phenomenon is inextricably linked to the historical and social construction of risk and vulnerability in the face of recurrent natural hazards. This process has persisted to the present day, leading to an exponential increase in the effects and impacts of the disasters associated with them.

The industrial revolution in Europe, which is widely regarded as the genesis of anthropogenic climate change, had its takeoff around 1750–1800. Concurrently, Latin American countries initiated the Age of Revolution, embarking on processes of emancipation from colonial rule and independent nation-building, even though many of their social and economic structures remained largely intact. However, as demonstrated in this volume, the long nineteenth century witnessed the integration of the regions under study into global capital markets, characterized by a strong export orientation. This integration led to the expansion of these regions' commodity frontiers, as evidenced by the development of the Southern Cone and the Andes. This volume emphasizes the intensification of extractive cultures, influenced by Western scientific knowledge and concepts of "modernity" and "civilization." As previously mentioned, the changes and intensification of land use and increasing urbanization are indicators of a slowly accelerating process of industrialization and thus of a late approach of our study regions to the era of anthropogenic Climate Change. However, it is crucial to acknowledge the significance of the historical contributions of Latin American nations in the context of the current climate crisis. When evaluated against the global climate policies of the United Nations Framework Convention on Climate Change (UNFCCC), which are pertinent to the phase of the Great Acceleration and thus the present Anthropocene epoch, these contributions pale in comparison to the historical debt owed by the industrialized West or the global North.

The phase of the Great Acceleration, and thus of the current Anthropocene, is considered to have begun in the 1950s and has since intensified. This period is characterized by the availability of substantial quantitative and qualitative data, which enables a precise attribution of climate change to anthropogenic activities. The advent of attribution science in the early 1950s marked a significant development in the field, providing a reliable framework for evaluating the role of human activity in causing extreme weather events. This represents a significant departure from the nineteenth century, when the collection of climate data commenced in the latter half of the century, or from the colonial era, when available data primarily took the form of qualitative descriptions of Climate Change that were not yet clearly influenced by human activity. The attribution of climate extremes to anthropogenic causation gives rise to new fields of global climate negotiations that are intricately intertwined with the history elucidated in this volume. Small island states, such as the Caribbean archipelago, are disproportionately affected by the ongoing climate crisis and its extremes. The historical attribution of blame for this crisis to the Global North and its industrialization process, which was closely linked to the exploitation of the Americas' resources, enables these Small Island States to claim reparations. The ongoing consequences of extreme weather events, which endanger the livelihoods and residences of numerous Caribbean individuals, serve to exacerbate the repercussions of historical racial capitalist exploitation and ecosystem degradation.

This region of the Americas and the world, therefore, provides a distinctive viewpoint on the broader critical discourse on Western modernity that has emerged specifically in the context of the Anthropocene and within the humanities and social sciences. This critical discourse has also sparked growing interest in alternatives to Western capitalist models that may help humanity survive on an increasingly warming planet. As a result, Indigenous and local knowledge systems and worldviews, among others, have moved to the forefront of social research on climate. These alternative understandings of the relationship between humans and nature—perspectives that have generally remained marginalized or overlooked—are among the themes that this volume seeks to highlight.

Final Words

We proudly present this volume as part of a series of handbooks that have carried out the pioneering task of approaching the Anthropocene from a specific regional perspective. Its realization has been made possible thanks to the dedicated work of a team of 20 editors and more than 180 authors of diverse disciplines from various regions of Latin America, the United States, and Europe.

For two and a half years, we have met at editorial conferences and workshops at CALAS headquarters in Guadalajara, Buenos Aires, Quito, and San José de Costa Rica, as well as at various virtual editorial conferences. These meetings have led to lively and, at times, controversial debates. Now, we present to you the product of this fruitful international and interdisciplinary collaboration.

We have made a significant contribution by approaching the planetary scale of the Anthropocene from a regional perspective. We have shown what the Anthropocene can mean in its socioenvironmental and sociotechnical dimensions, as well as in a long-term perspective. Assuming a perspective from Latin America involves turning to existing debates and problems related to multiple socioenvironmental conflicts, which require critical perspectives from the social sciences and the humanities. With our work, we hope to have promoted the debate on the Anthropocene from critical Latin American perspectives and to have provided inspiration for perspectives on confronting the multiple crises in the Anthropocene. Last but not least, we hope to serve as an example for other regional perspectives on the planetary in relation to the Anthropocene, especially from the Global South.

Colonial Period

Source: Fernando Efrén Sandoval Herrera (2021)

Introduction: Climate Change and the Anthropocene in Colonial Latin America

Eleonora Rohland, Virginia García Acosta, Javier Taks, and Anthony Goebel McDermott

In the general introduction we laid out why this Handbook covers such a long historical timespan that includes the colonial history of the Americas for understanding and accounting for the Anthropocene from a Latin American Perspective. Following other authors (e.g. Moore 2017; Wendt 2016), we underline the slow aggregation of "anthropocenic" processes during the colonial era and before the Great Acceleration. This also accounts for the topic of Climate Change as one of the crises of the Anthropocene. Yet, the topic of Climate Change is somewhat peculiar in this respect, too, since the classical division with regard to anthropogenic influences on the climate is that they only begin with the industrial revolution, that is, largely after 1800 or even 1850. These years, however, almost already lie outside the scope the colonial history epoch of this handbook. In other words, we are seemingly faced with the paradox that climatology assumes natural and not human-made variability of the climate between 1492 and the 1810s – so, where is the anthropos or the anthropocenic aggregation mentioned above with regard to climate during the colonial period?

In order to understand this question and the importance of the colonial era in Latin America and the Caribbean for the role of Climate Change in the Anthropocene we will need to oscillate continuously between two perspectives throughout this introduction (and the colonial period of this volume): the emic (historical agents') and the etic (our contemporary) perspective. That is, we need to understand, how contemporaries in 1492 and after understood the concept of "climate" in order to understand its explanatory power and therefore its long-term effects regarding human agency.

At the same time, it is important to know that Latin America's and the Caribbean's colonial era lies squarely in what has been called the Little Ice Age (LIA) by climate historians and historical climatologists. The Little Ice Age was, from our present-day, etic, perspective, an era of noticeable climatic change and variability. It was a period of, on average, cooler climatic conditions that occurred after the so-called Medieval Climate Anomaly, roughly spanning from the late Middle Ages to the mid-nineteenth century. However, there is some debate among scholars regarding the LIA's precise timing. Some suggest it began around 1300, while others argue for a later start in the fifteenth century (Pfister et al. 2018; Alberola 2014). The end of the LIA is generally placed between 1800 and 1850, coinciding with the above-mentioned Industrial Revolution and thus modern warming trends. In a general perspective, the LIA is characterized by a series of regional climate anomalies, rather than a continuous global event. It involved periods of cooler temperatures, advancing glaciers, and fluctuating weather patterns. The LIA's influence was felt across the northern hemisphere, particularly in Europe and North America, where evidence includes historical records of harsh winters, (sometimes multiple) crop failures, and glacial advances. In terms of its spatial extent, while the LIA is most often associated with the northern hemisphere, its impacts varied globally. There is now evidence that the southern hemisphere experienced climatic changes related to the HSP, although perhaps less pronounced or long-lasting – as in the agricultural crises caused by droughts and subsequent plagues in Mexico and parts of Central America, with disastrous consequences (García Acosta et al. 2003; Arrioja 2019). To this we could add its effect on migrations, as suggested by studies for the territory of Uruguay, considering its association with the arrival of Iberian colonizers with an "anthropocenic" or rather "anthropocentric" mentality, in the sense that as sons and daughters of the famines in the Old World caused precisely by the vagaries of the LIA, they carried a mentality of destruction and control without measure (Inda 2016). Overall, we can state that the LIA was not a monolithic event, but rather a complex and multifaceted period of climate variability that influenced human societies and the environment differently from region to region.

This also accounts for Latin America and the Caribbean, where the effects of the LIA were diverse and influenced by the region's complex geography and climatic systems. In the Andes, for example, there is evidence of glacier advances and cooler temperatures, which impacted local agriculture and water resources. Historical records and paleoclimatic data suggest that the LIA contributed to significant ecological changes, affecting indigenous societies and colonial economies. The interaction between the LIA and the El Niño-Southern Oscillation (ENSO) was particularly notable. ENSO events, including both El Niño and La Niña phases, are likewise part of climatic variability and have historically affected the region in multiple ways, including through changes in precipitation, temperature, and cyclone and hurricane activity (Prieto 2007; Malaizé 2011; Burn et al. 2015; Parker 1983; García Acosta and Padilla 2021; García Acosta and Alberola 2021). During the LIA, the frequency and intensity of ENSO events may have altered precipitation patterns, leading to periods of drought and flooding that further stressed agricultural systems, given their association with worsening social and economic conditions – that is, with increased vulnerability and greater exposure to risk among the population (García Acosta 2019), as we will see in some of the contributions to the colonial epoch part of this volume.

Regarding the historical contemporaries' perspective and the beginning of the colonial epoch this introduction is covering, did "climate" or even "Climate Change" play a role in Christopher Columbus' venturing out westward across the Atlantic in search of India, and in accidentally happening upon the Americas? The answer is that it did not if we take the modern, current (etic) understanding of climate as average weather or values of precipitation and temperature across a certain timespan. The reasons for Columbus' adventurous course across the Atlantic are well known, they were largely economic in nature. In particular, the search for gold and silver mines to replace dwindling European resources and therefore to end the scarcity in specie and appendant difficulties for European courts to finance their lavish lifestyles and continuous wars (Parker 1983). However, if we "go fully emic" and look at the meaning the term "climate" had for Columbus and his contemporaries in 1492 (and, in fact, long after), the picture might look somewhat different.

"Climate" (from Greek *klima*) only came to acquire its present-day meteorological meaning during the nineteenth century. The term originally referred to a geographical demarcation meaning "inclination," specifically in reference to the inclination of the sun's rays, which varies with latitude. In Ptolemaic world maps and globes, *klima* demarcated half-hour differences in solar radiation on the longest day of the year. It was a geographic measure used to locate places on a map and not a term related to meteorology. "Speaking of the 'climate' of a place was equivalent to giving its latitudinal coordinates on the globe rather than explaining heat or cold, rainfall or humidity" (Mauelshagen 2018: 566). The concept of meteorological "zones," which included the "torrid," "temperate," and "frigid zones," was distinct from the *klima*. It was first mentioned in Aristotle's Meteorology and existed independently of "climate." Nevertheless, these two concepts would of course frequently appear together, in particular, since Greek geographers Hipparchus (c. 190–120 BCE) and Ptolemy (second century CE) developed the notion of the seven climates of the inhabited world (the *oikumene*). These *klimata* (i.e. geographical latitudes) were associated with meteorological properties and their imagined effects on the human individual and on societies by way of the humoral pathological (Hippocratic) understanding of health and the human body (Glacken 1969; Siraisi 1990; Earle 2012).

Already during the fifth century BCE, the Greeks started developing an understanding of the tropics as a geographical space located between the tropic of cancer and the tropic of Capricorn. This space coincided with the meteorological "torrid zone" and was considered very hot and humid. It was this knowledge-background from Greek antiquity that informed Portuguese and Spanish explorers of the fifteenth and early sixteenth century in their ventures along the African coastline and to the Canary and other Atlantic islands. Importantly for our question whether climate played a role in Columbus' plan to reach India by sailing west, the Portuguese, in exploring the African west coast, had sailed into the "torrid zone" (i.e. "the tropics"), and discovered that, while hot and humid, it was not a barren and uninhabitable space but, on the contrary, that lush environments, desirable commodities (gold, ivory, spices) and diverse peoples (some of which the Portuguese enslaved), lay between the two lines of the tropics (Cagle 2015; Cagle 2018; Wey Gómez 2008; Gerbi 1973). Already early during the fifteenth century, the Portuguese appealed to the pope in order to secure their newly "discovered" territories and in order to keep potential rivals (the Spanish) at bay. Bulls issued by popes Nicholas V in 1454 and Calixtus III in 1456 delineated the Portuguese sphere of influence as including the territories from Cape Bojador and Cape Nam along Africa's meridional coastline through all of Guinea and "all the way to the Indians" (Wey Gómez 2008: 308).

Of course, such exploratory success in a geographical (and meteorological) realm previously thought uninhabitable and undesirable, sanctioned by the highest Christian authority, stoked the Spanish crown's interest and desires. As the papal bulls did not allow the Spanish to compete with the Portuguese along the African west coast, alternative ways to the tropical riches the Portuguese had found, had to be sought. Comparison with Portuguese exploration practices and experience thus definitely informed Christopher Columbus' plans to sail west to find India. However, not only did he sail to the west but also to the south, after passing the Canary Islands, a region which the treaty of Alcáçovas (1479) designated as belonging to the Portuguese sphere of influence in which the Spanish were, in fact, not allowed to sail (Wey Gómez 2008: 209). Columbus' western *and southern* course was clearly informed by the idea that the riches the Portuguese had found in the tropical realm of Africa, might also be found on the same latitude around the globe in India. The geographical-meteorological expectation of same meteorological conditions prevailing in neat belts of the same climate (*klima*) thus deeply informed the budding European imaginary of the tropics and Columbus' "discovery" of the Americas, in particular. So, while climate or Climate Change in our present-day understanding was not a driving factor for European exploration and contact with the Americas in the fifteenth century, climate in the historical understanding of the contemporaries and its appendant meteorological and environmental properties (under which the existence of gold, ivory, spices and "enslaveable" humans were subsumed), certainly did play a very important role.

Climate in our present-day, etic, understanding, and in particular the new and unfamiliar climate(s) and environment(s) was (and were) a conundrum for each colonial power who came to the Americas with the intent to establish long-term settlements. In other words, the idea that thesame meteorological conditions would be prevailing throughout the same climate (latitude) not only informed Columbus' sailing course but also Spanish (and Portuguese and later French and English and Dutch etc.) expectations of the crops that would grow in different parts of the Americas. That is, climate (etic sense) and in particular, at least initially, the constant comparison between the familiar (home) climate and the unfamiliar (American) climate and environment is a constant theme in the colonial discourse. This is not surprising, considering that crop-growth was not just an economic question but first and foremostly one of the survival of the Spanish and Portuguese settlers that came to the Americas. In other words, the Greek geographical notion of climates and their meteorological and environmental conditions lie at the background of the intentional part of the Columbian Exchange. That is, it informed which flora and fauna the Spanish brought to the Americas intentionally. Thanks to Alfred Crosby, we know that the unintentional part of the Columbian Exchange (pathogens as well as plants and animals that turned into weeds and pests because they had no natural enemies in the ecosystems of the Americas) was at least as important for the history of the double continent as the intentional part. At the background of the intentional part of the Columbian Exchange and connected with the ancient Greek understanding of climate lies the early modern European perception of health and the human body – the already mentioned humoral pathology.

The early modern conception of the human body and its maintenance centered on the notion of "complexion" (Groebner 2004), which formed the center of humoral pathology. This concept had been developed from the extant corpus of writings collected in the *Corpus Hippocraticum* in the fourth century BCE and subsequently integrated into Galenic medical knowledge during the second century CE. These ancient traditions underwent a process of reinterpretation and adaptation in Europe, including the Arabian texts of Avicenna and Averroes during the eleventh and twelfth centuries (Rütten 2012: 61; Siraisi 1990). Beyond the scope of mere facial or skin characteristics, complexion importantly encompassed an individual's overall appearance, behavior, moral integrity, and intellectual aptitude. Each person was believed to possess a unique complexion, governed by a specific balance of the four humors – blood, phlegm, black bile, and yellow bile – which were regarded as the fundamental components of human health and well-being. Each humor was associated with specific qualities, such as heat or cold, dryness or moisture, and was believed to be inherently linked to the four elements that constituted the fundamental building blocks of all matter. Moreover, each humor, along with its associated quality and element, was thought to be connected to a particular season (Earle 2012: 26). Furthermore, the celestial bodies, such as the stars and planets, were believed to have exerted a substantial influence on the complexion. This is due to the fact that the elemental qualities of the complexion were reflected in the various planets. For instance, Mars was believed to be hot and dry, while Venus was regarded as cold and wet (Groebner 2004: 365–368). This preliminary overview suggests that the relationship between humans and their physical environment, which encompasses the planets, was perceived to be profoundly intertwined. The human body and constitution were thus governed on the macro-scale by geographical region (*klima*) and the respective astrological constellations. On the micro-level, individual habits, meteorological conditions, and dietary choices could influence a person's health and complexion.

Understanding the early modern link between climate (emic sense) and its appendant environmental conditions with an individual's or collective's morality allows us to better grasp the importance the Spanish (and other European colonizers) attributed to planting or importing the right foodstuffs. The latter would allow them to maintain their Spanishness in the face of unfamiliar and seemingly detrimental environments (Earle 2012; Feros 2017; see also: Livingstone 1991). The perception that the American environment(s) was (were) somehow deficient and inferior to the European one(s) has become known to present-day historians as "The Dispute of the New World" (Gerbi 1973) or as the "Degenerate Americas" trope, which is usually located discursively in the eighteenth century. In particular, it is tied to the exchange between the French naturalist George-Louis Leclerc, Comte de Buffon and Thomas Jefferson. In his *histoire naturelle, générale et particulière* (published in 44 volumes between 1749 and 1809), Buffon described the environments of South, Central and North America as unhealthy places which had only been able to bring forth small and degenerate animals, plants and humans. Thomas Jefferson in his *Notes on the State of Virginia* (1785) retaliated and explained why the American environment was indeed healthy and home of large animals (the moose) and strong people(s) (Dugatkin 2009). Buffon's reference to the "Degenerate Americas" is, however not a phenomenon of the eighteenth century but rather the endpoint of a discourse that had started with Spanish colonization of the Americas (Cañizares-Esguerra 1999; Cañizares-Esguerra 2009; Earle 2012). In other words, the expectation of what kind of environments and conditions could be found "under the climate of the tropics" and the comparison between the "African tropics," the emerging "American tropics" and European and American climates (emic sense) in general led the Spanish and later colonial powers to conclude that the Americas were different and inferior to Eurasia. The scientific knowledge about the origin of these significant differences in American flora and fauna only emerged comparatively recently and was first summarized and popularized, again, by Alfred Crosby (1973). So, evidently, the contemporary, early modern understanding of climate as a geographical concept, interwoven with its meteorological properties (hot, cold, dry, moist etc.) and their effect on porous human – or should we say Christian? – bodies formed the lens through which Spanish, Portuguese and later French and English and other European colonists were perceiving the Americas, its flora, fauna and peoples.

The comparison between the "African tropics" and the "American tropics" also was one factor that informed the Spanish and Portuguese idea that enslaved Africans from the "African tropics" would be somehow "preadapted" to the "American tropics" and would thus be better suited to the labor needed in this realm than Whites or even the seemingly sickly indigenous population itself, which was dying from diseases that had long become endemic in European populations (Rohland 2021: 54–55). In other words, climate (emic sense) and its meteorological conditions entangled with the humoral pathological perception of the human body and morality not only informed how the Spanish were perceiving themselves and the maintenance of their own health and moral integrity in the unfamiliar and potentially threatening environment of the Americas, it also informed such large scale colonial undertakings as the transatlantic slave trade.

This humoral perception of human bodies as entangled with their environments and climates (etic sense) in 1492 got projected on a densely populated continent with a high diversity and rich history of cultural developments, the fabrics of which were largely destroyed by contact with European colonizers. Glimpses of indigenous cultures and their cosmologies can be gleaned whenever Europeans sought indigenous knowledge for their survival and thriving in these new and unfamiliar environments and climates (etic sense) (Rohland and García Acosta 2020). One of the most notable and climate-related cases is the process of the Spanish getting familiar with Hurricanes during the early years of conquest in the Caribbean. Starting with the Taíno term *huracán* (the name of a malicious demon or wind god) which the Spanish adopted, and which has since spread into many European languages (English *hurricane*, French *ouragan*, German *Orkan*), the colonizers learned that those extremely strong storms had winds blowing from all directions of the compass and that they could bring excessive rainfall with them. The indigenous term likely got integrated into European languages since the Greek meteorological vocabulary had no concept for such violent storms (Rohland 2019; Schwartz 2015). Along with the terminology came accounts of the frequency of hurricanes, precious knowledge that Europeans had to otherwise gather painstakingly over decades of direct, practical experience. The sophistication of indigenous natural observation (or science) emerges when studying indigenous stone engravings of the deity of *huracán*, dancing the “dance of the hurricane” (Ortiz 1947: 635). These show *huracán* with a round head and one arm circling clockwise behind his head, the other clockwise in front of his head. The arms symbolize the vortex of the hurricane, and, most significantly, its direction of gyration (clockwise on the northern hemisphere of the globe) (Ortiz 1947: 28–31). Indigenous societies which had developed pictographic writing systems such as the Aztecs and Mayans compiled manuscripts and ritual calendars that contained information on natural hazards that sometimes resulted in disasters such as heavy snowfalls, frosts and droughts, or recorded the occurrence of earthquakes, as well as epidemics and famines. They generally noted the precise date of their occurrence in those calendars (Prieto and Rojas 2028: 213; García Acosta et al. 2003; García Acosta and Padilla 2021). These could theoretically have extended Europeans’ long-term knowledge of climatic extremes (a.k.a. disaster memory) in the Americas, had not religious bias prevented them from even considering this option (Rohland 2019: 20).

Maybe one of the earliest, tangibly “anthropocenic” moments of the colonial period of Latin America is the debate about forest depletion and conservation which already began in the 1560s in the Caribbean, but which takes on a “climatic turn” in the 1760s, which is also the moment we can observe the beginning of a semantic shift in the understanding of "climate" from the geographical to the meteorological meaning. While most European colonists adhered to the ancient Greek belief that local climates (etic sense) could be "improved" (i.e. made warmer and saner) by removing forest well into the eighteenth century, colonial administrators on the smaller and larger islands of the Caribbean archipelago were quickly noticing the detrimental effects of rapid deforestation and consequent erosion of soils used for sugar plantations. In other words, simultaneously with the early capitalist exploitation of the Caribbean environments emerged a sensitivity for their protection (Grove 1994: 3–6). In particular, in the French Caribbean, theories of desiccation as a result of deforestation emerged throughout the last half of the eighteenth century. Removing tree-cover was considered to reduce rainfall (which, incidentally, is true, however, the process was not recognized for the correct bio-meteorological reasons at the time) and hence, to create dryer and hotter climatic conditions which could affect the agricultural productivity of island ecosystems. "Climate Change," even if local, thus emerged as a threat to the colonial enterprise and its economic projects in the Caribbean but also elsewhere in Latin America, as Alexander von Humboldt's 1805 *Essay on the geography of plants* shows. At the same time, the anthropogenic nature of this Climate Change made its control appear desirable and feasible (Grove 1994: 266, 275). One could thus righteously claim that early ideas of climate engineering by de- and reforestation (and conservation) were forged in the Caribbean archipelago from the 1760s onwards (Schäfer and Mauelshagen 2021). We find similar examples in the continental Americas.

In sum, it is crucial to understand the static nature of the colonial, early modern notion of climate (emic sense) and its connections to individual and collective human health, character and morality as well as plant and animal growth. Ideas of "Climate Change" and thus of climate as a dynamic, changeable entity, only (or already?) emerged towards the end of the eighteenth century. The stable early modern notion of climate and its abovementioned foundation for human, animal and plant-life was hugely influential for many colonial projects historians have become used to consider part of the fabric of Western Modernity. Understanding climate in this way, the picture of the evolution of Western Modernity may become more complete, may gain more density or dimension. Western Modernity could not have emerged without the colonization of the Americas and of Latin America and the Caribbean in particular. Yet, Western Modernity with exactly this "colonial baggage" – a casual term subsuming large-scale and violent processes such as the Great Dying of the continent's original population or the Transatlantic Slave Trade – has righteously come under new scrutiny in the humanist debate of the Anthropocene.

References

Alberola Romá, Armando. 2014. *Los cambios climáticos. La Pequeña Edad de Hielo en España*. Madrid: Cátedra.

Arrioja Díaz Viruell, Luis Alberto (2019). *Bajo el crepúsculo de los insectos. Clima, plagas y trastornos sociales en el Reino de Guatemala (1768–1805)*. Mexico City: El Colegio de Michoacán – Universidad de San Carlos – FLACSO – Universidad Autónoma de Honduras.

Buffon, George-Louis Leclerc, comte de. 1749–1767. *Histoire naturelle, générale et particuliére, avec la description du Cabinet du Roi*. Paris: Imprimerie Royale.

Burn, Michael J., and Suzanne E. Palmer. 2015. "Atlantic Hurricane Activity During the Last Millennium." *Scientific Reports* 5: 1–11.

Cagle, Hugh. 2015. "Beyond the Senegal: Inventing the Tropics in the Late Middle Ages." *Journal of Medieval Iberian Studies* 7, no. 2: 197–217.

———. 2018. *Assembling the Tropics: Science and Medicine in Portugal's Empire, 1450–1700*. Cambridge: Cambridge University Press.

Cañizares-Esguerra, Jorge. 1999. "New World, New Stars: Patriotic Astrology and the Invention of Indian and Creole Bodies in Colonial Spanish America, 1600–1650." *The American Historical Review* 104, no. 1: 33–68.

———. 2009. "Demons, Stars and the Imagination. The early modern body in the Tropics." In *The Origins of Racism in the West*, ed. Ben Isaac, Miriam Eliav-Feldon, and Yossi Ziegler, 313–325. Cambridge: Cambridge University Press.

Crosby, Alfred W. 2003. *The Columbian Exchange. Biological and Cultural Consequences of 1492*. Westport: Praeger. Orig. pub. 1973.

Dugatkin, Lee Alan. 2009. *Mr. Jefferson and the Giant Moose. Natural History in Early America*. Chicago: University of Chicago Press.

Earle, Rebecca. 2012. *The body of the Conquistador: Food, Race, and the Colonial Experience in Spanish America, 1492–1700*. Cambridge: Cambridge University Press.

Feros, Antonio. 2017. *Speaking of Spain: The Evolution of Race and Nation in the Hispanic World*. Cambridge: Harvard University Press.

García Acosta, Virginia. 2019. "Unnatural disasters and the Anthropocene: lessons learnt from anthropological and historical perspectives in Latin America." In *Disasters in popular cultures*, ed. Giovanni Gugg, Elisabetta Dall'O, and Domenica Borriello, 237–248. Rende: Il Sileno Edizioni.

García Acosta, Virginia, América Molina, and Juan Manuel Pérez. 2003. *Desastres agrícolas en México. Catálogo histórico*. Vol. 1, Épocas prehispánica y colonial (958–1822). Mexico City: Fondo de Cultura Económica.

García Acosta, Virginia, and Raymundo Padilla. 2021. *Historia y memoria de los huracanes y otros episodios hidrometeorológicos extremos en México. Cinco siglos: del año 5 Pedernal a Janet*. Mexico City: CIESAS/Universidad de Colima/Universidad Veracruzana.

García Acosta, Virginia, and Armando Alberola. 2021. "Vaivenes climáticos en la península ibérica y Nueva España en los años ochenta del siglo XVIII. Entre la 'anomalía Maldá' y los 'ciclos de El Niño'." In *La Pequeña Edad del Hielo a ambos lados del Atlántico. Episodios climáticos extremos, terremotos, erupciones volcánicas y crisis*, ed. Armando Alberola and Virginia García Acosta, 55–94. Alicante: Universidad de Alicante.

Gerbi, Antonello. 1973. *The Dispute of the New World. The History of a Polemic, 1750–1900*. Pittsburgh: University of Pittsburgh Press.

Glacken, Clarence J. 1967. *Traces on the Rhodian Shore. Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century*. Berkeley: University of California Press.

Groebner, Valentin. 2004. "Complexio/Complexion: Categorizing Individual Natures, 1250–1600." In *The Moral Authority of Nature*, ed. Lorraine Daston and Fernando Vidal, 361–383. Chicago: Chicago University Press.

Grove, Richard H. 1994. *Green Imperialism. Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism 1600–1860*. Cambridge: Cambridge University Press.

Inda, Hugo. 2016. "El antropoceno en el sudeste de Uruguay: causas, indicadores y consecuencias." PhD diss., Universidad de la República.

Jefferson, Thomas. 1785. *Notes on the State of Virginia*. Philadelphia: Pritchard and Hall.

Livingstone, David N. 1991. "The Moral Discourse of Climate: Historical Considerations on Race, Place and Virtue." *Journal of Historical Geography* 17, no. 4: 413–434.

Malaizé, Bruno, Pascal Bertran, Pierre Carbonel, et al. 2011. "Hurricanes and Climate in the Caribbean During the Past 3700 Years BP." *The Holocene* 21, no. 6: 911–924.

Mauelshagen, Franz. 2018. "Climate as a Scientific Paradigm – Early History of Climatology to 1800." In *The Palgrave Handbook of Climate History*, ed. Sam White, Christian Pfister, and Franz Mauelshagen, 565–588. Basingstoke: Palgrave Macmillan.

Moore, Jason. 2017. "The Capitalocene, Part I: on the nature and origins of our ecological crisis." *The Journal of Peasant Studies* 44, no. 3: 594–630.

Ortiz Fernández, Fernando. 1947. *El huracán, su mitología y sus símbolos*. Mexico City: Fondo de Cultura Económica.

Parker, Geoffrey. 1983. "Die Entstehung Des Modernen Geld- Und Finanzwesens in Europa 1500–1730." In *Europäische Wirtschaftsgeschichte*, ed. Carlo M. Cipolla, and Knut Borchardt, 335–379. Stuttgart: Gustav Fischer Verlag.

Pfister, Christian, Rudolf Brázdil, Jürg Lutherbacher, et al. 2018. "Early Modern Europe." In *The Palgrave Handbook of Climate History*, ed. Sam White, Christian Pfister, and Franz Mauelshagen, 265–295. Basingstoke: Palgrave Macmillan.

Prieto, María del Rosario. 2007. "ENSO Signals in South America: Rains and Floods in the Paraná River Region during Colonial Times." *Climatic Change* 83: 39–54.

Prieto, María del Rosario, and Facundo Rojas. 2018. "Climate History in Latin America." In *The Palgrave Handbook of Climate History*, ed. Sam White, Christian Pfister, and Franz Mauelshagen, 213–224. Basingstoke: Palgrave Macmillan.

Rohland, Eleonora. 2019. *Changes in the Air. Hurricanes in New Orleans from 1718 to the Present*. New York: Berghahn Books.

Rohland, Eleonora, and Virginia García Acosta. 2020. "Disaster." In *The Routledge Handbook on Political Economy and Governance in the Americas. Part II: Geopolitics and Governance in the Americas*, ed. Olaf Kaltmeier, Anne Tittor, Daniel Hawkins, et al., 350–361. London: Routledge.

Rohland, Eleonora. 2021. *Entangled History and the Environment. Socio-Environmental Transformations in the Caribbean 1492–1800*. Tier/New Orleans: WVT/University of New Orleans Press.

Rütten, Markus. 2012. "Early Modern Medicine." In T*he Oxford Handbook of the History of Medicine*, ed. Mark Jackson, 60–81. Oxford: Oxford University Press.

Schäfer, Stefan, and Franz Mauelshagen. 2021. "Die Technologische Kolonisierung Des Klimas." In *Climate Engineering. Imaginationsgeschichten Künstlichen Klimas*, ed. Urs Büttner, and Dorit Müller, 39–57. Berlin: Matthes & Seitz.

Schwartz, Stuart B. 2015. *Sea of Storms. A History of Hurricanes in the Greater Caribbean from Columbus to Katrina*. Princeton: Princeton University Press.

Siraisi, Nancy G. 1990. *Medieval and Early Renaissance Medicine: An Introduction to Knowledge and Practice*. Chicago: University of Chicago Press.

Wendt, Helge. 2016. "Epilogue: The Iberian Way into the Anthropocene." In *Proceedings "The Globalization of Knowledge in the Iberian Colonial World,"* ed. Helge Wendt, 297–314. Berlin: Max-Planck-Gesellschaft zur Förderung der Wissenschaften.

Wey Gomez, Nicolás. 2008. *The Tropics of Empire. Why Columbus Sailed South to the Indies*. Cambridge: MIT Press.

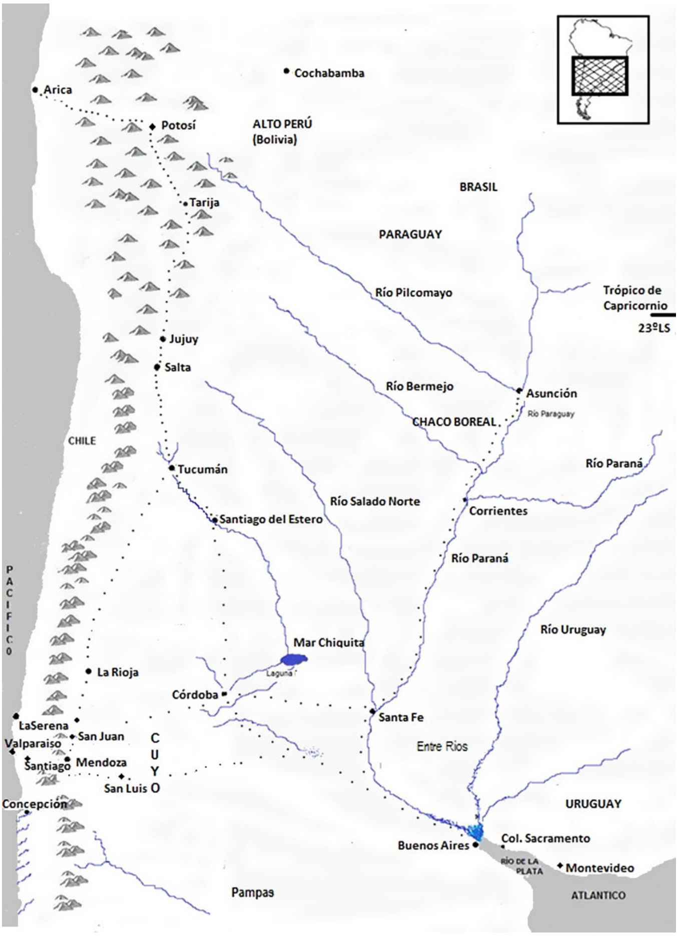
Climate Change in the Southern Cone during the Colonial Period

Margarita Gascón

Historical sources provide social indicators or proxies that reflect how human communities responded to climate change, as evidenced by variations in temperature, water availability, road trafficability, and food production. The practice of reconstructing past climates using social proxies dates back to 1971, beginning with Emmanuel Le Roy Ladurie (1929–2023), who observed that climate is consistently documented – albeit indirectly – through changes in agricultural product prices resulting from frost, droughts, or floods. Records of extreme weather events are also prevalent, as such occurrences often lead to infrastructure damage and subsequent outbreaks of diseases and pests (Florescano 1969; Swan 1982; García Acosta 1988; Beckman and Mahoney 1998; Stenseth et al. 2002; Endfield 2008; Gascón 2014; Rohland 2016; Otto 2017; Leal, Soluri, and Pádua 2019; Arrioja Díaz 2019; Skopyk 2020). However, climate reconstruction with historical sources has been accused of containing misinterpreted data, simplifications, overly broad temporal and geographic scales, and a tendency to focus on shocks and collapses (Degroot et al. 2021: 541). Likewise, it has been pointed out that there are events that may not refer to climate at all but to the interaction of multiple other variables (Gallini 2004; Moore 2016). Such criticisms serve to avoid errors in interpretation, but do not invalidate the fact that historical documentation helps in the reconstruction of paleoclimates and illustrates why climate is a relevant factor in the lives of peoples.

Colonial societies' responses to climate change play a role in ongoing discussions about the Anthropocene as a multidimensional crisis. Since Nobel Laureate Paul Crutzen (1923–2021) highlighted in 2000 that planetary changes are directly linked to human activities, the concept of the Anthropocene has been debated regarding both its interpretive value and scientific accuracy (Thomas 2022). To clarify its meaning and establish its timeline, scholars have introduced descriptive categories for the historical processes involved, including terms like the Capitalocene (Moore 2016), Plantationocene, and Chthulucene (Haraway 2015). The aim of this chapter is to contribute to a chronological anchoring (Heyd 2022), as the series "Handbook of the Anthropocene in Latin America" seeks to establish indicators of the initial stage in the continent: the Proto-Anthropocene (Wendt 2016) "that cannot be separated from coloniality and the emergence of the capitalist world system and racial capitalism" (General Introduction, this volume).

Fig. 1: Main Towns (Sixteenth Century)



Source: Author's Elaboration

Throughout the colonial era, the Americas experienced three significant global climate events linked to solar activity: the Little Ice Age (LIA), the Maunder Minimum (MM), and the Thermal Rebound (TR). These broad climate shifts were further influenced by regular variations from the El Niño-Southern Oscillation (ENSO). The LIA, with variations between the mid and high latitudes in the Northern and

Southern hemispheres, has been confirmed by both geochronology and social proxies (Kupperman 1982; Politis 1983; Fagan 2002; Neto 2006; Gil Montero, Morales, and Villalba 2010; Herrera, Prieto, and Rojas 2011; Parker 2013; Masson-Delmotte et al. 2013; Alberola 2014; Garza-Merodio 2014; Prieto and Rojas 2015; Degroot 2018; Bloom 2019; Mora Pacheco 2019). The mid-seventeenth century MM has been the most recent major solar minimum in the last 8,000 years (Eddy 1976; Usoskin 2017; Miyahara et al. 2021). The TR marks the end of the LIA. This chapter includes ENSOs that alter the snow precipitation regime in the Andes, causing river swells and floods, droughts, and extreme weather (Quinn, Neal, and Antúnez de Mayolo 1992; Quinn and Neal 1995; Caviedes 2001; Huertas 2009; Gascón and Caviedes 2012).

The area under consideration is the Hispanic Southern Cone. It currently includes territories in Argentina, Chile, Uruguay, southern Bolivia, and Paraguay. The area had main population centers located in a territorial strip between 19° and 34° parallels south (Figure 1).

The Little Ice Age in the South of South America

The LIA was a global change in climate that occurred when the Spanish were in the process of reconnaissance and conquest of the southernmost territories of Spanish America. The expedition into Chile from Peru registered a cold climate that, according to them, was in the name itself, since *Anchachire* (where *Chire* or Chile would later come from) in the Indigenous language meant "great cold" (Vivar 1966: II, 37). The indigenous people told the Spaniards that even in the mild Central Valley, where Santiago was founded in 1551, the climate was colder than usual, causing a food crisis; early settlers reported running out of wheat and having rats gnaw through their clothes (Gascón 2007: 59).

A decade prior to the founding of Santiago, Diego de Almagro (1475–1538) encountered severe weather conditions during his 1536 expedition. Traversing the Andes into Chile from Argentina via the *Comecaballos* or *Pircas Negras* pass (28° S), Almagro followed a pre-Columbian route that was part of the Inca *Qhapac-ñan*. He had no indication that the journey would prove so arduous, nor did he anticipate that the challenges faced would ultimately deter him from incorporating these territories into the Spanish crown. Among the challenges encountered was an atypical snowstorm occurring approximately 150 km north of the Central Valley. This notable period of cold and extreme weather has been preserved in Araucanian legend. Intertwined with elements of the biblical narrative of the universal flood, eighteenth-century Indigenous accounts describe a historical era marked by devastating floods, symbolized by the conflict between two giant serpents. The malevolent Cai-Cai is said to have caused severe storms with the intent to destroy the world, while the benevolent Ten-Ten protected humanity by guiding them to higher ground (Vicuña Mackena 1877: 18–19, 22, 36).

The experiences in Chile were not unique, as evidenced by severe storms reported in Buenos Aires in 1536 (Brailovsky 2011: 16) and accounts of swollen rivers in Paraguay in 1539, which prevented the governor from departing Asunción to address an Indigenous uprising. Simultaneously, expeditions north of Asunción del Paraguay to explore new territories were delayed due to poorly drained flatlands. Soldiers faced significant challenges, including wading through waist-deep water, limited ability to prepare food, and reliance on poor-quality water sources (Schmidl 1995 [1567]: 73). Nevertheless, it remains challenging to determine whether these circumstances were exceptional, given the region's sensitivity to seasonal variations – both dry and rainy periods – and ENSO anomalies. Ulrico Schmidl, chronicler, soldier and member of the earliest campaign in the region, reports that between 1553 and 1554, there was a severe drought lasting three months: "it had not rained for three months […] There was a great scarcity of water, so much so that one did not care for gold nor silver nor food nor other goods, as only water mattered" (Schmidl 1995: 97). Another document suggests this event might have been linked to an ENSO phenomenon. In the Bolivian Chiquitanía, Father Esquiluz wrote in 1696 about an elderly Moxos resident who claimed that, over more than seventy years, fewer than five years had passed without the river overflowing its banks – often once or twice annually – causing destruction to yucca *(Manihot esculent*a), the main staple of the native population, as well as flooding their homes and depriving them of firewood (Esquiluz 1884: 47). Although they benefited from fishing during these floods, they could not preserve fish due to the absence of salt mines. Instead, the locals produced salt by extracting it from vegetable leaves using a laborious and sophisticated method (Paucke 2010: 542).

For the first colonial decades, the town council minutes of Santiago de Chile show rainy years with snowfalls in the Andes and floods and overflows of the Mapocho River. If these episodes are compared with the series of ENSO events for Peru and Ecuador (Quinn, Neal, and Antúnez de Mayolo 1992; Ortlieb 1994), Chile must have been affected by strong ENSOs in 1559 and 1574, and by a moderate one in 1567–1568. A Mega-ENSO was recorded in 1578–1579 when a resident of Araucania described a significant deterioration of environmental conditions. In relation to a rat infestation that he called a "biblical plague," he describes an exaggerated scene of rodents eating babies in their cribs: "And the plague with which our Lord visited these people was a great sum of mice so innumerable that they covered the land and not only entered the houses and farms to eat what was edible, but they also went to the cradles of the children and killed them, eating parts of them" (Mariño de Lovera 1960 [1861]: 520).

Between 1583 and 1605, the Bolivian highlands experienced an unusually cold period (Prieto, Herrera, and Dussel 1998), which may have influenced the fate of two settlements in the Strait of Magellan in 1584. The populations of both Rey Felipe and Nombre de Jesús rapidly declined, and by 1587, only a few survivors remained, rescued by the English pirate Thomas Cavendish. This unfavorable outcome impacted the southern part of the continent, as Spain decided not to attempt further colonization in the region for the remainder of the colonial era. Later, when Spain was informed in 1680 about supposed English plans to settle the Strait of Magellan and search for the legendary City of Caesars, the Council of the Indies simply dismissed the reports, declaring the territory "completely inhospitable" (Brouwer 1646).

Additionally, when placing this event in southern Spanish America within a continental context, similar cases occurred in North America. In Roanoke, the first English colony, about one hundred settlers vanished between 1587 and 1590 – the latter coinciding with strong ENSO effects verified by geochronology (Browning and Goodwin 2015). Similarly, early Jamestown records from its founding in 1607 mention conflict with native peoples and persistent harsh weather, leading to crop failures so severe that reports of cannibalism emerged (Alvarez 1778: 27; Kupperman 2007; Blanton 2000). Like the Spanish settlements in the Strait of Magellan, Jamestown's population shrank to just one third during its first year (Kupperman 1982). On a broader scale, 1607 also proved difficult for the small settlement of Buenos Aires, which suffered flour and bread shortages. The town council responded by ordering surveillance of local farms to prevent grain hoarding. To underscore the widespread nature of the crisis, a swarm of Chaco locusts descended on the Rio de la Plata pampas in October of the same year (Archivo General de la Nación 1895).

Another significant ENSO event was documented by several colonies in 1609–1610. One indicator of this occurrence is the experience of Chilean captain Pedro Martínez de Zavala, who was assigned to procure horses for the Araucanian frontier army. Initially directed to source horses from Paraguay, Captain Martínez de Zavala was unable to cross the swollen Paraná River and subsequently redirected his efforts to the markets of Córdoba and Tucumán. However, he encountered further challenges as local breeders had already sold most livestock due to outbreaks of pests, locusts, and limited pasture availability. Geo-chronological evidence indicates that the Little Ice Age (LIA) induced notable ecological changes in Córdoba (Cioccale 1999). While this ENSO event may not have been the sole cause of these difficulties, it likely exacerbated them; global climate change is considered to amplify local fluctuations. Upon returning to Chile with a small number of horses, Martínez de Zavala found the mountain passes of Mendoza blocked by heavy snowfall. Ultimately, his ruinous expedition concluded with legal proceedings to determine responsibility for the unfortunate outcome (Gascón 2007).

Additional proxies confirm that Martínez de Zavala's experiences were shaped by the region's weather patterns. Jesuit Diego de Rosales claimed that "this winter [of 1609 in Araucanía] was extremely rainy and humid; there were so many mice it resembled the plagues of Egypt." The *Carta Annua* from 1610 also describes major flooding across the Paraná basin (Vicuña Mackenna 1877: 18–19, 25). Further research by Earth system scientists shows that the Frías and Río Manso glaciers advanced due to colder and wetter conditions in the Patagonian Andes (Masiokas et al. 2009). Simultaneously, other parts of the world experienced severe cold: Japan recorded its coldest spring of the century in 1616, and in 1620, the Bosphorus froze over, allowing people to walk between continents (Parker 2013: xxvii).

As global climatic changes have generated enduring environmental conditions, native flora and fauna have either expanded or contracted their distributions. These shifts are also evident in altered animal behaviors, with all such natural phenomena serving as biological indicators or proxies (Tonni 2017). Historical chronicles frequently cite examples of these proxies, such as the migratory patterns of locusts and rodents. Variations in rainfall directly impact food resourc*e availability*, compelling insect and mammal populations to migrate in search of sustenance; such migration may result from both drought and excessive moisture (Madsen and Shine et al. 2009). Pathogens are likewise affected by environmental factors including temperature and humidity. For instance, the Variola virus, responsible for smallpox, is known to proliferate in cold, dry climates (Frederiksen et al. 1960: 209). Recent studies have correlated pandemics between 1750 and 2020 with solar activity and planetary changes associated with solar cycles (Nasirpour et al. 2021).

Documentary evidence shows that societies' social responses to climate change often appeared as daily struggles: securing water and food, finding vital resources like firewood, and providing pasture for livestock. Archaeological findings reveal that Indigenous communities adapted by migrating – either relocating themselves or their agricultural plots – or by switching crops entirely. For instance, in the Bolivian Puna and Peru, these traditional methods of coping with dramatic climate changes have existed for thousands of years (Cardich 1980). In northwestern Argentina, archaeological data indicate technological innovations linked to climate shifts, such as an increase in *hornitos* – baked clay silos – for grain storage during the Little Ice Age (Laguens 1999). By the colonial era, Indigenous groups broadened their diets by including new crops and domesticated animals introduced by Europeans.

Spanish urban societies employed various approaches to address food shortages linked to climate variability. In 1626, Santiago de Chile experienced an ENSO event in its dry phase (La Niña), which led to reduced food output. In response, the town council mandated *rogativas* (prayers) and concurrently adopted policies to secure meat supplies for the following two years. During the Mega-El Niño of 1629–1630, which affected the Pacific coast of South America, officials explored alternative food sources for urban residents experiencing poverty and enforced stricter price controls. Globally, the 1630 ENSO event was marked by famine in Geneva and a doubling of grain prices compared to their 1627 levels (Parker 2017).

The Maunder Minimum (MM)

Social proxies provide valuable insight into the proposal by Vaquero and Trigo (2014) regarding Europe, which identifies two distinct phases of the Maunder Minimum (MM). The "deep" phase is estimated to have occurred between approximately 1645 and 1700, while the "extended" phase spans from around 1618 to 1723. Historian Geoffrey Parker, who does not distinguish the Little Ice Age (LIA) from the MM, presents data for this deep phase in Europe. He notes that the decade of 1640 experienced significant crop failures in Spain; the summer of 1641 was documented as the coldest in the Northern Hemisphere over six centuries, and the winter of that same year was recorded as the second coldest in New England and the coldest ever observed in Scandinavia (Parker 2017: xx).

In Araucania, the deep phase of the MM has been geo-chronologically identified by Earth system science through the advance of the Manso River Glacier, which is situated at the same southern latitude as Araucania but on the eastern slope of the Andes (Villalba et al. 1990). In 1639, an outbreak of the variola virus resulted in high mortality rates among the Indigenous population, followed by an eruption of the Villarrica volcano. These events are highlighted here because recent research has increasingly examined connections between pandemics and climate variability. Furthermore, the local climatic impact of volcanic activity due to ash emissions, as well as the global effects from sulfur dioxide release into the upper atmosphere, are well documented. The convergence of these factors contributed to a pivotal moment in the Araucanian war: the truce reached in 1641 between the Spanish and Indigenous rebels, known as the *Parlamento de Quillín*, which also represented a traditional Araucanian *koyagtun*.

The Araucania tribes convened a *koyagtun*, following a lunar calendar, to address issues such as conflict resolution, the causes of rivalries, peace agreements or declarations of war, and matrimonial celebrations. The gatherings also included social activities, culminating in several days of communal meals and consumption of alcohol upon the successful completion of deliberations. In the 1641 koyagtun held at Quillín, while engaged in hostilities with the Spanish, the Araucanians invited the Governor of Chile, the Marquis de Baides, to negotiate peace, requesting food as "gifts" in exchange for a cessation of warfare. This request was likely influenced by an environmental crisis compounded by the deep phase of the MM and the eruption of Villarrica, which destroyed crops and polluted the freshwater sources in the region (Baides 1642; Ovalle 1646). Jesuit Alonso de Ovalle (1603–1651) documented the relationship between the meeting at Quillín and the Villarrica eruption, recounting that a monstrous apparition accompanied by ash and smoke appeared in the sky, forming an image of Saint James the "Moor-slayer," Spain's patron saint. According to Ovalle, these phenomena led to fear among the indigenous people, resulting in their acceptance of evangelization. The following illustration is featured in his book:

Fig. 2: James "matamoros"

Source: Ovalle (1646: 302–303)

Other proxies for the deep phase of the MM are found in the documentary sources produced in Chile and the Netherlands after Hendrik Brouwer (1581–1643) arrived in Valdivia in 1643. Dutch explorer Brouwer navigated the Le Maire Strait to travel from the Atlantic to the Pacific, hoping to establish a colony along the South Pacific coast to support the trade route to Asia from northeastern Brazil, which had been under Dutch control since 1623. After arriving in southern Chile – where the Spanish had abandoned the fortifications of Valdivia years earlier – Brouwer died soon thereafter. His crew remained briefly in Valdivia, but according to their diary, the local Indigenous people offered little food, saying it rained heavily and they barely had enough provisions for themselves. The famine was just as threatening as the fact that the Indigenous people would only trade their cattle and food for weapons and ammunition. Eventually, the invaders withdrew and never tried to occupy southern Chile again (Brouwer 1646). Given the vulnerability of the South Pacific's defenses, officials in Santiago ordered Valdivia to be fortified. Reports from Valdivia explained that progress was delayed due to a shortage of workers, insufficient food, and the area's extremely rainy and cold climate (Enrich 1891: 497).

Between 1647 and 1652, three ENSO episodes were documented in northern Peru, which may have been associated regionally with a locust infestation in Corrientes, as well as reports of crop failures by residents of Santa Fe on the banks of the Paraná River in 1652 (Roverano 1983: 88). On October 9, 1654, the Santa Fe town council established a fixed bread price in response to a wheat shortage (Archivo General de la Provincia de Santa Fe 1999). Continued dissatisfaction among settlers contributed to the decision to expedite the relocation of the colony in 1657. Three years later, the new settlement of Santa Fe was established approximately 80 kilometers further south at its present location, thereby enhancing access to trade routes, though environmental challenges persisted. Santa Fe encountered challenges in agricultural production due to locust swarms originating from the Chaco region. These swarms posed a recurring problem for European settlers; however, Indigenous populations regarded the insects as a food source. Demonstrating adaptability, the Mocovíes, as documented by Jesuit Florián Paucke (1719–1779), utilized locusts as a protein source during periods of scarcity. They collected smaller locusts, immersed them in water, and processed them into a form of lard, which was then stored for use during climatic crises and food shortages (Gobierno de Santa Fe 2006).

During the MM, increases in river flow significantly influenced the destiny of communities situated along their banks; for example, the Dulce River had a notable impact on Santiago del Estero. Ultimately, this settlement was relocated in 1670. However, it is important to interpret social proxies cautiously and consider them alongside other indicators, as flooding may result from factors such as poor environmental management or proximity to riverbanks without adequate breakwater infrastructure. This was similarly observed in Santiago de Chile with the Mapocho River. In response, the town council periodically ordered repairs to the breakwater and advocated for enhanced riverbank forestation with willows to mitigate flooding. Regarding the floods in Buenos Aires, the town council indicated that the banks of streams such as the Riachuelo were frequently lowered due to cattle being herded from the pampas into the city. This practice often occurred intentionally to enable wagons to approach the small boats that transported contraband. Consequently, flooding within the urban areas of Buenos Aires could transpire even without exceptionally heavy rainfall. Additionally, storms originating in the South Pacific serve as a proxy for the MM. These storms led to an unusually high incidence of shipwrecks, prompting the viceroy in 1673 to prohibit coastal navigation in Chile between May 15 and August 15.

Thermal Rebound (TR)

Beginning in the late seventeenth century, thermal changes were documented as the Bourbons implemented administrative reforms to enhance governance and fiscal collection. During the eighteenth century, territorial organization was restructured with the establishment of the Viceroyalty of the Río de la Plata in 1776 and the creation of *intendencias* (regional governments). Legislation during this period aimed to encourage further settlement and strengthen the defense of territories bordering Indigenous populations (see map two).

Permanent transformations were made that reshaped both producer and consumer markets. In Chile's Central Valley, for instance, a combination of favorable environmental factors – such as temperature and humidity – and supportive economic conditions facilitated the growth of viticulture. Conversely, in Peru's established wine-producing and exporting regions like Ica, Nazca, and Pisco, reduced yields caused by the local effects of TR, which resulted in limited irrigation water, hindered production efforts. Consequently, by the 1770s, imported wine from Chile accounted for 75 percent of the wine consumed in Lima (Schlüpmann 2005: 11).

Complaints about drought served as social indicators for TR. For example, beginning in 1668, general grievances were recorded in Córdoba, and by 1714, the local council reported a fourteen-year water shortage, prompting appeals for regular rainfall (Segreti 1973). During this period, the councils of Santa Fe, Buenos Aires, and Córdoba sought to define their territorial boundaries to secure rights to grazing land, watering sites, and wild livestock. Another sign of drought was that bighorn cattle hunts started shifting south into the pampas, as animals searched for pastures and sources of water in those regions (Gascón 2007). Approximately two hundred kilometers south of Buenos Aires, a 1678 source reports challenges attributed to drought conditions (Deschamps, Otero, and Tonni 2003), while geo-chronological evidence suggests the salinization of the large Chascomús lagoon resulted from decreased freshwater inputs, serving as a natural indicator of prolonged drought (Laprida, Orgeida, and García Chapori 2009). Paleolimnological studies of the Mar Chiquita Lagoon in northern Córdoba reveal salinity cycles linked to a period of significant water scarcity beginning in the 1770s (Pirovano et al. 2002). In the far south, dendrochronological analysis of *Austrocedrus chilensis* corroborates rainfall deficits spanning 1770 to 1820 (Villalba 1994). Archaeological data indicate that much of the eighteenth century in the Puna was characterized by arid conditions, with further intensification during the years 1801–1805 (Yacobaccio 2015; Tandeter 1991).

In Paraguay, beginning in the 1730s, persistent droughts had an unintended influence on evangelization efforts by prompting Indigenous peoples to seek assistance from Jesuit missionaries. The Jesuits provided food in exchange for conversion, effectively making religious practice part of a survival strategy (Santamaria 1986). However, these environmental and food crises brought about by climate change did not always benefit missionary objectives. For instance, in 1691, Jesuits in Iguazú reported that local communities were leaving for the jungle due to food shortages caused by drought. According to their accounts, those who maintained "Christian and civilized" practices adapted by eating locusts and consuming palm hearts, while others reportedly reverted to cannibalism (Reinegg 1704).

In regions with irrigated farming, such as Mendoza, there are also social indicators of change: reduced food production prompted mitigation measures, including price controls and a ban on grain exports by the town council in 1760, along with regulation of irrigation water quotas from the Mendoza River. Reports indicate that alfalfa fields limited the water available to irrigate cereal crops near the city (Archivo Histórico de la Provincia de Mendoza 1786). By the early nineteenth century, the Guanacache Lagoons – sustained by the Mendoza and San Juan rivers – had become so depleted that, due to a shortage of fish, church authorities granted permission to eat other kinds of meat during Lent (Gascón and Caviedes 2012).

Starting in 1715, Santiago de Chile regulated the use of water from the Mapocho River for city supply and farm irrigation. However, periods of heavy rains caused by ENSO in 1723–1724 led to flooding in the urban center. In Tucumán, the most severe droughts occurred between 1780 and 1784, while in northernmost Chaco, Indigenous peoples approached Francisco Arias's reconnaissance expedition in 1837, offering assistance in return for food. During the drought of 1790, Santiago de Chile looked to religious intercession, invoking the Virgin of the Rosary, the Virgin of Mercy, and Saint Isidore to end the crisis. The Mendoza town council noted a time of "extreme aridity" in 1789, which forced herders traveling to Buenos Aires to abandon their journeys as they could not keep their commitments; lack of water and pasture had resulted in the death of their animals along the way (Archivo Histórico de la Provincia de Mendoza 1789). In 1790, an unusually heavy snowfall occurred in the Andes, which subsequently supplied the rivers with water during the summer months. During that year, the Bolivian highlands also went through what was described as an "insufferable" winter by an official in Potosí (Archivo General de Indias n.d.).

During his expedition to Paraguay for the purpose of setting borders, Captain Azara, an explorer and scientist, documented several notable extreme weather events. He reported that an extraordinary lightning storm in 1793 resulted in thirty-seven injuries and nineteen fatalities in Buenos Aires. Severe winds and hail were recorded in Asunción del Paraguay in 1789, reportedly causing significant damage, including the decapitation of a horse and the destruction of property. Additionally, another storm swept through Atira, leading to multiple casualties and loss of vehicles. In Montevideo, a tempest in the same year stranded eight large ships and numerous smaller vessels along the beach. Based on these events, Azara concluded that unique atmospheric conditions existed in the region from Paraguay to the Río de la Plata, contributing to the frequency and severity of such storms (Azara 1847: 45–46). Nearly fifty years earlier, Jesuit Florián Paucke also wrote about lightning storms that astonished him. He recounted remarkable incidents, such as a Jesuit being struck by lightning without injury, and a story of a priest from Córdoba who performed exorcisms to dispel electrical storms. Interestingly, the local Indigenous people responded differently, finding joy in the lightning, storms, and thunder (Paucke 2010: 630).

Towards the end of the colonial era, significant social proxies were marked by extreme events. In 1798, Asunción del Paraguay reported hurricane-force winds and substantial hail. Montevideo entered the new century experiencing severe storms. In 1803, locusts destroyed crops in the Argentine pampas, while residents of Cordoba cited locust swarms in addition to ongoing issues with pests, wind, and hail. The same year, inhabitants of Santa Fe intensified prayers to their patron saint to counter drought conditions, encouraged neighbors to decorate streets with laurels, and promoted penitential flagellation during processions (Cabildo de Santa Fe 1803). However, local weather conditions shifted due to ENSO phenomena recorded in 1804 and 1810, resulting in increased rainfall in Buenos Aires and frequent snowstorms in the Andes.

Conclusions

Historical sources from societies situated between the 19° and 34° southern parallels document three major global climatic fluctuations that affected the Americas during the colonial era. The environmental impacts were observed at various times through changes in food production and availability, pastures, water resources, road disruptions, outbreaks of pests and diseases, and severe hydro-meteorological events. These records serve as social proxies, which should be cross-referenced with additional indicators supplied by Earth system sciences.

The objective of this chapter is to contextualize globally recognized and temporally defined climate changes from an American perspective. Key events discussed include the Little Ice Age, the Maunder Minimum, and the Thermal Rebound. In addition to these global phenomena – documented through records produced by individuals and officials – the local effects of ENSOs must also be considered. Societal responses to climate change function as social proxies, encompassing religious practices such as prayers and processions, as well as governmental actions including food production controls, price regulations, adjustments in supply routes and markets, alterations in access to strategic natural resources, and technological or urban modifications. From a historical standpoint, it can be asserted that no society has remained unaffected by climate change; there have consistently been efforts either to mitigate or exacerbate its impacts.

This chapter has analyzed the effects of the LIA, MM, and TR on populations in southern South America. Evidence from documentary sources highlights the strong interconnection between climate and society. Local social proxies have been linked to regional, continental, and global events, as well as geo-chronological reference points. The chapter approaches climate as a historical agent, given that societies have always responded to climatic impacts on their environments. It aims to contribute to ongoing discussions surrounding the notion of the "Anthropocene as a Multiple Crisis," using examples from colonial Latin American societies in the far south. In doing so, and in line with the work of other scholars, it seeks to support a chronological framework that is neither basic nor exclusively Eurocentric (see Wendt 2016).

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References

Alberola, Armando. 2014. *Los cambios climáticos. La PEH en España*. Madrid: Cátedra.

Álvarez, Francisco. 1778. *Noticia del establecimiento y población de las colonias inglesas en la América Septentrional*. Madrid: A. Fernández.

Arrioja Díaz Viruell, Luis Alberto. 2019. *Bajo el crepúsculo de los insectos. Climas, plagas y trastornos sociales en el reino de Guatemala (1768–1805)*. Zamora: El Colegio de Michoacán.

Arias, Francisco Gavino. 1837. *Diario de la expedición reduccional del año de 1780, mandada practicar por orden del Virrey de Buenos-Aires, a cargo de su ministro don Francisco Arias, coronel del regimiento de caballería San Fernando.* Buenos Aires: Imprenta del Estado.

Archivo General de la Nación. 1895. *Acuerdos del Extinguido Cabildo de Buenos Aires*. Vol. 1. Buenos Aires: Kraft.

Archivo General de la Provincia de Santa Fe. 1999. *En Santa Fe el día 19 de Octubre de 1654*. Santa Fe: Sistema Provincial de Archivos. Orig. pub. 1654. https://actascabildo.santafe.gob.ar/actascabildo/default/ficha/969-19_de_Octubre_de_1654.

Archivo General de Indias. n.d. *Buenos Aires 109*.

Archivo Histórico de la Provincia de Mendoza. 1786. *Actas capitulares 1786–1799, acta de 14 de enero de 1786 colonial, gobierno* [Carpeta 17].

Archivo Histórico de la Provincia de Mendoza. 1789. *Presentación del 5 de diciembre de 1789 colonial* [Expediente 27, documento 15].

Azara, Félix de. 1850. *Viajes por la América del Sur de Don Félix de Azara…*. 2nd ed. Montevideo.

Baides, Diego López de Zúñiga y Velazco Marqués de. 1642. *Relación Verdadera de las Pazes que Capituló con el araucano rebelado, el marqués de Baides, conde de Pedrosa, govemador y capitán general del reyno de Chile, y presidente de la Real Audiencia. / Sacada de sus informes y cartas y de los padres de la Compañía de Jesús, que aco[m]pañaron al real ejército en la jornada que hizo para este efecto el año pasado de 1641*. Madrid: Francisco Maroto.

Blanton, Dennis B. 2000. "Drought as a Factor in the Jamestown Colony, 1607–1612." *Historical Archaeology* 34, no. 4: 74–81.

Beckman, John, and Terry Mahoney. 1998. "The Maunder Minimum and Climate Change: Have Historical Records Aided Current Research?." *Library and Information Services in Astronomy III* 153: 212–217.

Bloom, Philip. 2019. *El motín de la naturaleza. Historia de la Pequeña Edad de Hielo (1570–1700)*. Barcelona: Anagrama.

Brailovsky, Antonio Elio. 2011. "Buenos Aires, ciudad inundable." *LHAWET – Revista del Instituto de Ecología y Ambiente Humano* 1, no. 1: 15–23.

Brouwer, Hendrick. 1646. *Jourmael ende historis verhael van der Reyse gedaen bij Costen de Straet Le Maire* [Biblioteca Nacional de Chile, Fondo Sala Medina, folios 53–69]. Amsterdam: Broer Jansz.

Browning, Stuart, and Ian Goodwin. 2015. "The Paleoclimate reanalysis project." *Climate Past Discussion* 11: 4159–4204.

Cabildo de Santa Fe. 1803. *Acta del 14 de marzo de 1803, Actas de Cabildo de Santa Fe de la Vera Cruz*.

Cardich, Augusto. 1980. "El fenómeno de las fluctuaciones de los límites superiores del cultivo en los Andes: su importancia." *Revista de la Sociedad Argentina de Antropología* 14, no. 1: 7–31.

Caviedes, César. 2001. *El Niño in History.* Gainesville: University Press of Florida.

Cioccale, Marcela. 1999. "La Pequeña Edad del Hielo en la región central de la República Argentina." *Estudios Geográficos* 60, no. 235: 249–270.

Deschamps, Jorge, Osvaldo Otero, and Eduardo Tonni. 2003. *Cambio climático en la pampa bonaerense: las precipitaciones desde los siglos XVIII al XX*. Buenos Aires: Universidad de Belgrano.

Degroot, Dagomar. 2018. *The Frigid Golden Age: Climate Change, the Little Ice Age, and the Dutch Republic, 1560–1720*. Cambridge: Cambridge University Press.

Degroot, Dagomar, Kevin Anchukaitis, Martin Bauch, et al. 2021. "Towards a rigorous understanding of societal responses to climate change." *Nature* 591: 539–550.

Enrich, Francisco. 1891. *Historia de la Compañía de Jesús en Chile.* Barcelona: Rosales.

Eddy, John. 1976. "The Maunder Minimum. A reappraisal." *Science* 192: 1189–1202.

Endfield, Georgina. 2008. *Climate and Society in Colonial Mexico: A Study in Vulnerability.* Oxford: Blackwell.

Esquiluz, Diego de. 1884. *Historia de la misión de Mojos en la República de Bolivia: escrita por Diego de Esquiluz.* Lima: Imprenta del Universo.

Fagan, Brian. 2002. *The Little Ice Age: how climate made history.* New York: Basic Books.

Florescano, Enrique. 1969. *Precios del maíz y crisis agrícolas en México (1708–1810).* Mexico City: El Colegio de México.

Frederiksen, Harald, Nemesio Torres Muñoz, and Alfredo Jauregui Molina. 1959. "Smallpox Erradication." *Public Health Report* 74, no. 9: 771–778.

Gallini, Stefanía. 2004. "Problemas de método en la Historia Ambiental de América Latina." *Anuario IEHS* 19: 141–171.

García Acosta, Virginia. 1988. *Los precios del trigo en la historia colonial de México*. Mexico City: CIESAS-Casa Chata.

Garza-Merodio, Gustavo. 2014. "Caracterización de la Pequeña Edad de Hielo en el México central a través de fuentes documentales." *Boletín del Instituto de Geografía* 85: 82–94.

Gascón, Margarita. 2007. *Naturaleza e imperio: Araucanía, Patagonia, Pampas, 1598–1740*. Buenos Aires: Dunken.

Gascón, Margarita. 2014. "Etnoclimatología en la Araucanía y las pampas. Clima y relaciones interétnicas entre los siglos XVI y XIX." *Dimensión Antropológica* 60: 37–60.

Gascón, Margarita, and César Caviedes. 2012. "Clima y Sociedad en Argentina y Chile durante el periodo colonial." *Anuario Colombiano de Historia social y de la Cultura* 39, no. 2: 159–185.

Gil Montero, Raquel, Mariano Morales, and Ricardo Villalba. 2010. "Población y economía en los Andes: las crisis de subsistencia en Talina entre los siglos XVII y XX." *Surandino Monográfico* 1: 1–33.

Gobierno de Santa Fe. 2006. *Banco de imágenes Florian Paucke*. Santa Fe. http://gobierno.santafe.gov.ar/archivo_general/florian_paucke/.

Haraway, Donna. 2015. "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making kin." *Environmental Humanities* 6: 159–165.

Heyd, Thomas. 2022. "Precursors and Antecedents of the Anthropocene." *Social Sciences* 11, no. 7: 286.

Herrera, Roberto, María Prieto, and Facundo Rojas. 2011. "Lluvias, sequías e inundaciones en el Chaco Semiárido argentino entre 1580 y 1900." *Revista de la Junta de Estudios Históricos de Santa Fe* 65: 173–200.

Huertas V., Felipe. 2009. *Injurias del tiempo. Desastres naturales en la Historia del Perú*. Lima: Universidad Ricardo Palma Editorial Universitaria.

Kupperman, Karen Ordahl. 1982. "The Puzzle of the American Climate in the Early Colonial Period." *American Historical Review* 87, no. 5: 1262–1265.

———. 2007. *The Jamestown Project*. Cambridge, MA: Belknap Press of Harvard University Press.

Laguens, Andrés. 1999. *Arqueología del contacto hispano-indígena. Un estudio de cambios y continuidades en las Sierras Centrales de Argentina*. Oxford: British Archaeological Reports Oxford.

Laprida, Cecilia, María Julia Orgeira, and Natalia García Chapori. 2009. "El registro de la Pequeña Edad de Hielo en lagunas pampeanas." *Revista de la Asociación Geológica Argentina* 65, no. 4: 603–611.

Leal, Claudia, John Soluri, and José Augusto Pádua, ed. 2019. *Un pasado vivo. Dos siglos de historia ambiental latinoamericana*. Bogotá: Fondo de Cultura Económica/Universidad de los Andes.

Madsen, Thomas, and Richard Shine. 2009. "Rainfall and rats: Climatically-driven dynamics of a tropical rodent population." *Australian Journal of Ecology* 24, no. 1: 80–89.

Mariño de Lovera, Pedro. 1960. "Crónica del Reino del Chile Escrita por el capitán D. Pedro Mariño de Lobera, dirigida al Excelentísimo Sr. D. García Hurtado de Mendoza, Marqués de Cañete, Vicerrey y Capitán General de los Reinos del Perú y Chile, Reducido a Nuevo Método y Estilo por el Padre Bartolomé de Escobar de la Compañía de Jesú." In *Crónicas del Reino de Chile Crónicas de Pedro de Valdivia-Góngora Marmolejo-Pedro Mariño Lobera*, ed. Francisco Esteve Barba. Madrid: Editorial Atlas.

Masiokas, Mariano, Andrés Rivera, Lydia E. Espizua, et al. 2009. "Glacier fluctuations in extra-tropical South America during the last 1000 years." *Palaeogeography, Palaeoclimatology, Palaeoecology* 281: 242–246.

Masson-Delmotte, Valerie, Michael Schulz, Ayako Abe-Ouchi, et al. 2014. "Information from paleoclimate archives." In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. IPCC, 383–464. Geneva: IPCC.

Miyahara, Hiroko, Fuyuki Tokanai, Toru Moriya, et al. 2021. "Gradual onset of the Maunder Minimum revealed by high-precision carbon-14 analyses." *Scientific Report* 11: 5482.

Moore, Jason. 2016. *Anthropocene or Capitalocene? Nature, History and the Crisis of Capitalism*. Oakland: PM Press.

Mora Pacheco, Katherinne. 2019. *Entre sequías, heladas e inundaciones. Clima y sociedad en la Sabana de Bogotá, 1690–1870*. Bogotá: Universidad Nacional de Colombia.

Nasirpour, Mohammad Hossein, Abbas Sharifi, Mohsen Ahmadi, et al. 2021. "Revealing the relationship between solar activity and COVID-19 and forecasting of possible future viruses using multi-step autoregression (MSAR)." *Environmental Science Pollution Research* 28: 38074–38084.

Neto, Joao Lima. 2006. "Primeiras impressões dos cronistas e viajantes sobre o tempo e o clima no Brasil colônial." *Biblio 3w: revista bibliográfica de geografía y ciencias sociales* 11, no. 691.

Ortlieb, Louis. 1994. "Las mayores precipitaciones históricas en Chile central y la cronología de los eventos ENOS en los siglos XVI–XIX." *Revista Chilena de Historia Natural* 67: 463–485.

Otto, Friederike. 2017. "Attribution of Weather and Climate Events." *Annual Review of Environnmental Resources* 42: 627–646.

Ovalle, Alonso de. 2007. *Histórica relación del Reino de Chile y de las misiones y ministerios que ejercita en él la Compañía de Jesús…* Alicante: Biblioteca Virtual Miguel de Cervantes. https://www.cervantesvirtual.com/obra/historica-relacion-del-reino-de-chile-y-de-las-misiones-y-ministerios-que-ejercita-en-el-la-compania-de-jesus--0/. Orig. pub. 1646.

Parker, Geoffrey. 2013. *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century.* New Haven: Yale University Press.

Parker, Geoffrey. 2017. *Europa en crisis, 1598–1648*. Madrid: Siglo XXI.

Paucke, Florián. 2010. *Hacia Allá y Para Acá*. Santa Fe: Ministerio de Innovación y Cultura.

Politis, Gustavo. 1983. "Climatic variations during historical times in Eastern Buenos Aires Pampas, Argentina." *Quaternary of South America and Antarctic Peninsula* 2: 133–161.

Prieto, María, Roberto Herrera, and Patricia Dussel. 1998. "Clima y disponibilidad hídrica en el sur de Bolivia y noroeste de Argentina entre 1560 y 1720. Los documentos españoles como fuente de datos ambientales." *Bamberger Geographische Schriften* 15: 35–56.

Prieto, María, and Facundo Rojas. 2015. "Determination of droughts and high floods of the Bermejo River (Argentina) based on documentary evidence (17th to 20th century)." *Journal of Hydrology* [Part 2] 529: 676–683.

Quinn, William, and Víctor Neal. 1995. "The historical record of El Niño events." In *Climate since A.D.1500*, ed. Raymond Bradley and Philip Jones, 623–648. London: Routledge.

Quinn, William, Víctor Neal, and Santiago Antunez. 1987. "El Niño occurrences over the past four and a half centuries." *Journal of Geophysical Research* 92, no. C13: 14449–14461.

Reinegg, Anton Seep von, et al. 1704. *An account of a voyage from Spain to Paraquaria: performed by the reverend fathers Anthony Seep and Anthony Behme… containing a description of all remarkable things and the inhabitants, as well as of missionaries residing in that country*. London: A. & J. Churchill.

Rohland, Eleonora. 2016. "Hurricanes on the Gulf Coast: Environmental Knowledge and Science in Louisiana, the Caribbean and the U.S., 1722–1900." In *Works of Nature: Global Scientific Practice During the Age of the Revolutions*, ed. Daniel Rood and Patrick Manning, 38–53. Pittsburg: University of Pittsburg Press.

Roverano, Andrés. 1983. *Santa Fe la Vieja*. Santa Fe: Colmegna.

Santamaría, Daniel. 1986. "Fronteras indígenas del oriente boliviano. La dominación colonial en Moxos y Chiquitos, 1675–1810." *Boletín americanista* 36: 197–28.

Segreti, Carlos S. A., ed. 1973. *Córdoba, ciudad y provincia, siglos XVI–XX*. Córdoba: Junta Provincial de Córdoba.

Schlüpmann, Jakob. 2005. "Les origines climatiques des problèmes agraires sur les côtes du Pérou à la fin du 17ème siècle: déclin viticole, maladie du blé et ´Late Maunder Minimum." *Histoire(s) de l´Amériqe latine* 1, no. 2: 1–24.

Schmidl, Ulrico. 1995. *Viaje al Río de la Plata*. Buenos Aires: Nuevo siglo. Orig. pub. 1567.

Stenseth, Niels et al. 2002. "Ecological effects of climate fluctuations." *Science* 297: 1292–1296.

Swan, Susan. 1982. “Drought and Mexico’s Struggle for Independence.” *Environmental Review* 6, no. 1: 54–62.

Skopyk, Bradley. 2020. *Colonial cataclysms: climate, landscape, and memory in Mexico’s Little Ice Age.* Tucson: University of Arizona Press.

Tandeter, Enrique. 1991. “Crisis in Upper Peru.” *HAHR* 71, no. 1: 35–71.

Thomas, Julia, ed. 2022. *Altered Earth. Getting the Anthropocene Right.* Cambridge: Cambridge University Press.

Tonni, Eduardo. 2017. “Cambios climáticos en la región pampeana oriental durante los últimos 1000 años. Una síntesis con énfasis en la información zoogeográfica.” *Revista del Museo de La Plata* 2, no. 1: 1–11.

Schmidl, Ulrico. 1995. *Viaje al Río de la Plata.* Buenos Aires: Nuevo siglo. Orig. pub. 1567.

Usoskin, Ilya. 2017. “History of Solar Activity over Millennia.” *Living Review of Solar Physics* 14, no. 3.

Vaquero, José, and Ricardo Trigo. 2014. “Redefining the limit dates of the Maunder Minimum.” *New Astronomy* 34: 1–6.

Vicuña Mackena, Benjamín. 1877. *Ensayo históricos sobre el clima de Chile.* Valparaiso: Imprenta del Mercurio.

Villalba, Ricardo, Juan C. Leiva, Sigfrido Rubulls, et al. 1990. “Climate, Tree-Ring, and Glacial Fluctuations in the Rio Frias Valley, Rio Negro, Argentina.” *Arctic and Alpine Research* 22, no. 3: 215–232.

Villalba, Ricardo. 1994. “Tree-ring and glacial evidence for the Medieval Warm Epoch and the Little Ice Age in southern south America.” *Climatic Change* 26: 183–197.

Vivar, Gerónimo de. 1966. *Crónica y relación copiosa y verdadera de los reinos de Chile*. Santiago de Chile: Fondo Histórico y Bibliográfico José Toribio Medina. Orig. pub. 1558.

Wendt, Helge. 2016. “Epilogue: The Iberian Way into the Anthropocene.” In *Proceedings “The Globalization of Knowledge in the Iberian Colonial World,”* ed. Helge Wendt, 297–314. Berlin: Max-Planck-Gesellschaft zur Förderung der Wissenschaften.

Yacobaccio, Hugo. 2015. “Presentación. Estudios paleoambientales en el NOA y su significado para la arqueología.” *Estudios Sociales del NOA* 16: 7–12.

Climate Change in the Andes during the Colonial Period

Andean Societies Facing *Temporales* under the Spanish Empire

Katherinne Mora Pacheco

During the three centuries of Spanish rule in the Americas, the Andean Mountain Range was one of the most densely populated regions where monarchical authority could be exercised. In this same region, important towns and cities were established as political-administrative and economic centers; prosperous haciendas were operated by individuals or the Catholic Church and its religious orders; and communal lands were delimited for the Indigenous population, which remained numerous compared to the Caribbean and Pacific coasts of South America and to this day represent a significant percentage of the Andean nations.

Due to the variety of soils and altitudinal microclimates in the Andes, agricultural activities are diverse and productive. However, from the mid-sixteenth century to the second decade of the nineteenth century, there were numerous situations in which the inhabitants of the Andes were affected by *mudanzas de temperamento* (climactic shifts) and *temporales* (inclemencies), denominations for a wide repertoire of meteorologically extreme phenomena such as droughts, frosts, hailstorms, floods, avalanches, cold and heat waves, and even agricultural pests related to changes in atmospheric events. These alterations were due to natural phenomena of intra-annual climate variability on a local and regional scale, such as the relationship between climate and altitude and the oscillation of the Intertropical Convergence Zone (ITCZ) throughout the year. They were also related to interannual climate variability due to the proximity of the Andes to the Pacific Ocean and the direct influence the El Niño-Southern Oscillation (ENSO) phenomenon exerted (Caviedes 2001). On a global scale, shorter-term disturbances, such as volcanic eruptions, or the longer-term influence of the Little Ice Age, especially during the Maunder (c. 1675–1715) and Dalton (c. 1790–1830) minima, also played a role (Le Roy Ladurie 2017).

This chapter reconstructs the crises related to hydrometeorological and climatic events that affected different populations in the tropical Andes or low latitudes in areas under the jurisdiction of the viceroyalties of Peru and New Granada, with as much emphasis as the sources from the eighteenth century and the dawn of independence permit. It should be noted that in the sixteenth and seventeenth centuries, these Andean territories were under the rule of the Viceroyalty of Peru, as the Viceroyalty of New Granada – which would cover the territories of present-day Venezuela, Colombia, Panama, and Ecuador – was not established until 1717. Shortly thereafter, the new viceroyalty was suppressed in 1723, only to be established again in 1739. It then was in operation until the declarations of independence in 1810. Six years later, however, it was reconstituted with the monarchical restoration before coming to its end after the independence campaigns between 1819 and 1821. Nevertheless, to facilitate the reading of this chapter, the term New Granada will be used to refer to the northern Andes, and priority will be given to the naming of the provinces and townships.

Beyond the chronological reconstruction and the description of the conjunctures – many of them related to natural climate variability – this chapter describes conditions that increased the vulnerability of specific social sectors or subregions due to factors such as the introduction of foreign species, the possession of land, land use, tax burdens, and supply policies for cities, among others. These factors, moreover, function as markers of an anthropogenic change that is here called the Proto-Anthropocene (Wendt 2016). Likewise, some of the social responses to hydrometeorological pressures (alterations in temperature, humidity and water availability, or winds that can affect socioeconomic systems, such as droughts, heavy rains and flooding, hailstorms, frosts, hurricanes, etc.) are highlighted, several of which saw long-term adoption, inviting reflection on current responses to climate change.

Before getting into the matter, a few words of warning are necessary about the methodological and historiographical challenges faced in writing this chapter. First, the Andes are a complex and diverse region in ecosystemic, topographic, and climatic terms. The *páramos* – an endemic high-mountain ecosystem in the intertropical northern Andes, above c. 2,800 meters above sea level (masl), characterized by shrubby vegetation – found in the peaks of the northern Andes and the *punas* – another endemic high-mountain ecosystem in the central Andes, above c. 3,500 masl, characterized by herbaceous vegetation – have particularities that are not found in any other part of the world or even in the same mountain range (Nieto, Cardona, and Agudelo 2015; Prieto and Rojas 2013). The plateaus and massifs that predominate in the central Andes differ from the northern branches, where the presence of inter-Andean valleys is significant, and warmer lands below 1,000 meters are only a one to two-day journey away. In climatic terms, tropical or equatorial regions enjoy the same sunshine throughout the year. Thus, they lack thermal seasons but have dry and rainy ones that are marked by the movement of the ITCZ. Microclimatic differences are also expressed with dissimilar effects. For example, if precipitation increases in the form of rain or snow at the sources of rivers, it is possible that the precipitation in the valleys and lower basins decreases, although sources for irrigation and watering holes would remain. Likewise, a single crop such as wheat, so widespread in the Andean region, can be differentially adapted to climates with different degrees of humidity (Prieto and Rojas 2013: 648). When talking about interannual variability, the effects of ENSO are heterogeneous and contrasting along the Andes. Although there are local and microclimatic variants, in general terms, El Niño usually causes droughts in the northern Andes, while in the Peruvian-Bolivian highlands, rainfall can occur at strange times, as well as in unusual places and amounts. In contrast, during La Niña, the northern regions receive an overabundance of water, while the central and southern regions experience a water deficit (Caviedes 2001; Huertas 2001; Pabón and Torres 2007; Poveda, Waylen, and Pulwarty 2006). Therefore, without ignoring this heterogeneity, this chapter shows that, despite the particularities, common hydrometeorological pressures and social responses existed.

A second challenge concerns spatial delimitation. Because highlands and lowlands were linked through biophysical and social interactions that often lay beyond human control and Hispanic territorial jurisdictions, the inter-Andean valleys and adjacent coasts must also be considered, even though the high mountains remain the main focus of this discussion.

Little Ice Age and ENSO in the Andes: Hydrometeorological Pressures and Other Stressors

In the three centuries between the arrival of Europeans to the Andes and the independence from the Spanish monarchy, there was an extensive repertoire of hydrometeorological pressures on the societies that inhabited this region. In the global context, the colonial period is completely framed within the Little Ice Age, characterized – among other features – by the advance of glaciers and high mountain ecosystems in lower altitudes and the increases and decreases of temperature and precipitation in abnormal levels or at unusual times of the year. Although it has been debated whether the extent of the Little Ice Age was limited to Europe or the Northern Hemisphere (Le Roy Ladurie 2017), studies from various disciplines and methodologies have demonstrated its manifestation in the Andean Mountain Range (Chambers et al. 2014; Flórez 1990; García 2021; Gioda and Prieto 1999; Mora 2019; Velásquez 2005; Villalba 1994). As shown in Table 1, the moments of greatest crisis for very distant and dissimilar populations along the Andes coincided precisely with the Maunder (c. 1675–1715) and Dalton (c. 1790–1830) minima. In both minima, droughts, abundant rainfall – and in abnormal periods – frosts, plagues, and epidemics knew no borders.

Along with and simultaneous to the Little Ice Age, as had been occurring for centuries, the Andes were also under the aperiodic and direct influence of ENSO, which, as indicated, has differentiated effects on the entire mountain range, both in its warm phase (El Niño) and in its cold phase (La Niña). In the chronology of Gergis and Fowler (2009), the following have been identified for the presently studied period as years of strong, very strong, or extreme El Niño occurrences: 1525, 1526, 1540, 1544, 1554, 1556, 1559, 1565, 1574, 1585, 1591, 1594, 1596, 1607, 1608, 1618, 1619, 1650, 1660, 1661, 1687, 1694, 1718, 1719, 1728, 1737, 1770, 1791, 1799, 1803, 1806, 1807, 1812, and 1817. Using the same criteria, La Niña occurrences are found for the years 1528, 1531–1533, 1535, 1538, 1540–1542, 1544, 1546, 1548, 1549, 1560, 1561, 1566, 1571–1573, 1576–1581, 1583, 1584, 1592, 1593, 1600, 1611, 1622–1624, 1626, 1629–1632, 1637, 1641, 1642, 1644, 1645, 1654, 1663, 1676, 1685, 1696, 1708, 1715, 1716, 1733, 1739–1743, 1745, 1750, 1752, 1753, 1755, 1763, 1765, 1779, 1780, 1786–1788, 1790, 1801, 1802, 1805, 1808–1811, 1819, and 1820. In addition to ENSO, the period's volcanic activity, whether in the Andes or other parts of the world, was a factor in altering atmospheric conditions on a global scale. There were critical periods, such as the 1690s, and 1693–94 in particular, due to the eruptions of Serua in Indonesia, Hekla in Iceland, Komagatake in Japan, and Vesuvius and Etna in Italy; 1707 to 1709 due to the eruptions of Vesuvius and Santorini in the Mediterranean basin, Fuji in Japan, and the Pico de la Fournase in Réunion; the 1780s due to the eruption of Laki in Iceland and Asama in Japan in 1783; and 1815 to 1819 due to the eruptions of Tambora in Indonesia and Colima in Mexico (Bradley and Jones 1995; Le Roy Ladurie 2017; Parker 2013). Although it is not possible to disaggregate which phenomena were caused by the Little Ice Age, ENSO, or volcanic eruptions – with some proposing their mutual exacerbation (Emile-Geay 2008; Fischer et al. 2007) – it is undeniable that Andean societies had to face numerous hydrometeorological pressures, which are summarized in Table 1.

Droughts, frosts, and abundant or prolonged rainfall and floods became pressures not only because, as will be seen in the next section, they met with vulnerable societies but also because they converged with and were mutually exacerbated by other phenomena or multiple stressors (Endfield 2012; Feola, Agudelo, and Contesse 2015). Thus, a severe or prolonged drought brings with it an irrigation deficit; the scalding of cereals; plagues of locust due to the biological mechanisms that the droughts activated in the insects, which increased their appetite and led them to form swarms (see Arrioja 2019); scourges of *alhorra*, *roya*, or *polvillo* – the most common names found in Andean sources of the fungus identified as *Ustilago tritici* or *Ustilago maydis*, depending, respectively, on whether it affects wheat or corn; a decreased production of milk, tallow, and wool; the mortality of livestock; and a scarcity of fish. Atypical rains and floods would destroy the roads necessary for exchange and encourage the spread of fungi and the rotting of crops, stored grains, and textiles. The confluence of droughts and floods within the same one-to-five-year period often proved fatal due to the loss of the few surviving animals and crops. For their part, epidemics appeared because, despite being caused by microbiological agents and not by the climate, they are mutually exacerbated by hydrological extremes. For example, malnourished bodies are more vulnerable to infections, simultaneously decreasing food supply due to a lack of agricultural laborers. Finally, although in many cases seismic and volcanic phenomena do not coincide with hydrometeorological anomalies, they must be taken into account because, on the one hand, they destroy irrigation and transportation infrastructure, and on the other, substances such as sulfur contaminate water and alter the atmosphere (Table 1).

Table 1: Some Andean Crises within the Framework of the Little Ice Age

Years→ / **Jurisdiction↓**	**1574**	**1578**	**1583–84**	**1593–94**	**1606–10**	**1618–19**
Tunja-Santafé						
Popayán						
Quito						
Piura						
Trujillo						
Lambayeque						
Potosí						
Arequipa						

Years→ Jurisdiction ↓	1630–33	1637–41	1644–45	1652–57	1660–65	1691–1711
Barquisimeto						
Mérida						
Tunja Santafé						
Popayán Neiva						
Quito						
Piura						
Trujillo						
Lambayeque						
Lima						
Ica						
Cuzco						
Potosí						
Arequipa						

Years→	1714–15	1719–25	1727–29	1743–48	1753–64	1768–72	1776–78
Jurisdiction ↓							
Barquisimeto							
Barinas							
Mérida							
Tunja Santafé							
Popayán Neiva							
Pasto							
Quito							
Piura							
Trujillo							
Lambayeque							
Lima							
Ica							
Cuzco							
Potosí							
Arequipa							

Years→ Jurisdiction ↓	1781–86	1788–90	1791–98	1802–08	1814	1818–20
Barquisimeto						
Tunja Santafé						
Popayán Neiva						
Pasto						
Quito						
Piura						
Trujillo						
Lima						
Fist						
La Paz						
Potosí						
Arequipa						

Legend

Climatic Events	
Severe drought	
Frost	
Atypical rains and floods	

Epidemics	
Peste (plague)	
Smallpox	
Measles	
Typhus – *Tabardillo*	
Tuberculosis	
Other respiratory condition	
Scarlet fever	
Dysentery	

Plagues	
Mice	
Locusts	
Worms	
Weevil – Termites	
Polvillo, *chahuistle* (corn fungus), *muque*	

Eruptions – Earthquakes	

Explicit famine	

No data	

Periods with at least one year of strong, very strong, or extreme ENSO (Gergis and Fowler 2009)	

Source: Author's elaboration based on Abadía (2021); Aldana (1996); Altez (2022); Carcelén (2009); Carcelén, Molina, and Medina (2020); Castañeda and Trujillo (2022); Castaño (2019); Caviedes and Waylen (1991); Córdoba (2023); García (2021); Gergis and Fowler (2009); Gil, Morales, and Villalba (2010); Huertas (2001); Mora (2019); Prieto and Rojas (2013); Quispe (2013); Quispe, (2017) Regarding the effects identified in Table 1 and the methodology to prepare it, the following clarifications are necessary:

- First, the proportion of these crises is rarely quantifiable in terms of degrees Celsius or rainfall volumes because the region did not have standardized, continuous systems of instrumented meteorological records until well into the nineteenth century. Therefore, crises can only be reconstructed based on the perception and degree of impact on the societies that experienced them. Nor would it be useful to pursue numerical data as a reference for current droughts or floods, as the conditions of vulnerability have changed.
- Second, any missing references to jurisdictions, boxes that are blank or without information, and cases in which famine was not explicitly identified are not indicators of the absence of phenomena but rather calls to investigate those regions and periods still not covered. For the first decades of European occupation in South America, there are records of food shortages and extremes of temperature and humidity, which were much more sporadic and linked to the lack of knowledge the colonizers had of the land they entered and the interpretation of their informants than with the actual occurrence of climatic anomalies (Saldarriaga 2012: 48–52). Hydrometeorological alterations began to appear with greater frequency and precision in a diversity of sources in the last decades of the sixteenth century, precisely when records of the state in which territories and communities were found increased as a result of disputes, *visitas a la tierra* (regular inspections by officials of the Real Audiencia to better enforce laws over Indigenous peoples), and *relaciones geográficas* (questionnaires distributed in the Viceroyalty of New Spain at the order of King Philip II to gather information of the region). This occurred in a period in which a variety of social pressures converged, such as tax impositions, relocations, and the decrease of Indigenous populations, as well as changes in land use and coverage due to the proliferation of foreign livestock and crops. The gaps in information encourage us to examine regions that did not possess the political and economic influence of the viceregal capitals, royal courts (*audiencias reales*), ports, or mining centers – areas where historical sources are most plentiful. However, as will be discussed later, these centers often managed their crises by sourcing food from places they viewed as peripheral.
- Third, the absence of locust plagues during droughts has to do with the concentration of the population in the Andes at altitudes 2,000 meters above sea level, where these insects supposedly do not reach. However, other phenomena that were equally feared and very frequent did still occur in the dry season, such as frost. Finally, in the studies consulted, there are very few references to dysentery or other types of gastrointestinal infections that are usually taken as an indirect indicator of the occurrence of drought due to the consumption of stagnant water and poor-quality food (Le Roy Ladurie 2017). More than the non-occurrence

of the disease, the lack of references may be due to the fact that the microbes causing specific illnesses were not yet known in the period nor the condition accurately recorded; the generic term "peste" is the one that predominates in the sources.

Once the moments of greatest hydrometeorological pressures have been identified, this chapter will explain in the following sections the social conditions that fueled the crises and how Andean societies responded to *temporales*.

Vulnerability to Hydrometeorological Pressures

A fundamental factor for the increase in vulnerability when faced with climate variability – at the same time part of the configuration of the Proto-Anthropocene in the Andes – was the "Columbian Exchange": the voluntary or involuntary introduction of epidemics, plagues, and domesticated crops and animals (Crosby 1972). Although for Alfred Crosby, this process considered "ecological imperialism" was a failure in the tropics and successful in the mid-latitudinal regions – where Europeans found climatic conditions similar to those of their places of origin – the conditions for those "New Europes," as he called them (Crosby 1998), were also found in the equatorial or tropical Andes: in the high mountains where cities had been founded according to the Hispanic model, population concentrated, and wheat fields and livestock were spread to supply them. Vulnerability to droughts or excessive rainfall and floods, combined with the consistent social perception of the severity of these phenomena, has been directly linked to the introduction of these crops and livestock over the long-term.

While wheat may not be classified strictly as a monoculture – given its historical cultivation alongside other cereals and legumes such as *garbanzos* (chickpeas), and the concurrent growth of native and introduced cereals, vegetables, and fruits throughout the Andes, even in primary agricultural regions – specialization in production within areas with Mediterranean-like climates, and at high altitudes where heat and humidity did not compromise the grain (for instance, in cities like Tunja, Pasto, or Quito), has led to several challenges. In times of hydrometeorological anomalies, recurrently throughout the seventeenth and eighteenth centuries (Table 1), *polvillo* or *roya* proliferated rapidly due to the large continuous extensions of wheat spikes the fungus could infect. Along with wheat and livestock, mice and rats were brought unintentionally from Europe. Due to the absence of predators and with the abundance of wheat, they became a plague in times of droughts or floods, in cases like that of the Peruvian provinces of Saña and Chimor in 1578 (Huertas 2001: 50).

Towards the end of the seventeenth century, within the Peruvian territory, a significant wheat crisis emerged following nearly a century of market supply extending as far as Panama. This crisis was attributed to factors such as intense seismic activity between October and December 1687, rust (*roya*), and increasing temperatures. In addition to addressing the plague and atmospheric alteration, it is important to consider the interests of the landowners who wanted to switch to sugarcane due to its high global demand. The earthquake of 1687 allowed merchants in Lima to acquire wheat from Chile while sugarcane production bolstered the power of the northern elite. The cities of Trujillo and Lambayeque in northern Peru abandoned wheat and grain crops and even livestock farming in favor of sugarcane. As a result, livestock production began to be supplied by Cajamarca in the Sierra and Piura on the coast (the latter mainly for extensive goat farming to sell as livestock or to make soaps and *cordobanes* [embossed leather products]), and wheat began concentrating in Huancabamba, in the low northern mountains, to supply Trujillo, Lambayeque, and Piura. Therefore, climate historian Susana Aldana (1996) remarks that the climatic phenomenon and its effects, in fact, served to hide an economic phenomenon (126–130).

In addition to wheat, the expansion of sugarcane and grapevines, which formed the basis for the production of distilled and fermented beverages, was also associated with vulnerability to drought. For, although they were not basic foods, necessary income could be derived from them to meet various financial obligations. For example, in 1600, the combination of abundant rain and ash fall from the eruption of the Huaynaputina Volcano over Arequipa and its jurisdiction led to decreased wine production, falling from 200,000 *botijas* (earthenware jugs) to only 10,000 (Huertas 2001: 47). In the first decade of the eighteenth century and in the midst of a period of general crisis in the Andes (Table 1), Lima, Ica, Pisco, and Nazca also experienced lower production in wine and spirits (Carcelén, Molina, and Medina 2020: 19–20). During the drought of 1804 and 1805, southern Peru and northern Chile were affected by a drop of between 30 and 50 percent in liquor production, which affected the payment of compulsory ecclesiastical taxes and obligations called *diezmos* (tithes) and *capellanías* (Quispe 2013).

Livestock farming emerged as an important activity in the Andes from the mid-sixteenth century onwards. Animals were not only used for labor and provided meat and milk, but also supplied raw materials such as bones, leather, wool, and tallow, which were essential for producing candles and soaps (Castaño 2019). These supply demands, combined with factors like the lack of tree vegetation in the high mountains, the presence of swamps and flooded areas unsuitable for wheat cultivation, and the nutritious pastures of the inter-Andean valleys, led to livestock specialization in various parts of western South America. In addition to the initial ecosystem impacts caused by the introduction of these foreign species, reliance on livestock farming also contributed to crises. Although livestock could move independently during floods, the speed of flooding at times precluded any effective response, resulting in many animals drowning. The surviving animals faced scarcity as pastures were submerged or decaying. It is important to note that the most severe crises occurred during droughts, when both pastures and water sources were depleted, leading to animal deaths from hunger and thirst. These crises impacted not only livestock farmers, who could be of either European or Indigenous origin (Aldana 1996; Mora 2019), but also the entire population. The situation was further complicated by hoarding, obligations to supply capital cities, and sales to the highest bidder. For instance, throughout the eighteenth century, although the cities of Santafé (referring to the capital of New Granada, later known as Bogotá) and Quito had nearby livestock areas, they competed for the cattle raised in the Alto Magdalena region, within the jurisdiction of Neiva, La Plata, and Timaná. Both these producing regions, along with other surrounding areas lacking political or economic power, experienced shortages (Castaño 2019; García 2021; Mora 2019).

In addition to the vulnerability caused by the introduction of domesticated animals and crops, the "Columbian Exchange" also involved the introduction of viruses, bacteria, and fungi that caused disease in a native population that lacked the immunity to combat them. In fact, despite the discussions that may arise in this regard, the very origin of the Little Ice Age has been linked to the demographic decline that occurred in the Americas during the first half of the sixteenth century, which can partly be explained as a result of the spread of such diseases, a hypothesis that points to much earlier anthropogenic climate change and serves as a marker of the Anthropocene or, at least, a Proto-Anthropocene. This explains why, with less population, carbon emissions from slash-and-burn agricultural practices decreased, while carbon capture increased due to the recovery of forests in previously agriculturally used areas without forest cover (Nevle et al. 2011; Ruddiman 2003; Ruddiman 2007).

Beyond the purely biological explanations of vulnerability, which could reduce the responsibility of human beings, the social conditions imposed by the Spanish Crown must also be considered. In the Andes, during the latter half of the sixteenth century and the first two decades of the seventeenth century, Indigenous populations were systematically concentrated in communities known as *reducciones* or *resguardos* (this name was used for the cases of Quito, New Granada and Venezuela). This effort aimed to convert them to Catholicism, preserve their population for tax revenue and food production, and free up land for European settlers and their descendants (Saito and Rosas 2017). This policy significantly influenced how the local populace responded to hydrometeorological anomalies.

In pre-Hispanic times, on the eastern branch of the northern Andes, there had been exploitation of slope lands around the Magdalena Valley and the foothills of the Orinoco plains (Langebaek 1987; Langebaek 2019). In the Inca territory, the management of high-altitude microclimates, known as the "vertical archipelago," allowed harvests to be obtained in different seasons. This management also helped keep provisions safe in case of frost in the highlands or, alternatively, preserve them in the elevated areas when the insects lurked in lowlands (Murra 1972). With the process of colonial reductions, the distribution of land and territory and, consequently, access to water, other microclimates, and hunting grounds changed (Mumford 2012). The relocations and new political-administrative jurisdictions affected biophysical conditions. For instance, in Peru, agricultural terraces (called *andenes*) in mountainous areas were abandoned for newly assigned lands, leading to accelerated soil degradation (Wernke 2010). Similarly, in regions such as the *Sabana de Bogotá* (the Spanish named the region "sabana" because it is a plain, it is not a savanna ecosystem), the Ecuadorian coasts and mountains, the Puno plateau, and Lake Titicaca, *camellones* (elevated crop fields), which helped regulate temperature and manage floods for agriculture, were gradually abandoned due to changes in spatial organization and distribution (Boada 2006; Valdez 2006).

However, as noted in the introduction, heterogeneity is a characteristic feature of the Andes. Not all Indigenous communities were affected to the same degree by the distribution of lands of low productivity or without access to other microclimates. On the one hand, many Indigenous people resisted the process of reduction, lived outside their communal lands, at least seasonally, and maintained access to other altitudes (Mumford 2012). On the other, to guarantee tax revenue and supply for the cities and towns, the same authorities issued stipulations that allowed Indigenous people a minimum of continuity with their ancestral territories (González 1970; Mumford 2012). Some towns even retained the possibility of accessing various microclimates as the delimited communal lands encompassed a variety of altitudes to obtain crops in different seasons and protect themselves from frost or insect pests. For example, this advantage was evident in the Andes of New Granada at the end of the 1770s, when a famine led to the decision to suppress and relocate sparsely populated towns. Some of the Indigenous people who refused the relocation argued that the varied *temporales* affecting their lands allowed them to survive and help others and that the lands to which they would be relocated would only allow them to obtain products from *tierra fría* (cold land, typically between 2,000 to 3,500 m in elevation) (Mora 2021b). The Spaniards themselves, whether on private or Catholic-Church-owned land, managed to control properties that covered several microclimates due to their extension or, in other cases, succeeded in producing food or raw materials through the possession of exceedingly diverse territories in warm and cold zones (Mora 2019; Córdoba 2023).

Regardless of whether there was a change in the extent and mobility in Indigenous territories due to the reductions, their susceptibility to hydrometeorological anomalies increased because of the tax burdens placed on them. In the second half of the sixteenth century and the first half of the seventeenth, when the forced indigenous labor system, the *encomiendas*, were still profitable and taxes were fixed or paid in kind, the Indigenous people were forced to expand their cultivated wheat bushels in various parts of the Andes. This added to the consequent problems already mentioned and additionally diminished the area for subsistence agriculture. Factors such as the value that woven blankets acquired in the jurisdictions of Tunja, Quito, Trujillo, or Cuzco, the rupture of their pre-Hispanic circuits of agricultural mobility and exchange, and the demands of *encomenderos* for payments higher than the fixed tax rates led the Indigenous people to dedicate themselves either to sheep farming (for wool) in the highlands or cotton planting in the lowlands. The abundant rainfall of 1578 is an example of the vulnerability generated by these choices since, throughout the Peruvian territory, Indigenous people were affected by the drowning of their sheep, the rotting of their wool or the clothing they had woven, and the waterlogging of their farms, as well as the invasion of locusts, worms, and mice in their cotton fields (Huertas 2001: 50, 71–72, 79–87). For the indigenous people of Piura, the issue was not with the fabrics, but rather with the taxes required to be paid in sardines and *toyos* (a small kind of shark; the toyo común is *Mustelus whitneyi*, in English Humpback smooth-hound). Due to the increase in sea temperatures caused by El Niño, fishing yields decreased, making it impossible to meet these tax obligations during the 1650s and 1660s (Huertas 2001: 43, 283–288). In the eighteenth century, despite the elimination of payment in kind and the gradual discontinuation of the *encomienda* system, other financial burdens remained significant within the context of hydrometeorological conditions. For example, in the jurisdiction of Lima in the 1740s, the Indigenous people were affected not only by a frigid winter and a resulting loss of wheat crops but also by the imposition of *alcabalas* and *gravámenes* (royal taxes charged for all commercial transactions whether for collection, sale, or contract) on products of "Spanish" (*de Castilla*) or "native" (*de la tierra*) origin (Carcelén, Molina, and Medina 2020: 21). In general, the inability to pay these obligatory taxes led the Indians to flee or work as water carriers, boatmen, muleteers, and day laborers (Aldana 1996; García 2021).

Finally, another vulnerability factor that must be considered for the eighteenth century throughout the Andes is the increase in the Creole and mestizo population and the migration to urban centers, which entailed a decrease in the agricultural workforce and an increase in the demand for food and raw materials in areas that did not produce them (Carcelén 2009). The recurring droughts and epidemics in the last three decades of the eighteenth century and the first decade of the nineteenth dealt another blow to agricultural production, endangering the supply to cities and towns that, as will be seen, used various strategies to avoid famine. So, next, let us look at the repertoire of responses to hydrometeorological pressures.

Social Responses to Crises

Societies do not usually remain unscathed when pressured by meteorological phenomena and, in the Andean case, the repertoire of responses combined symbolic and material strategies and measures imposed by authorities or generated from below. Among these strategies – in a Catholic world in syncretism with pre-Hispanic beliefs and practices – emerged providential explanations of these hydrometeorological phenomena and their association with sin and punishment. For this reason, festivals were to be celebrated annually to protect the crops, such as those in honor of San Isidro Labrador or the Holy Cross in May, or, occasionally, processions, pilgrimages, and public acts of repentance known as rogations were to be performed. Depending on the severity of the drought, these prayers were directed to different invocations of Christ, the Virgin Mary, or specific saints. For example, in the eastern Andes of New Granada, prayers to Our Lady of the Field, the Fallen Lord, or Saint Barbara and Saint Victorinus were common, while in the western Andean jurisdiction of Popayán, much more prone to locust plagues, Saint John the Baptist was a central figure (Abadía 2021; Mora 2021a). In the jurisdiction of Lima, Our Lady of Mercy, Saint Rose of Lima, Saint Marcellus, and Saint Roch were preferred (Carcelén, Molina, and Medina 2020). Regardless of the saint to whom they were directed, the prayers not only were a strategy of emotional control or refuge for believers but also had a material component. During these occasions, to demonstrate the virtue of charity, food was shared with those in need, and the musicians and artisans who participated in the organization and celebration of such ceremonies were able to earn income (Mora 2021a).

In the Andes, the most frequent prayers were those to alleviate drought, *pro pluvia*, whereas those organized to stop the rains, *pro serenitae*, are scarce or non-existent in the sources (Carcelén, Molina, and Medina 2020; Mora 2019). Among the few cases found, the prayers addressed to Saint Barbara in Popayán to calm the storm of December 1639 and those to Our Lady of the Rosary in August 1800 serve as examples of the latter. For its part, the excessive rains of January 1780 in the jurisdiction of Pasto, which caused the death of livestock and, above all, threatened the corn and potato crops of the haciendas of the female order *Monjas Conceptas*, led residents to cry out to the Virgin (Abadía 2021; Córdoba 2023). Coincidentally, these two cities are very close to the Chocó Jungle on the Pacific Coast, one of the rainiest regions in the world, and therefore a possible explanation for the volume of the torrential rains (Duque Gardezabal 2023). In the broader Andean context, the lower frequency of *pro serenitae* supplications does not imply that excessive rainfall did not occur. Rather, it reflects the various ways agrarian societies perceived water. This notion is tied to a secondary strategy related to water and land use. Excess water – potentially disastrous for urban areas, with merchants facing transport disruptions, or farmers facing flooded fields – was considered advantageous by those with access to different altitudes or who had already completed their harvests and required the nutrient-rich silt for their fields. Ranchers benefitted from the increased number of watering holes and could anticipate abundant pastures once the waters receded. Even during agricultural crises, ranchers, such as those around Santafé, Nueva Granada who fattened their cattle, reaped these advantages (Mora 2019).

A third strategy to face hydrometeorological pressures was the use of public and, above all, private food depositories. Unlike New Spain (Endfield 2008; Florescano 1969) and despite royal decrees that promoted their creation to control resale and speculation, in the Andes, the *pósitos* (municipal granaries) and *alhóndigas reales* (royal warehouses) did not prosper as public grain depositories. In the case of Lima, the decision to establish an *alhóndiga* that would protect wheat from humidity was made in 1555, driven by the lack of rainfall in the city. This public depository only functioned from 1558 to 1622 and, in its short life, faced problems related to the refusal of producers to deliver their grain, the cost of land transportation from the irrigated valleys of Peru, or the shipments of cargo from the port of Callao to Panama. After its closure, until the crisis beginning in 1687 (Table 1), the strategy did not focus on the control of wheat or flour stocks but rather on price regulation (Bell 2013). In New Granada, there are only two known construction projects for *alhóndigas*, neither of which materialized: one in Santafé in 1603 and another in Antioquia in 1787 (Patiño 1965: 330–331).

However, in these and other cases where more research is required, the constant complaints of grain hoarding indicate the existence of private depositories that allowed the families who owned them to face the crisis. As can be established from the case of New Granada, Indian towns preserved and stored other types of food by salting meat, keeping freshwater fish in reservoirs, or producing cheeses and butter that were used both for sale as well as for self-consumption (Mora 2019). In the Peruvian case, the confluence of rain and a plague of mice, locusts, and worms in 1578 highlighted the existence of other storage practices, such as burying corn, sweet potatoes, and beans under their homes and in the sand – which was, in this case, not effective – or the use of jugs, jars, and gourds as grain reservoirs, which allowed some to avoid famine (Huertas 2001).

The fourth mechanism to alleviate crises was the use of petitions to free themselves of fiscal burdens, supply obligations, and religious precepts. The drought was not only an argument for a few Indian towns to be exempted from their taxes (Aldana 1996; Huertas 2001), it was also used effectively by other communities. The meat suppliers for Quito and Santafé in the Cauca and Magdalena valleys used drought and locusts as a frequent argument for not complying with their obligation to pay taxes (Castaño 2019; Mora 2019). Cities and towns also had to apply for exemptions. For example, in the 1660s, damage caused by floods and the eruption of Guagua Pichincha, along with associated seismic activity, motivated petitions from Quito to the *Consejo de Indias* (Council of the Indies) for the alleviation of *alcabalas* and *papel sellado* (documents with a taxed royal stamp levied by the Crown) (García 2021: 99). After the drought of 1724 and the floods of 1725, the destruction of crops and herds not only led to reduced censuses but an exemption from fees for religious ceremonies was declared due to extreme poverty. However, the decision contrasts with the response to the prolongation of the crisis until 1728, a year of droughts and frosts, which motivated the Quito council to refuse to celebrate the wedding of Philip V, a decision in turn disapproved by the *Real Audiencia* (Royal Court) (García 2021: 107). Regarding religious precepts, throughout the eighteenth century and in the first decade of the nineteenth century, there were several occasions when requests were made to the ecclesiastical authorities in Santafé to eat meat during Lent due to the shortage of fish caused by the drought (Mora 2019: 89).

A final strategy employed by cities with significant political and economic power, such as Santafé, Quito, and Lima, to address hydrometeorological extremes involved ensuring food and water supply, which inadvertently increased the vulnerability of other populations. In terms of food supply, this strategy included measures against speculators, prohibiting extraction (*sacas*) and sales to other regions, and mandating supply to distant areas. For instance, between 1652 and 1654, when heavy rainfall damaged corn and wheat crops in the Quito jurisdiction and fraud accusations were made against bakeries, authorities pursued speculators and imposed regulated prices for wheat, corn, and bread. Over a century later, in 1775, similar conditions led to the discovery that wheat producers were hoarding their product to sell at inflated prices. Consequently, it was decided to empty the granaries (*trojes*) and sell the grain at prevailing market prices (García 2021: 99, 109).

In response to the water extremes of the 1690s, Santafé and Quito independently implemented similar measures. They both prohibited the extraction and sale of wheat in other locations and established an inventory of wheat produced within their jurisdictions and beyond. Following the practices used during the droughts of 1607 and 1632, the authorities of Santafé inspected the wheat-producing ranches in the Leyva Valley within the province of Tunja and restricted its transport to Caribbean cities such as Cartagena or Maracaibo at the end of the seventeenth century (Mora 2015: 120–124). In Quito, attractive prices were established to prevent wheat from being diverted to other regions. When this approach proved ineffective, all producers, including ecclesiastical figures, were mandated to declare their wheat bushels under the threat of fines. Additionally, production in Cuenca, Riobamba, Latacunga, Otavalo, and Ibarra was closely monitored (García 2021: 101–102). During extreme situations, such as the succession of abundant rains and droughts in 1783 and 1785, or the severe drought and locust plague in 1806–1807, even a city like Pasto, which might have appeared vulnerable in its food control due to its position between Quito and Popayán – centers of greater power – implemented prohibitive measures on flour extraction. These measures included requiring contributions of bread to the local population (Córdoba 2023: 151, 207–208). Regardless of which city imposed these types of restrictions, the regulations were transgressed, and the control mechanisms that prioritized the needs of urban environments that were, in turn, centers of power became manifest.

While Indigenous populations in the sixteenth and seventeenth centuries were also tasked with responsibilities such as maintaining irrigation ditches, significant advancements in water supply management emerged during the eighteenth century. These improvements occurred within an enlightenment and modernizing context marked by the rise of physiocracy – an economic school of thought that considered land and the capacity to exploit it as the source of a nation's wealth. This ideological shift motivated the Bourbons to initiate projects aimed at enhancing agricultural lands through drainage or irrigation systems and improving road infrastructure to facilitate commerce (Alberola 2021). In the case of Santafé, for instance, the regulation of private construction of ditches (*acequias* and *zanjas*) that obstructed roads commenced, and there was a notable increase in the construction of bridges over rivers such as the Bogotá during the late eighteenth century. This development was crucial for facilitating communication between the capital and both the Magdalena Valley and the Caribbean Sea (González 2011). This phase of water management, which began to define the Anthropocene from the Andes, as will be discussed in a subsequent chapter, continued to intensify throughout the nineteenth and twentieth centuries.

Conclusions

In the colonial period, hydrometeorological alterations were not just a matter of perception. The contrast of sources, teleconnections, and evidence from the "natural archive" demonstrate that moments of glacial advance, cold or heat waves, droughts, frosts, and prolonged rains did occur. Many episodes were related to intra-annual climate variability due to oscillations of the ITCZ, or interannual variability due mainly to the occurrence of ENSO. Other phenomena were exacerbated by the global conditions of the Little Ice Age, especially during the Maunder and Dalton sunspot minima and their confluence with large volcanic eruptions that also altered the atmosphere. Although for the period analyzed, Andean societies were not consumers of fossil fuels that would force anthropogenic climate change like the current one, in this Proto-Anthropocene, the modifying capacity of human beings cannot be ruled out, especially due to changes in vegetation cover that in turn modified carbon emissions and captures. This matter should be the subject to further investigation.

Along with drivers of climate variability and change, it is crucial to consider the social conditions that exacerbated hydrometeorological pressures. Thus, the introduction of domesticated animals and crops not only altered ecosystems but also generated new demands for water and a generalized crisis for areas that specialized in wheat or livestock production. Transformations in land ownership, such as the delimitation of communal lands (*resguardos*) for Indigenous people or their extinction at the end of the eighteenth century, reduced the advantage of accessing different altitudinal microclimates or made pre-Hispanic forms of cultivation such as *camellones* untenable. The supply demands for the main cities increased water requirements and the amount of land dedicated to pastures and wheat fields in their surroundings. This shift impacted other subsistence products and made farmers and ranchers vulnerable due to a lack of irrigation and watering holes, or the obligation to deliver their production to these urban centers. In other words, the imposition of supply charges prevented famine in the main cities where power was concentrated but increased the vulnerability of supply areas. Finally, especially from the second half of the eighteenth century onwards, these conditions culminated in the promotion of hydraulic infrastructure, which not only altered the dynamics of the basins as a hallmark of the Proto-Anthropocene but also contributed to the construction of a negative perception of floods and generated other disasters linked to the unsuccessful domestication of water.

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References

Abadía, Carolina. 2021. "Devoción, pestes y tempestades. De la fiesta de los Quince Santos Auxiliadores a las fiestas votadas de la ciudad de Popayán, 1618–1800." In *Estudios sobre historia y clima. Argentina, Colombia, Chile, España, Guatemala, México y Venezuela,* ed. Luis Arrioja and Armando Alberola, 295–327. Zamora: El Colegio de Michoacán.

Alberola, Armando. 2021. "Reformismo hidráulico y extremismo hidrometeorológico en España durante la fase final de la Pequeña Edad de Hielo." In *Estudios sobre historia y clima. Argentina, Colombia, Chile, España, Guatemala, México y Venezuela,* ed. Luis Arrioja and Armando Alberola, 129–166. Zamora: El Colegio de Michoacán – Universidad de Alicante – El Colegio de San Luis – Instituto Mora.

Aldana, Susana. 1996. "¿Ocurrencias del tiempo? Fenómenos naturales y sociedad en el Perú colonial." In *Historia y desastres en América Latina* Vol.1, ed. Virginia García, 167–194. Bogotá: CIESAS – La Red.

Altez, Rogelio. 2022. *A duras penas. Sociedad y naturaleza en Venezuela durante el periodo colonial.* Madrid: Consejo Superior de Investigaciones Científicas.

Arrioja, Luis. 2019. *Bajo el crepúsculo de los insectos. Clima, plagas y trastornos sociales en el reino de Guatemala (1768–1805)*. México City: El Colegio de Michoacán.

Bell, Martha. 2013. "The governance of food technology and environmental resource flows: Connecting mills, water, wheat, and people in colonial Lima, Perú (1535–1700)." PhD diss., The Pennsylvania State University.

Boada, Ana María. 2006. *patrones de asentamiento regional y sistemas de agricultura intensiva en Cota y Suba, Sabana de Bogotá (Colombia).* Bogotá: Fundación de Investigaciones Arqueológicas Nacionales, Banco de la República.

Bradley, Raymond, and Philip Jones. 1995. "Records of explosive volcanic eruptions over the last 500 years." In *Climate since A.D.1500,* ed. Raymond Bradley and Philip Jones, 606–622. London: Routledge.

Carcelén, Carlos. 2009. "Historia del clima y el medio ambiente en Lima y el Perú Central, en el siglo XVIII: problemas de investigación y fuentes históricas." *Revista de Historia de América* 140: 51–94.

Carcelén, Carlos, Miller Molina, and Víctor Medina. 2020. "La crisis agrícola a fines del siglo XVII e inicios del XVIII en Lima y el centro del Perú: Método historiográfico para el conocimiento del cambio climático en los Andes." *ISHRA, Revista del Instituto Seminario de Historia Rural Andina* 5: 7–26.

Castañeda, Juan, and Isaac Trujillo. 2022. "Las lluvias extraordinarias de 1818 a través de la correspondencia del doctrinero de Cajabamba." *Desde el Sur* 14, no. 1: 1–16.

Castaño, Yoer. 2019. *Eslabones del mundo andino. Comercio, mercados y circuitos pecuarios en el Nuevo Reino de Granada y la Audiencia de Quito 1580–1715*. Medellín: EAFIT.

Caviedes, César. 2001. *El Niño in history. Storming through the ages*. Gainesville: University Press of Florida.

Caviedes, César, and Peter Waylen. 1991. "Chapters for a Climatic History of South America." *Beiträge zur Regionalen und Angewandten Klimatologie, Freiburger Geographische Hefte* 32: 149–180.

Chambers, Frank, Sally Brain, Dmitri Mauquoy, et al. 2014. "The 'Little Ice Age' in the Southern Hemisphere in the context of the last 3000 years: Peat-based proxy-climate data from Tierra del Fuego." *The Holocene* 24, no. 12: 1649–1656.

Córdoba, Mario. 2023. "Historia y variabilidad climática en el Altiplano de Pasto (Colombia), ambiente y sociedad de 1780 a 1870." Master's thesis, FLACSO Ecuador.

Crosby, Alfred. 1972. *The Columbian exchange: Biological and cultural consequences of 1492*. Westport: Greenwood Press.

———. 1998. *Imperialismo ecológico: La expansión biológica de Europa, 900–1900*. Barcelona: Crítica.

Duque Gardeazabal, Nicolás. 2023. Personal communication, May 23.

Emile-Geay, Julien. 2008. "Volcanoes and ENSO over the Past Millennium." *Journal of Climate* 21: 3134–3149.

Endfield, Georgina. 2008. *Climate and society in colonial Mexico. A study in vulnerability.* Malden: Blackwell Publishing.

———. 2012. "The resilience and adaptive capacity of social-environmental systems in colonial Mexico." *Proceedings of the National Academy of Sciences* 109, no. 10: 3676–3681.

Feola, Giuseppe, Luis Agudelo, and Berna Contesse. 2015. "Colombian agriculture under multiple exposures: A review and research agenda." *Climate and Development* 7, no. 3: 278–292.

Fischer, Erich, Jürg Luterbacher, Eduardo Zorita, et al. 2007. "European Climate Response to Tropical Volcanic Eruptions over the Last Half Millennium." *Geophysical Research Letters* 34: 1–6.

Florescano, Enrique. 1969. *Precios del Maíz y Crisis Agrícolas en México (1708–1810): Ensayo sobre el Movimiento de los Precios y sus Consecuencias Económicas y Sociales*. México City: El Colegio de México.

Flórez, Antonio. 1990. "La recesión de los glaciares colombianos desde la pequeña edad glaciar." *Colombia Geográfica, revista del Instituto Geográfico Agustín Codazzi* 16, no. 1: 7–16.

García, Adrián. 2021. "Clima y desastre en Quito (Ecuador) durante la Pequeña Edad del Hielo: 1640–1800." In *La Pequeña Edad del Hielo a ambos lados del Atlántico. Episodios climáticos extremos, terremotos, erupciones volcánicas y crisis,* ed. Armando Alberola and Virginia García, 95–114. San Vicente del Raspeig: Universidad de Alicante.

Gergis, Jöelle, and Anthony Fowler. 2009. "A history of ENSO events since A.D. 1525: Implications for future climate change." *Climatic Change* 92: 343–387.

Gil, Raquel, Mariano Morales, and Ricardo Villalba. 2010. "Población y economía en los Andes: Las crisis de subsistencia en Talina entre los siglos XVII y XX." *Surandino Monográfico, segunda sección del prohal monográfico* 1, no. 2: 1–33.

Gioda, Alain, and María del Rosario Prieto. 1999. "Histoire des sécheresses andines. Potosi, El Nino et Le Petit Âge Glaciaire." *La Météorologie* 27: 33–42.

González, Margarita. 1970. *El resguardo en el Nuevo Reino de Granada*. Bogotá: Universidad Nacional de Colombia.

González, Nelson. 2011. *Entre el acceso y la circulación. Agua y gestión de obras públicas en la ciudad de Santafé (1757–1810)*. Bogotá: Universidad de los Andes.

Huertas, Lorenzo. 2001. *Diluvios andinos a través de las fuentes documentales*. Lima: Pontificia Universidad Católica del Perú.

Langebaek, Carl. 1987. *Mercados, poblamiento e integración étnica entre los muiscas. Siglo XVI*. Bogotá: Banco de la República.

———. 2019. *Los Muiscas. La historia milenaria de un pueblo chibcha*. Bogotá: Debate.

Le Roy Ladurie, Emmanuel. 2017. *Historia humana y comparada del clima*. México City: Fondo de Cultura Económica.

Mora, Katherinne. 2015. *Prácticas agropecuarias coloniales y degradación del suelo en el Valle de Saquencipá, Provincia de Tunja, siglos XVI y XVII*. Bogotá: Universidad Nacional de Colombia.

———. 2019. *Entre sequías, heladas e inundaciones. Clima y sociedad en la Sabana de Bogotá, 1690–1870*. Bogotá: Universidad Nacional de Colombia.

———. 2021a. "Clima y religiosidad neogranadina, siglos XVI a XIX." In *Historia de la religión en Colombia, 1510–2021*, ed. José David Cortés, 119–130. Bogotá: Universidad del Rosario.

———. 2021b. "'Y vi un caballo negro y el que lo montaba tenía una balanza en la mano'. Hambrunas en la Nueva Granada, 1690–1820." *Memorias. Revista digital de Historia y Arqueología desde el Caribe colombiano* 45: 62–92.

Mumford, Jeremy. 2012. *Vertical Empire. The General Resettlement of Indians in the Colonial Andes*. Durham: Duke University Press.

Murra, John. 1972. *El control vertical de un máximo de pisos ecológicos en la economía de las sociedades andinas*. Huanuco: Universidad Hermilio Valdizan.

Nevle, Richard, Dennis Bird, William Ruddiman, et al. 2011. "Neotropical Human–Landscape Interactions, Fire, and Atmospheric CO_2 during European Conquest." *The Holocene* 21: 853–864.

Nieto, Margarita, Luisa Cardona, and Catherine Agudelo. 2015. *Análisis de servicios ecosistémicos. Provisión y regulación hídrica*. Vol. 4, *Hojas de ruta. Guías para el estudio socioecológico de la alta montaña en Colombia*. Bogotá: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt.

Pabón, José Daniel, and Germán Torres. 2007. "Impacto socioeconómico de los fenómenos El Niño y La Niña en la Sabana de Bogotá durante el siglo XX." *Cuadernos de Geografía* 16: 81–94.

Parker, Geoffrey. 2013. *Global crisis: War, climate change and catastrophe in the seventeenth century*. New Haven: Yale University Press.

Patiño, Víctor. 1965. *Historia de la actividad agropecuaria en América Equinoccial.* Cali: Imprenta Departamental.

Poveda, Germán, Peter Waylen, and Roger Pulwarty. 2006. "Annual and inter-annual variability of the present climate in northern South America and southern Mesoamerica." *Palaeogeography, Palaeoclimatology, Palaeoecology* 234, no. 1: 3–27.

Prieto, María del Rosario, and Facundo Rojas. 2013. "Climate anomalies and epidemics in South America at the end of the Colonial Period." *Climatic Change* 118: 641–658.

Quispe, Edison. 2013. "Entre la magnitud y la vulnerabilidad. Variaciones climáticas, economía y sociedad: Estudios de caso y de larga data; Arequipa, siglos XVIII y XIX." Paper presented at I Congreso Peruano de Historia Económica, Asociación Peruana de Historia Económica, Huamanga, August 12–14.

———. 2017. "Historia, clima y sociedad: Una aproximación a la historia climática a partir de los desastres en el sur andino; siglos XVI–XIX." Paper presented at International Congress on Climate Change and its Impacts -ICCCI-, Cultural Center of Huaraz, Huaraz, November 29–December 1.

Ruddiman, William. 2003. "The Anthropogenic Greenhouse Era began thousands of years ago." *Climatic Change* 61: 261–293.

——— 2007. "The early anthropogenic hypothesis: Challenges and responses." *Reviews of Geophysics* 45, no. 4: 1–37.

Saito, Akira, and Claudia Rosas, eds. 2017. *Reducciones: La concentración forzada de las poblaciones indígenas en el Virreinato del Perú*. Lima: Pontificia Universidad Católica del Perú.

Saldarriaga, Gregorio. 2012. *Alimentación e identidades en el Nuevo Reino de Granada, siglos XVI y XVII*. Bogotá: Ministerio de Cultura.

Valdez, Francisco, ed. 2006. *Agricultura ancestral camellones y albarradas: contexto social, usos y retos del pasado y del presente: coloquio agricultura prehispánica sistemas basados en el drenaje y en la elevación de los suelos cultivados*. Quito: Editorial Abya Yala.

Velásquez, César. 2005. *Paleoecología de Alta Resolución del Holoceno Tardío en el Páramo de Frontino, Antioquia*. Medellín: Universidad Nacional de Colombia.

Villalba, Ricardo. 1994. "Tree-ring and glacial evidence for the Medieval Warm Epoch and the Little Ice Age in Southern South America." *Climatic Change* 26: 183–197.

Wendt, Helge. 2016. "Epilogue: The Iberian Way into the Anthropocene." In *The Globalization of Knowledge in the Iberian Colonial World,* ed. Helge Wendt, 297–311. Berlin: Edition Open Access.

Wernke, Steven. 2010. "A Reduced Landscape: Toward a Multi-Causal Understanding of Historic Period Agricultural Deintensification in Highland Peru." *Journal of Latin American Geography* 9, no. 3: 51–83.

Climate Change in the Amazon during the Colonial Period

Climate Perceptions as Portents of the Environmental Crisis

Wesley Oliveira Kettle and Carlos Augusto de Castro Bastos

The principal authors who have examined the history of the region known as the Amazon were influenced by intellectual traditions that positioned Europe as a primary reference point. Consequently, these scholars evaluated climate conditions based on European standards. Their accounts consistently described perceptions of heat or cold in relation to prevailing norms on the European continent.

This chapter examines the interplay between climate and society within the colonial Amazon, considering both Portuguese and Spanish regions of the Amazon Valley. For the areas under Spanish colonization, the analysis focuses on the Orinoco River basin – corresponding to the province of Guiana in Venezuela – and the Andean-Amazonian zones spanning the northeastern expanse that includes New Granada, the *Audiencia* of Quito, and the Viceroyalty of Peru. The discussion begins with an overview of European perspectives on the Amazonian climate during the colonial era, addressing first the Portuguese Amazon, followed by the Spanish-controlled Amazonian territories.

Among scholars who have examined the Amazon's history and its relationship with climate, Jaime Cortesão is particularly noteworthy. In the 1950s, Cortesão analyzed Brazilian history by considering factors such as the nature of soil and climate, the interplay between economic activity and geographical features, and the resulting influence of natural laws on a society's economy, constitution, and governance (Cortesão 1950: 152–153 [our translation]). Cortesão recognized the significant insight this perspective offered in understanding historical development.

More recently, in his reflection on the so-called "Myth of the Island of Brazil," Jaime Cortesão incorporates the Amazon to emphasize the distinctions within Brazilian territory. These distinctions encompass "distinct geographical formations and genres of life," including plateaus and plains, dense forests and open fields, livestock and crops, as well as "the climate of the tropics and the temperate zone [that] encounter each other and combine." (Cortesão 1993: 427 [our translation]). Because Cortesão includes questions of climate among these characteristics to help explain the territorial integration of different biomes and the establishment of biogeographical boundaries, we are able to identify climate as a significant dimension in classical historiography. Far from serving as a mere addition, this dimension plays an important role in Cortesão's work.

In addition to identifying the tropical climate as an impediment to the development of economic activities in the Amazon during the colonial period, Jaime Cortesão also associates the climate with religious challenges. He notes that historical sources indicate diseases affecting members of the clergy hindered evangelization efforts due to the "unhealthy climate of their residences" (Cortesão 1984: 342 [our translation]). These observations highlight both historiographical perspectives and the experiences of historical actors during the colonial era.

This type of narrative underscores the significance of geographical foundations and habitat conditions in shaping human populations, aiding our understanding of territorial formation – not as environmental determinants, but as factors deserving attention in historical research (Fonseca Gadelha 2002: 63 [our translation]). In this sense, climate is presented as a definition of boundaries, either from a physiographic perspective or as a factor through which cultural differences might be explained.

This chapter does not suggest that historical actors were concerned with climate issues in ways comparable to current perspectives. Rather, it aims to demonstrate how this topic appears in classical discussions about the colonization of the Amazon.

This passage highlights the colonizers' view of climate as inherently stable, unaffected by factors such as reduced vegetation cover, deforestation, or urban development, even though these changes have contributed significantly to rising temperatures and adversely impacted diverse forms of life over time. Nevertheless, anthropogenic modifications to the forest extend back millennia, preceding European arrival in the Amazon valley. Archaeological research indicates that processes of plant and animal domestication occurred throughout 10,000 to 13,000 years of continuous human presence (Clement et al. 2010) changes that facilitated the development of dense populations linked by intricate migration and exchange networks (Schaan 2008). This process of forest modification accelerated during European colonization between the sixteenth and eighteenth centuries. However, the most profound ecological shifts occurred from the nineteenth century onward, driven by the global expansion of capitalism. These changes in climate, and the resulting shifts in local ecological dynamics, mark the beginning of significant transformations that have negatively affected the Amazon's ecological balance. This phenomenon is known as the Anthropocene – a term used to describe how human activities are driving changes in geological time and the biosphere (Crutzen and Stoermer 2000). The idea of the Anthropocene has gained traction in academia as well as in media discussions of environmental problems, which frequently use the Amazon as a key touchstone in this context.

This chapter acknowledges both the widespread acceptance and the impact of the Anthropocene concept in highlighting the global environmental crisis. However, it is essential to emphasize that not all human groups inhabiting the Amazon during the colonial period contributed to biome degradation. Works such as Jason Moore's (2022) compile significant scholarship that demonstrates economic systems are fundamentally responsible for these considerable environmental impacts. In this way, Moore gives visibility to Indigenous peoples and their actions, which maintained the balance of the forest for many centuries, unlike by contrast, Europeans developed and implemented a system of economic exploitation capable of negatively transforming the Amazon.

In seeking to show how different authors consider climate, Fernand Braudel emphasized its significance for historical research. He believed that it was crucial to examine topics like "understanding the actual climate" and "the relationship between humans and climate" (Braudel 1992: 147 [our translation]). This proposal – to examine "the influence of this 'real' climate on biological man" (Gascón 1992: 147 [our translation]) – aligns with our objective to analyze the actors involved in Amazonian colonization. This analysis extends to the anthropogenic transformation of the landscape and the subsequent climatic alterations that have contributed to the Anthropocene. By framing the colonizing process in this way, the study connects historical social dynamics to the new, scientifically recognized geological epoch defined by human impact on the Earth's systems.

Fernand Braudel references Maximilien Sorre, noting that discussion should center on humanity – both contemporary individuals and those from the past. The historian's perspective broadens the scope of analysis by encouraging consideration of people throughout history who recognized that their interactions with the natural world could yield both positive and negative consequences. Through this lens, it becomes possible to construct a narrative that evokes diverse landscapes and conveys the atmosphere of previous eras, enriched by direct experience and scientific insight. For example, historical or legendary details situated along the banks of the Amazon basin are contextualized as part of the lived experiences of these individuals (Braudel 1992: 147).

This viewpoint enables a deeper understanding of Amazonian history, echoing Fernand Braudel's idea that "history is man and everything else. Everything is history: soil, climate, geological movements." (Braudel 1984: 18–24).

The significance of Emmanuel Le Roy Ladurie's research in climate history is particularly notable for its critique of anthropocentric perspectives commonly found among scholars in the field. According to Ladurie, the environment "is a function of time; it varies, is subject to fluctuations, and is the object of history" (1991: 35). Consequently, the approaches developed in this chapter draw on insights from historians such as Ladurie to inform and strengthen our understanding of climate history.

During the eighteenth century, European perspectives on the Americas often focused on how the local climate might influence both nature and the people living there. Many believed that these environmental conditions contributed to what they viewed as the Americas' "immature" and "inferior" state. Antonello Gerbi's 1955 work is a key reference on this topic. When it came to descriptions of climate, Europeans frequently highlighted the humidity of American lands, portraying the continent as swampy, filled with damp and unhealthy air that encouraged dense vegetation, decay, insect breeding, and outbreaks of disease (Gerbi 1982: 12–17). This climate, in turn, would also result in physical weakness and political inferiority of the continent (Gerbi 1982: 53), supposedly making Native Americans naturally predisposed to slavery (Gerbi 1982: 96). These interpretations did not go unchallenged in their own time, as Gerbi also analyzes.

An examination of climate within the colonial history of the Amazon stands to gain valuable insight from engaging with scholarly works that consider other regions in the Americas. Such research addresses varied scientific and cultural perspectives on the interplay between climate and society during the colonial period. Notable studies include Luis Alberto Arrioja Díaz (2019), as well as Viruell's (2022) analysis of Guatemala, which explores the relationship between climatic disruptions, pest outbreaks, and their ensuing economic impacts. Also significant is the recent scholarship of Carlos Guillermo Carcelén Reluz (2022), which examines political and administrative governance in Lima and the adjacent Serrana region. His work specifically analyzes how climatic fluctuations influenced societal stability and administrative decision-making during the colonial period.

Recent developments in historiographical research have broadened and diversified the range of sources available for examining the relationship between climate and society in the American colonial worlds. This approach includes not only scientific texts specifically focused on measuring and recording climate and climatic phenomena, but also incorporates a varied collection of administrative, economic, and territorial management documents (Valenzuela Olivares & Cabrera Sánchez 2022). Margarita Gascón and César N. Caviedes (2012) analyze historical records from the sixteenth through eighteenth centuries to demonstrate how climate functioned as a primary environmental factor, influencing food production, commerce, and resource-driven conflicts. Within this framework, climatic crises or fluctuations are viewed as catalysts that significantly impact societal structures and elicit varied human responses. This perspective informs the present study of the Ibero-Amazonian region, which utilizes a diverse corpus of Portuguese and Spanish administrative sources to examine how colonial actors interpreted the climate and its role in shaping the development of regional societies.

Although Gascón and Caviedes focus on colonial Chile and Argentina, their work provides a vital methodological template for this study. They construct an analysis that correlates climate and society by prioritizing shared environmental conditions over colonial or national political boundaries. Adopting this borderless approach allows for a more cohesive examination of the South American Amazon, treating it as a singular climatic territory rather than a collection of fragmented administrative zones.

Climate in Eighteenth-Century Accounts of the Portuguese Amazon

The surveyors responsible for marking borders were officials working for the Portuguese Crown who served on demarcation commissions. These commissions undertook expeditions to recognize and define political boundaries. Their activities were guided by diplomatic treaties signed with Spain, such as those agreed upon in Madrid (1750) and Santo Ildefonso (1777). The activities of the surveyors – including not only military officials but also religious and scientific figures – contributed significantly to the accumulation of extensive knowledge regarding the Amazonian region. This body of knowledge was facilitated through interactions and mediation with Indigenous populations (see also Kettle 2015). Among the notable accounts produced by the boundary surveyors who traversed the Amazon basin, the Jesuit priest Ignác Szentmártonyi wrote his description of the Rio Negro titled *Sequente Notitiate de Rio Negro*. Written in Latin, this document – a primary source for the historical understanding of the Indigenous populations inhabiting the Rio Negro during the eighteenth century – addresses the Indigenous nations that lived in the regions along said tributary, striving to present the location of these communities, a strategic aspect within the context of territorial demarcations. According to Robin Wright – who translated the manuscript from Latin into English and subsequently into Portuguese – Szentmártonyi's data was derived from his close associations with the Indigenous individuals and military personnel documented in the text (Szentmártonyi in Wright 2005).

Appointed as an astronomer for the demarcation commission, Szentmártonyi arrived in the state of Pará in 1753. Prior to joining the demarcation expedition led by Governor Mendonça Furtado, he conducted latitude and longitude measurements in the Lower Amazon region. As noted by Carlos Moura (2008), he calculated the distances between Belém, Macapá, and Mariuá. Beyond documenting his direct interactions with the Amazonian environment, Ignácio Szentmártonyi recorded detailed impressions of the climate during his tenure as a surveyor.

In describing his passage along the Orinoco, he noted arriving after "a fortnight with favorable winds and adverse currents" (Szentmártonyi in Wright 2005: 38). His accounts, often expressed with a sense of relief upon reaching a destination, utilize descriptions of wind patterns, precipitation, and fluvial currents to provide a more comprehensive understanding of the Amazonian landscape during the pivotal era of colonial boundary demarcations.

The astronomer's account notes the rains as a defining feature of the region's climate during his exploration of the Black River. Additionally, storms and falling trees frequently disrupted the commissioners, requiring their constant attention to sudden wind shifts that could interrupt or hinder progress – both on land and along the principal rivers and smaller tributaries used as primary transportation routes by the survey teams.

In this context, climate played a pivotal role in their work, facilitating an examination of the significance of indigenous knowledge with respect to climatic conditions that contrast markedly with those familiar to most Europeans.

Another astronomer involved in the survey was Ângelo Brunelli. Originally from Bologna, he became a secular priest before relocating to Grão-Pará. Brunelli made significant contributions by describing the Amazonian environment, notably emphasizing how climate influenced travel and exploration in the region. His book, *Roteiro da viagem do Governador*, is particularly noteworthy as it recounts his journey between Belém do Pará and Mariuá on the Río Negro (Brunelli in Papavero et al. 2010: 504 [our translation]).

Brunelli's account of survey work is written in a somewhat mysterious tone and emphasizes his identity as a scientist experiencing events firsthand. He describes a "quite dark night" and "very wide" waters that caused significant worry for the commissioners involved. Unstable weather conditions made their journey across the river all the more hazardous. As evening fell, Brunelli noted, "It was barely dark, bad weather." The challenging climate troubled these scientists, pushing them to seek shelter from storms among small islands scattered in the river. "Thunder and lightning and rain" signaled the start of a typical rainy December in the Amazon region (Brunelli in Papavero et al. 2010: 509 [our translation]).

The *Roteiro* not only describes the harsh weather – such as blizzards, thunder, heavy rains, and storms – but also highlights the favorable winds that propelled the boats forward, as well as routes "free of any sort of stones" that allowed canoes to glide smoothly along the waterways. It mentions beaches and islands that provided places for rest. Engaging with their surroundings – navigating intricate island networks and waiting out the rain – these engineers, astronomers, surgeons, and other scholars played an active role in colonizing the Amazon. Their contributions extended far beyond the offices and grand halls built by royal architects, challenging the narrow perspective often seen in traditional historical accounts.

Another scholarly work by Brunelli, titled *Sobre o rio Amazonas,* offers an analysis of the region's eighteenth-century climate. Noting that the Amazon River originates in the Andes, Brunelli describes this mountain range as "a conspicuous series of very high peaks" and emphasizes the temperature disparities between these geographically proximate areas. He carefully examines the impact of Andean altitude on the Amazon's climate, highlighting the pronounced variations in temperature and atmospheric conditions observed between the elevated Andean regions and the low-lying Amazon basin:

> The highest peaks of these mountains and their slopes are eternally loaded with perpetual snow. Although these mountains rise almost from the middle of the same torrid zone, the valleys and lower places are filled most of the time with the greatest heat; [...] if one imagines a surface in the air as suspended and almost parallel to the horizon [...] you will see everything above that surface loaded with perpetual snow and ice; meanwhile, below the same surface, with an already milder cold. (Brunelli in Papavero et al. 2010: 524 [our translation])

The passage describes the Andean region adjacent to the Amazon River, emphasizing climatic observations and the unexpected presence of cold conditions, with references to "perpetual snow and ice." In contrast, it notes that certain lower-lying areas experience markedly higher, even warm, temperatures (Brunelli in Papavero et al. 2010: 524 [our translation]). Utilizing terminology like the "torrid zone" evokes a European gaze that stigmatized the Americas as economically stagnant – a condition attributed primarily to high temperatures. This contrast between the Andean highlands and the tropical Amazon illustrates the extent to which subjective climate perceptions influenced the understanding of the environment and its perceived suitability for colonial enterprise (Moura 2020). Shifting focus from the rugged mountainous terrain to the "immense plain" – where the current stabilizes in contrast to the cataract-dense regions of present-day Peru – the author notes that only storms disrupted the voyage with "fear" and "ruin." He observes that such atmospheric disturbances occurred with "frequent regularity, repeatedly destabilizing the river's natural tranquility" (Moura 2020). Brunelli's account also highlights the problems caused by heavy rains, with winds lasting "three or four days," toppling trees and killing animals in jungles. Another consequence of this type of phenomenon was delayed travel and shipwrecks on the rivers of the Amazon (Brunelli in Papavero et al. 2010: 524 [our translation]):

> Thus, there is no safety in boat navigation; those who boldly put themselves into the violence of the storm will be wrecked or even killed first and foremost. These storms, however, which are very rare and occur once or twice a year, usually arrive fearfully without rain and without any rumble from the sky. (Brunelli in Papavero et al. 2010: 528 [our translation])

The excerpt highlights the technological constraints that hindered the commission's ability to analyze climatic dynamics. This underscores an environmental historiography that emphasizes the biological aspect of the subject – viewed as an entity "sensitive to heat and cold, to wind, to drought, to lack of sunlight, to insufficient air pressure, an entity unremittingly occupied with seeking and securing food, and finally constrained to defend himself." (Braudel 1992: 144 [our translation]).

Within this "biological subject" framework, Francisco Mendonça Furtado – then-governor of Grão-Pará – framed the Amazonian climate as a primary determinant of European living conditions and economic viability. In his accounts, temperature is characterized as a significant barrier to be surmounted for the success of Portuguese imperial commerce. The governor observed that the ailments he suffered during the Atlantic crossing persisted upon his arrival; his health continued to decline, a deterioration he attributed to a climate "quite opposite" to his physiological constitution. Nevertheless, he remained committed to his duties, encouraged by reports that other Europeans had successfully adapted to the region's high temperatures (Mendonça Furtado 2005c [1751]: 194). Mendonça Furtado maintained his administrative responsibilities despite persistent physical distress attributed to the tropical heat. He documented a range of symptoms – including nocturnal restlessness, respiratory congestion, and chronic malaise – which contradicted his expectations of a benign and "healthy" climate (Mendonça Furtado 2005b [1751]: 186). Such recorded astonishment highlights how, even by the mid-eighteenth century, the American environment remained a source of profound empirical surprise, with climate serving as a primary site of bodily and colonial friction. Diseases affecting colonial agents were of concern because they prevented the occupation of the Amazon. Azorean settlers in Macapá, for example, requested a surgeon to help them with health problems. In recounting this request, the governor identifies climate changes as the cause of the islanders' illness:

> The climate is extremely warm and irregular, not as healthy as they had told me. As the pores are always open, and suddenly there are great winds, there are unending colds and extreme lethargy, one must have much care to not take advantage of the cool breeze. The nights are often excellent, but it is always a climate completely opposite to our own, and on the equinoctial line. (Mendonça Furtado 2005a [1751]: 165)

Climate emerged as a critical variable in Amazonian colonial strategy, intrinsically linked to the prevalence of disease. The region's erratic thermal fluctuations confounded Europeans accustomed to more predictable seasonal cycles, forcing border surveyors to contend with "infinite colds and numerous stupors." Ultimately, analyzing these climatic perceptions through the dual lenses of political strategy and human biology significantly broadens our historical understanding of the Amazonian colonial project.

The Climate in the Accounts of the Spanish Colonization of the Amazon

Similar to the Portuguese records concerning the Amazon valley, Spanish sources also developed varied interpretations of the climate within their administrative regions of the Amazon, integrating assessments of its variability and influence on colonial societies. These considerations are evident, for instance, in the differing characterizations of the climate along the Orinoco River. Documentation produced by Jesuit missionaries operating throughout the province of Guiana during the seventeenth and eighteenth centuries often emphasized climate as a significant challenge encountered during efforts to convert Indigenous populations. In 1683, Father Gaspar Pöck noted the considerable difficulties associated with religious work "among such barbaric men" in a land where "an unhappy climate and barren sands […] prevail[ed]" that would require much work to turn into a fertile field (Rey Fajardo 2017: 91). In the late seventeenth-century text *Misión del Río Orinoco en el Nuevo Reyno*, the climate was characterized as a primary source of contagion, particularly regarding "fevers brought by exhalations" as river levels receded.

While coastal regions were perceived as "healthy" – where shade and fresh springs mitigated the solar intensity – the interior heat was described as "intolerable." This heat, coupled with severe droughts, reportedly "burned everything" (Rey Fajardo 2017: 101). By the 1690s, Jesuit accounts further emphasized this environmental hostility, noting that the "perpetual heat" and pervasive moisture induced rapid putrefaction, hindering trade by corrupting all food supplies (Rey Fajardo 2017: 217). In 1715, another missionary, Matías de Tapia, underscored how the "sterile climate" of the river hindered food cultivation, creating significant subsistence challenges for the stationed military. This scarcity facilitated desertion, leaving missionaries "helpless" and vulnerable to the perceived "tyranny" of Indigenous Caribbean groups inhabiting the Orinoco delta (Rey Fajardo 2017: 433).

Such environmental hardships were frequently contrasted with the more temperate conditions of neighboring coastal and Caribbean colonies. For instance, Jesuit accounts compared Spanish territories unfavorably with the Dutch colony of Curaçao, which was deemed to possess a more moderate climate "favorable to the complexion of the Dutch" (Rey Fajardo 2017: 165). Within the Jesuit literary corpus of the Orinoco basin, José Gumilla's *El Orinoco Ilustrado y Defendido* (published in the 1740s) warrants particular attention. As a seminal synthesis of missionary activity, the text offers a comprehensive survey of the natural environment, economic prospects, and Indigenous ethnography based on Gumilla's decades of experience in the region. The work functions simultaneously as a scientific treatise and a piece of Jesuit propaganda; furthermore, it serves as a geopolitical defense of Spanish sovereignty over the Orinoco.

This territorial assertion was crucial given the ongoing boundary disputes with neighboring Dutch and Portuguese colonial interests. In the fourth chapter of his work, titled "Clima y temperamento del Orinoco y alguna noticia de sus frutos," José Gumilla analyzes the climatic conditions of the Orinoco and its tributaries. While theorizing on the river's origins – noting its source in the Kingdom of Quito and its course through the equatorial zone – he characterizes the riparian lands as belonging to the "torrid zone." Gumilla describes these regions as subject to "very serious and perpetual heat," creating a sharp environmental contrast with the frigid, high-altitude terrain of the New Kingdom of Granada. It is noteworthy that the author articulates his depiction of the equatorial climate of the Orinoco by referencing both the neighboring Andean regions and the climatic experiences of Europe. This comparative approach serves to contextualize the subject matter for the intended readership. For instance, Gumilla characterizes the summer heat in the Orinoco as "greater than that suffered in July and August in Seville" (Gumilla n.d.: 73–74).

A distinction between hot and cold regions is articulated through discussion of the climatic influences on agricultural production. In cold zones, crops native to hot climates – such as rice, tobacco, cotton, sugarcane, cocoa, sugar, bananas, papayas, pineapples, oranges, lemons, loquats, and sapotes – cannot be cultivated, while fruits like apples or grains like wheat are not found in hot zones. Drawing a parallel with Europe, the Jesuit observer noted that such climatic diversity exists simultaneously within this region, whereas in Europe comparable changes are experienced across different seasons. Gumilla, expressing his surprise, recorded the local custom of referring to rainy periods as "winter" and to times of scarcity as "summer" (Gumilla n.d.: 74–75).

Although Gumilla dedicated a distinct chapter to systematically address his observations on the local climate, he continued to reference this topic throughout his work. For instance, when examining the challenges encountered by Indigenous populations in the missions, the Jesuit noted the significant mortality risk they faced –especially among young children – arising from exposure to extreme environmental conditions such as intense sunlight or heavy rainfall (Gumilla n.d.: 511). Conversely, certain passages of Gumilla's work evaluate the climate through its influence on the physical environment and regional agricultural productivity. Discussing the purported fertility of the Orinoco basin, he highlighted how moisture from Andean runoff fostered forest ecosystems suitable for cacao cultivation. Gumilla reported discovering vast tracts of wild cacao, particularly in the southern Orinoco, arguing that these natural fields were more conducive to plantations than those in the Caracas province. Furthermore, he claimed that Guiana possessed cinnamon trees rivaling the quality of those in the Kingdom of Quito or the renowned cinnamon of Ceylon. According to Gumilla, the local terrain and temperatures also uniquely favored the large-scale production of sugarcane, tobacco, coffee, indigo, and vanilla (Gumilla n.d.: 247–252).

The climatic conditions of the Orinoco basin were considered an important variable in the development and implementation of reformist policies in the region during the latter half of the eighteenth century. This consideration emerged from assessments conducted by Manuel Centurión, who served as governor and general commander of the province of Guiana from 1766 to 1776. Notably, rainfall patterns significantly influenced both administrative and economic interactions within the area, as connections between Santa Fé and Guiana relied on the Meta, Casanare, and Orinoco rivers, followed by overland travel through the plains. However, during the rainy season, extensive flooding of the plains frequently disrupted communication with the capital of the New Kingdom of Grenada (González Del Campo 1984: 60).

Venezuelan colonial authorities prioritized the use of river networks as vital communication corridors, specifically seeking to expand tobacco trade by linking the plains to the Orinoco and Essequibo rivers (Altez 2022: 126). Governor Manuel Centurión identified climatic conditions as a primary obstacle to spatial management and territorial control. This was particularly evident in the difficulties of establishing interior missions, where the "intense tropical climate" facilitated the spread of disease, severely impacting both Indigenous populations and missionary personnel (González Del Campo 1984: 255). Centurión personally attributed his persistent illnesses to the regional climate. Unable to find an effective cure through the limited medical resources available in Guiana, the governor requested a return to Spain, seeking the restorative "airs of Madrid." He subsequently reported that this environmental shift left him "entirely healthy" (González Del Campo 1984: 326–327).

Understanding the nexus between climate and fluvial systems was a strategic necessity for river navigation, as it dictated the efficiency and safety of colonial operations. Documenting the Spanish demarcation commission's journey through the Upper Orinoco in the 1750s, José Solano noted the logistical difficulties faced by vessels traveling from Trinidad to the Guiana garrison in July. He attributed these delays to the seasonal cessation of easterly "general winds" and the onset of heavy rains, which not only hindered progress but also induced widespread illness among the crew (Solano 1909: 262).

This relationship played a crucial role in shaping the timing of economic activities within the region, as well as in influencing interactions between Indigenous peoples and colonial authorities. In his account of the Spaniards' engagement with Indigenous communities in the Upper Orinoco, Solano observed that, prior to the onset of the winter season – characterized by rainfall and rising rivers – the Indigenous peoples planted their crops and secured supplies of game and fish. This practice ensured they could meet their daily needs during the subsequent rainy period when such activities would be impeded. The winter period also made travel difficult, "whereby [the Indigenous people were] occupied themselves with repairing their fortifications and preparing offensive and defensive weapons, or in making nets three rods wide and two long" (Solano 1909: 280–281). In addition, winter was particularly harmful to the health of Indigenous people and soldiers, as the air's moisture easily penetrated homes, which were "huts covered in palms down to the ground," and also corrupting food (Solano 1909: 303).

Hot, humid weather was also a challenge for trade. Because of these conditions and the long travel distances, many local products spoiled quickly, making it difficult to transport them to coastal ports for shipment to Spain. As a result, Governor Manuel Centurión saw trading with nearby European colonies as a more practical option, selling items like "cocoa, sugarcane, coffee, tobacco, indigo, and other commercial fruits." (Solano 1909: 207). Notably, the volume of trade – both licit and illicit – between Guiana and the Dutch and French Caribbean establishments was so significant that its preservation became a strategic priority. Centurión defended these local commercial interests by citing Amazonian climatic conditions, among other factors, thereby reinforcing established trade practices within the region (Izard 1978). Regarding the northeastern Amazon region adjacent to the Andes, European observers linked climatic variations to the proximity of forested areas relative to the Andean Mountain Range, viewing this relationship as indicative of climate change. In his 1789 work, *Historia del Reino de Quito*, Jesuit Juan de Velasco described the eastern provinces – Mocoa and Sucumbíos, Quijos, Macas, Yaguarzongo, and Jaén – located "behind the great eastern range" as comprising partially mountainous lowlands characterized by hot, humid conditions and irregular precipitation. Consequently, he noted that "many of those countries considered healthy were not all healthy."

Conversely, elevated humidity levels would have supported the cultivation and production of various goods, including timber, fruits, gums, resins, balms, cinnamon, vanilla, wax, honey, cocoa, medicinal plants, sugarcane, tobacco, cotton, and rice. Nonetheless, such a climate, in combination with extensive forests, could also pose significant challenges due to the presence of numerous potentially hazardous animals, snakes, and insects (Velasco 1981: 403–404). Discussing the missions and provinces along the Marañón rivers – more distant from the Andean range – Velasco characterized the climate as generally warm, albeit with significant regional variations ranging from extreme heat to moderate conditions in elevated areas. In these sectors, humidity levels were not as excessive as those in the eastern territories of the Audiencia de Quito; instead, they followed a more temperate and "healthier" precipitation pattern conducive to human habitation (Velasco 1981: 458–459). Colonial accounts regarding the impact of climate on health in the Amazon were varied. Velasco considered the region's conditions comparatively healthy, whereas others observed a correlation between climate and disease. Dr. Sebastián José Lopes Ruiz, a physician and botanist, departed from Santa Fé in the New Kingdom of Granada to survey the Caquetá and Putumayo rivers within the Amazonian territories of the viceroyalty. The principal objective of his extensive expedition was to evaluate the economic potential of the forest, with particular emphasis on the commercial viability of cinnamon trees. He characterized the Caquetá and Putumayo regions as possessing a "warm and humid temperament," noting that the soil remained consistently moist due to either dense vegetation preventing sunlight from evaporating moisture or the area experiencing frequent rainfall for approximately eight months each year. He found this climate challenging, considering it conducive to malaria – a disease from which he personally suffered – reporting symptoms such as persistent fatigue, malaise, headache, and warmth each afternoon. These conditions impeded his progress in locating cinnamon trees (López Ruiz 1783).

While engaged in missionary activities among the Maynas near the Marañón River, Jesuit Francisco Xavier Veigl provides a notably positive account that bolstered the optimism of the Ignatian order concerning the prospects of their efforts along the Amazonian edges of Andean America. Veigl observes that, although the majority of this extensive province lies within the "torrid zone" characterized by "inordinate heat" – conditions he notes could render "regions unsuitable for human habitation" – he asserts that, through "miraculous and wise providence," the land has been rendered highly fertile by the creator. According to Veigl, maximizing the potential of this land would require only that it "be [...] cultivated in the same way as in Europe." (Veigl 2006: 97–100). Conversely, Veigel acknowledges the impossibility of cultivating temperate crops in Maynas, attributing this failure to an "entirely adverse climate" rather than soil quality. This environmental constraint fundamentally altered local dietary patterns; as wheat, rye, and barley could not be produced, cassava flour became the primary substitute. The necessity of obtaining wheat flour for the Eucharist required annual shipments from Quito – a logistical feat fraught with difficulty, as even minor delays could lead to total spoilage. Similarly, sacramental wine had to be imported from Quito, requiring meticulous care to prevent it from "turning to vinegar," a common outcome in such extreme tropical heat (Veigel 2006: 158–159).

According to Veigel, wet and dry periods were considered optimal for fruit planting. This typically took place in early June, when rain clouds were dispersed by cool, dry winds originating from the east and south. During this time, temperatures would decrease for three to five days, reportedly causing "people to tremble with cold." For Indigenous communities, this period signified the commencement of summer – a lengthy dry season characterized by the receding waters of rivers and lakes. Additionally, large shoals of fish would enter the Marañón River and its tributaries, creating visible disturbance in the water. This event attracted Indigenous peoples of all ages, who harvested the fish using "the blow of sticks, oars, or any other instrument at their disposal" (Veigel 2006: 158).

According to Veigel, the climate was characterized by the absence of distinct winter, spring, or autumn seasons, with "an eternal summer" prevailing and certain months experiencing more frequent and intense rainfall. Between January and June, widespread flooding occurred across all rivers – a phenomenon referred to locally as "winter," although Veigel notes this term is used inaccurately. In the subsequent summer months, the Marañón River typically receded to its natural level, revealing islands covered in forests and beaches. The region's thermal conditions were defined by consistently high temperatures near the equator and significant moisture from precipitation, lakes, and rivers, though forest cover could mitigate these effects. As Veigel observes, "throughout the territory of Maynas there is usually nothing but water and forests" (Veigel 2006: 97–100).

Although the Marañón River region usually has a steady climate marked by heavy storms during the rainy season, Veigel reports witnessing hail just once – an event that "caused the surprise of the Indians who have never seen such a phenomenon in their lives." Veigel notes how Indigenous communities in Jesuit missions responded to natural phenomena, showing no fear of lightning or thunder; instead, they would shout with joy regardless of the storm's intensity. He suggests this might be because lightning-related deaths were uncommon, likely due to the many trees in the vast jungle serving as natural lightning rods (Veigel 2006: 157). The Franciscan Juan de Santa Gertrudis documented similar responses to the violent storms of the Putumayo River region. While the frequent "thunder, bolts, and lightning" profoundly unsettled the missionary – driving him from his bed in fear – he observed with astonishment that the Indigenous populations remained unfazed. Instead of seeking shelter, they responded to the atmospheric intensity with ritual drumming and dance (Santa Gertrudis 1956: 206).

This contrast serves as a significant indicator of the cultural chasm between European and Indigenous perceptions of, and relationships with, climatic and atmospheric phenomena. Rainfall patterns consistently dictated the rhythm of work and accessibility within the northeastern territories, particularly in the transitional zones between the Andean range and the Amazon basin. In 1777, as plans were formulated to construct a road from Papallacta to the Napo River – a key route intended to link Quito with the Audiencia's Amazonian region – Francisco Requena, a Spanish soldier responsible for mapping the area, emphasized the necessity of commencing operations in September. He advised that activities should proceed continuously, insofar as weather conditions permitted, during periods when rainfall east of the Cordillera subsided. In other months of the year, "[the downpours were] so continuous and heavy that no pauses remain[ed] to be able to work the site." In the initial months of the year, road travel was frequently hindered by fallen trees and swamp formation. Moreover, high humidity rendered gunpowder ineffective, spoiled provisions, and contributed to the proliferation of disease (Costales y Costales 1977: 119–120).

In 1790, Father Narciso Girbal y Barceló's expedition – traveling from the Colegio de Santa Rosa de Ocopa in the Peruvian Andes toward the Amazonian interior – was halted by violent storms and gales that lashed the Marañón River (Sobreviela 1861: 55). Francisco Requena, as previously referenced, played a pivotal role along the Amazonian border during the 1780s and 1790s. In his capacity as colonel, Requena assumed the responsibilities of governor of the province of Maynas and commander of the Spanish demarcation expedition. This expedition operated in collaboration with the Portuguese demarcation commission to delineate the Portuguese-Spanish border in the Amazon region, as stipulated by the Treaty of Santo Ildefonso (1777). Substantial portions of the commissions' work were conducted within Portuguese-American territories, specifically in the captaincy of Río Negro. Requena compiled comprehensive documentation of this era, detailing both the demarcation proceedings and interactions with the Portuguese, as well as offering his observations and analyses regarding the Amazonian environment. With respect to climate adaptation, Requena noted that members of the Portuguese commission demonstrated greater acclimatization to the temperatures typical of the Amazonian region than their Spanish counterparts, who were more familiar with the climates of the coast and the Andes. During reconnaissance activities along the Apaporis River, both Portuguese and Spanish expeditions experienced the impact of an epidemic; however, Spanish personnel suffered more severely, facing higher mortality rates and pronounced debilitation due to fever. Requena attributed this disparity to the Spanish soldiers' origins in Quito, which rendered them less suited to the Amazonian environment compared to the Portuguese, who were predominantly "criollos of these rivers and temperaments, more adapted to the local climate" (Archivo General de la Nación – Colombia 1783).

Historical records concerning the Amazon region underscore the connection between rainfall patterns and river levels. Nonetheless, in certain areas nearer to the Andes, additional factors may have influenced local hydrography. For instance, in Macas province – located in the eastern part of the mountain range and bordering Maynas and the Marañón River – a significant event occurred on February 4, 1797. A powerful earthquake struck that morning, followed by a series of less intense aftershocks in subsequent days. This seismic activity, which devastated the city of Riobamba, also impacted Macas province by altering river levels and causing widespread flooding in the surrounding jungles. Seismic activity resulted in fallen trees and road closures, disrupting the transportation of tobacco, a significant commodity in the regional economy. Subsequently, the Sangay volcano, located within Macas province, erupted. The combined impacts of the earthquake and volcanic eruption prompted members of the Indigenous Jivaroan community to relocate closer to the city of Macas. This migration raised concerns among local residents, given the historical tensions between settlers and the Indigenous nation (Archivo Nacional del Ecuador 1797; see also: Costales y Costales 1977).

Conclusions

The concept of the Anthropocene denotes the significant impact of human activities on the geosphere, marking the onset of a new geological epoch characterized by alterations to Earth's geochemical cycles. This designation references historical industrial revolutions and, more notably, the "Great Acceleration" of the twentieth century, which precipitated a socio-ecological crisis with profound consequences for numerous species. Reflecting on this context, the colonial history of the Amazon illustrates how European civilizational projects and interventions in the natural environment contributed to the emergence of conditions conducive to future socio-environmental instability, effectively serving as an early precursor to the Anthropocene.

This chapter acknowledges that the Amazon is currently a central topic in discussions related to the Anthropocene. Through an environmental historical lens, it examines the concerns of colonizers regarding the region's natural conditions for exploitation. Particular emphasis is given to factors such as climate, precipitation, and the correlation with diseases that presented challenges for colonial activities in the rainforest. By comparing Portuguese and Spanish accounts of the Amazonian climate, the chapter demonstrates how European frameworks influenced these observations, thereby providing important insights into the subject.

The alterations to the landscape brought about by these interventions, as well as the resulting ecological damage, are not documented in historical records in a way that clearly demonstrates the impact of colonial activities. Nevertheless, the significant role of Indigenous peoples in understanding the jungle can be discerned, alongside their resistance to territorial encroachment and the associated environmental consequences.

The initial actions taken by European colonizers, described by Malcom Ferdinand as "colonial habitation," included the practice of "clearing" – the removal of trees for both resource extraction and as a symbol of territorial conquest. These activities contributed to significant environmental degradation and the spread of diseases that impacted Indigenous populations, enslaved Africans, and the colonizers themselves. Such processes set the stage for what is now termed the Anthropocene. The analyses presented in this study indicate that viable alternatives can only be achieved through a fundamental transformation of the prevailing economic system and its associated social inequalities – a phenomenon Ferdinand refers to as the "colonial constitution of the Anthropocene" (Ferdinand 2022: 53–54).

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References

Altez, Rogelio. 2022. A Duras Penas. *Sociedad y naturaleza en Venezuela durante el período colonial*. Madrid: CSIC.

Archivo General de la Nación – Colombia. 1783. “Comunicación de Francisco Requena a Luis de Unzaga y Amezaga, Capitán General de Caracas.” January 16. Ega. ASUNTOS-IMPORTANTES:SAA-I.2, 1, D.11.

Archivo Nacional del Ecuador. 1797. Serie Estancos, caja 19, expediente 20. Macas.

Arrioja Díaz Viruell, Luis Alberto. 2019. *Bajo el Crepúsculo de los Insectos: clima, plagas y trastornos sociales en el reino de Guatemala (1768–1805)*. Zamora: El Colegio de Michoacan/USAC Tricentenaria, Universidad Nacional Autónoma de Honduras.

Braudel, Fernand. 1984. “Une vie pour l’histoire.” *Magazine Literaire* 212: 18–24.

———. 1992. “Há uma geografia do indivíduo biológico?.” In *Escritos sobre a história*, ed. Fernand Braudel, 143–160. São Paulo: Perspectiva.

Carcelén Reluz, Carlos Guillermo. 2022. “Variabilidad climática en el Perú colonial (siglo XVIII): implicaciones culturales y sociales en Lima y su entorno.” PhD diss., Universidad Pablo de Olavide.

Clement, Charles R., Michelly de Cristo-Araújo, Geo Coppens d’Eeckenbrugge, et al. 2010. “Origin and Domesticacion of Native Amazonian Crops.” *Diversity* 2: 72–106.

Cortesão, Jaime Zuzarte. 1950. *Alexandre de Gusmão e o Tratado de Madrid*. Vol. 1. Rio de Janeiro: Ministério das Relações Exteriores.

———. 1984. *Alexandre de Gusmão e o Tratado de Madrid*. Vol. 2. Lisbon: Livros Horizonte.

———. 1993. *História da expansão portuguesa*. Lisbon: Imprensa Nacional – Casa da Moeda.

Costales, Piedad, and Alfredo Costales. 1977. *Relaciones Geográficas de la Presidencia de Quito (1776–1818)*. Quito: Abya-Yala.

———. 1996. *Historia Colonial del Gobierno de Macas 1563–1820*. Quito: Casa de la Cultura Ecuatoriana Benjamín Carrrión.

Crutzen, Paul, and Eugene Stoermer. 2000. “The ‘Anthropocene’.” *Global Change Newsletter* 41: 17–18.

Ferdinand, Malcom. 2022. *Uma ecologia decolonial: pensar a partir do mundo caribenho.* São Paulo: Ubu Editora.

Fonseca Gadelha, Regina Maria A. 2002. “Conquista e ocupação da Amazônia: a fronteira Norte do Brasil.” *Estudos Avançados* 16, no. 45: 63–80.

Gascón, Margarita, and César N. Caviedes. 2012. “Clima y sociedade en Argentina y Chile durante el periodo colonial.” *Anuario Colombiano de Historia Social y de la Cultura* 39, no. 2: 159–185.

Gerbi, Antonello. 1982. *La Disputa del Nuevo Mundo. Historia de una polémica, 1750–1900*. Mexico City: Fondo de Cultura Económica.

González del Campo, María Isabel. 1984. “Manuel Centurión, Gobernador y Comandante General de Guayana.” PhD diss., Universidad Complutense de Madrid.

Gumilla, P. José. n.d. *El Orinoco Ilustrado*. Madrid: M. Aguilar Editor.

Izard, Miguel. 1978. “Contrabandistas, comerciantes e ilustrados.” *Boletín Americanista* 28: 23–86.

Kettle, Wesley Oliveira. 2015. “Ciclopes e Profetas no Vale Amazônico: Visões de natureza no Tempo das Demarcações (1750–1799).” PhD diss., Universidad Federal de Río de Janeiro.

Le Roy Ladurie, Emmanuel. 1991. *Historia del clima desde el Año Mil*. Mexico City: Fondo de Cultura Económica.

López Ruiz, Sebastián José. 1783. *Relación del viage que de la Capital de Santa Fé de Bogotá en el Nuebo Reyno de Granada, hizo a las montañas de los Andaquies, y Misiones de los Rios Caquetá y Putumayo para inspeccionar, y cultivar los arboles de canela silvestre, que hay en aquellas selvas, Dn. Sebastian Josef Lopez Ruiz, en cumplimiento de las Rs. Comisiones que S.M. se dignó poner a su cuidado*. Archivo del Ministerio de las Relaciones Exteriores del Ecuador, Serie Archivos de España. Santa Fe.

Mendonça Furtado, Francisco Xavier de. 2005a. “Carta a Diogo de Mendonça, na qual faz referência à ajuda de custo que lhe fora outorgada, e justificando o atraso da sua chegada a Belém. Pará, 10 de dezembro de 1751.” In *A amazônia na era pombalina: Correspondência do governador e capitão-general do estado do Grão-Pará e Maranhão Francisco Xavier de Mendonça Furtado: 1751–1759*. 2nd ed., Vol. 1, ed. Marcos Carneiro de Mendonça, 165. Brasilia: Senado Federal. Orig. pub. 1751.

Mendonça Furtado, Francisco Xavier de. 2005b [1751]. “4ª Carta a Sebastião José, tratando de assuntos de família, quando faz referência à quinta de Oeiras e à Rua Formosa, hoje Rua do Século, de Lisboa. O assunto Ouvidor Manuel Luis era por ele considerado de suma importância para o prestígio da sua posição à testa do governo. Pará, 22 de dezembro de 1751.” In *A amazônia na era pombalina: Correspondência do governador e capitão-general do estado do Grão-Pará e Maranhão Francisco Xavier de Mendonça Furtado: 1751–1759*. 2nd ed., Vol. 1, ed. Marcos Carneiro de Mendonça, 186. Brasilia: Senado Federal. Orig. pub. 1751.

Mendonça Furtado, Francisco Xavier de. 2005c [1751]. “Carta a Diogo de Mendonça sobre a falta de obediência dos moradores do Estado, que o foram cumprimentar, ao disposto no § 32 das Instruções que lhe foram passadas a 31 de maio de 1751. Pará, 24 de dezembro de 1751.” In *A amazônia na era pombalina: Correspondência do governador e capitão-general do estado do Grão-Pará e Maranhão Francisco Xavier de Mendonça Furtado: 1751–1759*. 2nd ed., Vol. 1, ed. Marcos Carneiro de Mendonça, 194. Brasilia: Senado Federal. Orig. pub. 1751.

Moore, Jason W. 2022. *Antropoceno ou capitaloceno. Natureza, história e a crise do capitalismo, organizado*. São Paulo: Elefante.

Moura, Carlos Francisco. 2008. *Astronomia na Amazônia no século XVIII [Tratado de Madri]: os astrônomos Szentmártonyi e Brunelli – instrumentos astronômicos e livros científicos*. Rio de Janeiro: Real Gabinete Português de Leitura.

Moura, Enrique Rodrigues. 2020. "Francisco Alves de Souza dialoga com o alferes Gonçalo Cordeiro no Rio de Janeiro de fins do século XVIII: Achegas à edição de um testemunho manuscrito de uma congregação católica de africanos Mina." *Romanica Olomucensia* 32, no. 2: 407–414.

Papavero, Nelson, Nelson Sanjad, Abner Chiquieri, et al. 2010. "Os escritos de Giovanni Angelo Brunelli, astrônomo da Comissão Demarcadora de Limites portuguesa (1753–1761), sobre a Amazônia brasileira." *Boletim do Museu Paraense Emílio Goeldi* 5, no. 2: 493–533.

Rey Fajardo, José del. 2017. *Historia y crónica orinoquense*. Vol. 3. Bogotá: Editorial Pontificia Universidad Javeriana.

Santa Gertrudis, Fray Juan de. 1956. *Maravillas de la Naturaleza*. Bogotá: Biblioteca da la Presidencia de Colombia.

Schaan, Denise Pahl. 2008. "A Amazônia em 1491." *Especiaria – Cadernos de Ciências Humanas* 11/12, no. 20/21: 55–82.

Sobreviela, Manuel. 1861. "Peregrinación por el rio Huallaga hasta la laguna de la gran Cocama, hecha por el Padre predicador apostólico Fray Manuel Sobreviela en el año de 1790." In *Biblioteca Peruana de Historia, Ciencias y Literatura. Colección de escritos del anterior y presente siglo. Antiguo Mercurio Peruano*. Vol. 1, ed. Manuel A. Fuentes, 49–66. Lima: Felipe Bailly Editor.

Solano, José. 1909. "Viaje de D. José Solano al alto Orinoco (1756–1760)." In *Relaciones Geográficas de la Gobernación de Venezuela (1767–68)*, ed. Ángel de Altolaguirre y Duvale, 243–288. Madrid: Imprenta del Patronato de Huérfanos de Administración Militar.

Valenzuela Olivares, Luis Andrés, and Gerardo Alonso Cabrera Sánchez. 2022. "Caracterización de fuentes en el estudio climático de América de los siglos XVI–XVII." *Revista de Historia de América* 163: 417–448.

Veigel, Francisco Xavier. 2006. *Noticias Detalladas sobre el Estado de la Provincia de Maynas en América Meridional hasta el año de 1769*. Iquitos: CETA.

Velasco, Juna de. 1981. *Historia del Reino de Quito*. Caracas: Biblioteca Ayacucho.

Wright, Robin Michael. 2005. *História indígena e do indigenismo no Alto Rio Negro*. Campinas/São Paulo: Mercado de Letras/Instituto Socioambiental.

Climate Change in Mesoamerica during the Colonial Period

Climatic Anomalies and Alterations

Luis Alberto Arrioja Díaz Viruell and María Dolores Ramírez Vega

An approach to the history of climate in Mesoamerica during the sixteenth, seventeenth and eighteenth centuries involves going into several evolutionary stages of the Little Ice Age (LIA) and linking with historical hydrometeorological processes, extreme natural phenomena, biological plagues and agricultural crises. It also requires reflection on the dynamism of atmospheric conditions and their implications in an extensive cultural area that geographically encompassed the Captaincy of Guatemala and the viceroyalty of New Spain, and involved numerous ecosystems and productive activities; as if this were not enough, it means delving into what Paul J. Crutzen has called the Anthropocene and – especially – into a series of processes where human groups and environmental conditions are linked, transformed and confronted at every moment (Crutzen 2002). For Mesoamerican societies, climate was fundamental for their subsistence, since a year with "normal" climatic conditions, i.e., stable temperatures, periods of humidity in time and form and absence of natural hazards, meant food availability, provision of cities and towns, price stability and security for households. However, when the weather experienced sudden changes or alterations, reality became difficult and full of limitations.

Today, the LIA is defined as a glaciation that occurred between the years 1300 and 1870, and involved a decrease in temperature – between 1.5 and 2 degrees Celsius –, the development of atmospheric oscillations and the presence of climatic anomalies. In some areas of the world, the LIA generated the growth of glaciers and the formation of ice at low altitudes; in other scenarios, it provoked extremely hot springs and cold summers. Atmospheric changes also occurred, causing declines in rainfall frequencies, increased temperatures, occurrences of droughts and frosts, and the formation of hurricanes and cyclones (Brooke 2014; Eriksdotter 2013). Studies on the LIA in northern and the Mediterranean region of Europe, North Africa, central portion of Asia, Oceania and America, confirm that it was a global phenomenon that altered atmospheric conditions between the thirteenth and nineteenth centuries and demonstrate that, throughout its stage, a series of oscillations occurred that manifested themselves through climatic phenomena (Brázdil et al. 2010; see also Alberola Romá 2014; Eriksdotter 2013; Pfister 2005; Fagan 2009). Christian Pfister and Emmanuel Le Roy Ladurie, for example, state that the peak phase of the LIA began in 1560–1570 and was characterized by a drop in temperatures, the advance of glaciers and a succession of cool, wet summers that disrupted the agricultural and livestock world in a large part of the planet; subsequently, several atmospheric pulses of continental scale occurred – between 1645 and 1720 – characterized by the predominance of long, harsh winters and dry, cold summers. These pulses have been recognized by the specialized historiography as the Maunder Minimum (1645–1715), a period in which there was a decrease in temperatures, a reduction in the flow of solar luminosity, the prolongation of winter climates, the loss of large cultivation and grazing areas in central and western Europe, the freezing of numerous rivers and lakes in the North Atlantic, the relocation of humid areas on the Mediterranean coast, the displacement of wind currents in the South Pacific, the formation of prolonged droughts in America, and the appearance of ice masses on ice caps and glaciers. In addition, it caused the lowest temperatures and the driest and most barren years in America, Africa and Asia in the seventeenth and eighteenth centuries (Pfister 1989; Le Roy Ladurie 2017; Parker 2013).

Other moments of climatic exacerbation occurred during the second half of the eighteenth century: the Maldá Oscillation (1760–1800) and the Dalton Minimum (1790–1830). The Maldá Oscillation – documented and analyzed by Spanish historiography – caused the presence of hydrometeorological events, thermal irregularities, biological plagues and diseases on the Mediterranean coast (Barriendos and Llasat 2003; Barriendos 2005); meanwhile, the Dalton Minimum, studied by British historiography, was distinguished by generating summer droughts, heat waves and recurrent cold spells in a large part of Europe and America (Wagner and Zorita 2005). These climatic variations were at least in part generated by volcanic activity that deposited aerosols in the atmosphere which, over time, obstructed solar radiation, the circulation of cloud strata and the flow of wind currents. The most notable eruptions were Laki (Iceland, 1783) and Tambora (Indonesia, 1815), which caused, among other things, the absence of summers in the American territories (Stevenson et al. 2003).

The history of Mesoamerica between 1521 and 1811 was linked to meteorological episodes and extreme natural phenomena. During this period, droughts were recurrent and combined with the effects of volcanism, biological plagues and epidemic outbreaks. In terms of spatial concurrence, certain areas were more susceptible than others to experience such calamities. The sources reveal that droughts were constant in the Pacific plains and the central Altiplano; in contrast, excess moisture precipitated in multiple forms on the Atlantic coast and the plains of the Gulf of Mexico; locust plagues, meanwhile, were felt most severely in the lowlands, the central lowlands, the Pacific plains and the Yucatan peninsula.

Throughout this chapter we examine the evolution of climate and the development of a series of atmospheric disorders in Mesoamerica during the sixteenth, seventeenth and eighteenth centuries; we also analyze the scope of climatic conditions and ponder elements – social, economic and political – that enhanced their effects, with the aim of verifying their concordance with the great oscillations of the LIA and evidencing the scope and limits of atmospheric conditions. However, we emphasize the experience of individuals, towns, cities and villages, and institutions in New Spain and Guatemala due to the availability and access to primary and secondary sources; likewise, we pay special attention to the second half of the eighteenth century, since this is a period in which the deterioration of climatic conditions and the accumulation of vulnerabilities in the study area can be observed very clearly. It should be noted that the reflections presented in this chapter are based on four referents of the social historiography of climate, in general, and of the LIA, in particular: Emmanuel Le Roy Ladurie, Christian Pfister, Brian Fagan and Armando Alberola Romá.

News about Hydrometeorological Events in the Sixteenth Century

Judging by Emmanuel Le Roy Ladurie, if anything distinguished from the second half of the sixteenth century, it was that climatic conditions over much of the globe progressively deteriorated and experienced sudden drops in temperatures (Le Roy Ladurie 2017: 123–128). In this sense, the experience of the viceroyalty of New Spain and the Captaincy of Guatemala was no exception, since during the period 1550–1600 they suffered cold and dry summers, intense and prolonged winters, and the formation of numerous biological problems as a consequence of the changes in climatic conditions. Focusing on the Captaincy of Guatemala, the records of Friar Francisco Vásquez show three major climatic episodes whose effects generated a series of environmental upheavals and socioeconomic setbacks. The first of these dates back to September 1541, when an unusual four-day storm overflowed the lake located in the crater of the water volcano in the vicinity of the city of Santiago de los Caballeros de Guatemala, causing a flood of mud, trees and stones that devastated the city. As if this were not enough, the landslide was accompanied by volcanic and geological activity that ended up collapsing the ruins of the small town (Vásquez [Vol. 1] 1937: 89–91; Fuentes and Guzman [Vol. 1] 1690: 240). The second episode dates back to 1563 and has to do with the "great drought" that spread throughout the Captaincy and wiped-out corn, wheat and other seed crops, in addition to causing higher food prices, food shortages and outbreaks of epidemic diseases. It is even known that this drought was seconded by a plague of locusts that "bothered this city of Guatemala and its districts, so numerous and so thick that it covered the sun, and that it was so thick that one could hardly see anything but locusts" (Vásquez

[Vol. 1] 1937: 154–155, 226–227; Remesal [Vol. 2] 1932: 239–241). Meanwhile, the third episode occurred in 1592 and is confined to the province of Chiapas, where, after experiencing a drought for more than eight months, a storm occurred that lasted for a week and caused a great flood in the provincial capital of Ciudad Real. A flood that revealed the extent of these hydrometeors and – above all – the drainage problems that existed in the city and its adjoining neighborhoods (Vásquez [Vol. 3] 1937: 206–209). Whatever it was, what is certain is that these extreme episodes of meteorology were – to paraphrase Le Roy Ladurie – a prelude to the LIA's unfolding also in Latin America with varying intensities and events. At the same time, it should be emphasized that the effects of these extreme events in the above-mentioned cities were early manifestations of the genealogy of the Anthropocene, in the sense that these urban centers accumulated vulnerabilities in their process of formation and growth and were exposed to numerous risks, such as volcanic eruptions, flooding of water currents, landslides, as well as irreversible damage to ecosystems.

In New Spain, in contrast, the climatic horizon was integrated by extreme and rigorous phenomena. Sixteenth century sources reveal that – year after year – intense frosts and continuous rainfall were detrimental to agricultural production, as well as droughts and insect infestations. Such phenomena triggered environmental, economic and social problems. Among such anomalies, the droughts of 1543, 1544 and 1576 caused disturbances in agricultural production, lack of grains, increased food prices and, in some way, provoked deadly epidemics (Malvido 1982: 171–172). A recent study suggests that the droughts of 1544 and 1576 resulted in a reduction in water and food resources, an increase in the rodent population and thus the spread of viral diseases among the human population, as was the case with the two Cocoliztli epidemics of the sixteenth century (Acuña-Soto et al. 2002). Cocoliztli (from the Nahuatl word for sickness or pestilence) was a type of viral hemorrhagic fever that affected the Indigenous peoples of Mesoamerica and decimated their population during the sixteenth century, following the arrival of the colonizers. Later, in the biennium 1590–1591, the rains were so recurrent that they had the capacity to flood the fields in the center and south of the viceroyalty, and to cause floods and inundations in numerous towns, villages and cities (García Acosta et al. 2003). The parallelism that can be seen in the chronology of the anomalies recorded in both areas highlights the complexity and strength of the climatic phenomena during the LIA.

The Seventeenth Century and the Droughts of the Period 1660–1710

An exhaustive review of specialized studies on the history of climate in New Spain and Guatemala reveals that the second half of the seventeenth century was especially calamitous due to the number and intensity of hydrometeorological events that occurred in both geographies. An account of events in the Captaincy of Guatemala reveals that temperatures and humidity cycles were permanently altered between 1660 and 1710. It should be noted that these alterations materialized in the form of droughts, low temperatures and the formation of biological pests. Proof of these processes dates from 1661–1663, a period in which the "ordinary and regular times of winter (rain) failed" and – thus – crops failed, giving way to a cycle of severe drought. The above was noted in Fuentes y Guzmán's *Recordación florida* where it is recorded that – during these three years – the most devout members of female religious orders that existed throughout the Captaincy left their convents to remedy with processions, prayers and supplications the effects that the lands and crops of the towns were suffering (Fuentes y Guzmán [Vol. 1] 1690: 240–241). It should be noted that the effects of this drought worsened with the appearance of a locust plague that devastated the fields of the provinces of Nicaragua, Comayagua, San Salvador, Guatemala and Chiapas; a plague that, in the words of Fuentes y Guzmán, "being so numerous […] the Indians killed it with sticks and stones in great quantities, without the need of nets or other instruments. They have this appearance and coming as an omen and demonstration of hunger" (Fuentes and Guzmán [Vol. 2] 1690: 141). As if this were not enough, the Dominican friar Francisco Ximénez warned that the effects of the drought and the plague provoked many *rogativas* (rogations) and processions to placate the "divine wrath," and even some parish priests did not hesitate to conjure against the insects with the intention of containing the misfortune (Ximénez [Vol. 2] 1930: 330–331).

As the seventeenth century dawned, droughts occurred more frequently in the Captaincy of Guatemala, as occurred in 1674, 1677–1678, 1686–1687 and 1694. The effects of these phenomena were so notorious that a good part of the valleys surrounding the cities of Santiago de los Caballeros, Ciudad Real, San Salvador and León in Nicaragua experienced irreversible damage to their agricultural production. In fact, these events were immediately felt in urban markets, a situation for which the municipalities did not hesitate to state that they were facing "adverse situations," since these "droughts" had demonstrated throughout history their capacity to generate convulsive times, whether due to the rigors of hunger, migrations or the deaths they caused. As far as can be observed, these events led to a decline in agricultural and livestock activities and, consequently, in everything that revolved around them. Thus, it was not surprising that the civil authorities in their correspondence revealed a reality marked by the loss of crops and animals, the shortage and increase in price of seeds, the illness and death of natives, the abandonment and relocation of towns, and the ruin of the public coffers. Regarding the latter, the requests of several Indian towns to postpone the payment of tribute, condone absent and dead natives, and absolve debts contracted with certain corporations to face misfortune stand out (Lutz 1982; Wortman 1982; Claxton 1986).

Everything seems to indicate that the climatic conditions that occurred in the Captaincy of Guatemala between 1699 and 1705 helped to compensate for the damages caused in the agricultural fields by droughts, floods and locust plagues. Judging from reports from the Guatemalan tithes, there was a drop in average temperatures, which in turn was accompanied by relatively normal humidity cycles. The situation was so evident that the Royal Court even stipulated that, as of 1706, the collection and liquidation of tithes should return to normal in all the districts of the Captaincy. A panoramic review of the General Archive of Central America shows that it was not until well into the eighteenth century when the climatic pulses returned to precipitate on the Guatemalan countryside and to the detriment of its population.

The New Spain of the seventeenth century was not exempt from climatic disturbances either. Despite the problem of the scarcity of sources reported in this century, it seems evident that droughts and floods were the most recurrent phenomena. In the light of the existing documents, a chaotic beginning for the Valley of Mexico can be observed due to the floods registered between 1601 and 1609, which caused serious damage to the architecture, the roads, the mills and the cultivated fields. It was during the seventeenth century when the largest number of floods in the history of Mexico City and its surroundings were recorded, the most remembered being that of 1628–1632, known as "the great flood." In the following decades, a series of climatic anomalies materialized in the form of frosts, torrential rains and droughts, of which the drought of 1624 stands out because it affected a large part of the viceroyalty due to the lack of grains, food shortages, the spread of diseases and social unrest (García Acosta et al. 2003; Malvido 1982). However, an analysis of the documentation corresponding to the seventeenth century reveals that between 1640 and 1690, droughts, hot seasons, epidemic outbreaks and insect plagues increased significantly. The increase of these phenomena, as well as their level of intensity, was not a product of chance, since they are framed within the period known as the Maunder Minimum. It is even known that the drought of 1692 unleashed one of the most violent social disturbances ever recorded in the capital of the viceroyalty, to the extent that the revolts ended with a great fire in the city and its public buildings (García Acosta et al. 2003: 205–210). In addition to these phenomena that demonstrated the complexity of the climate, there were also other events that had a negative impact on meteorological conditions, such as volcanic eruptions. The first occurred in 1664, when the volcano of San Martín (Veracruz) "vomited flames and sand" and forced the inhabitants of San Andrés Tuxtla to abandon their town. The second occurred in 1665, when the Popocatépetl volcano, accompanied by tremors, for four days "emitted a lot of smoke, then turned into fire and finally returned to give off very thick and abundant black smoke," causing serious damage to the foliage, as well as to the corn fields that ended up burned due to the heat of the ashes (García Acosta et al. 2003: 193), Finally, we must mention that the effects of all kinds of climatic, meteorological or geological events in an agricultural society, whose subsistence depended exclusively on climatic stability, disrupted the agrarian, social, political and economic structures of all human groups, especially the most vulnerable, who fell ill due to deficient caloric intake, incurred tax debts with the Royal Treasury and were forced to abandon their villages. Members of the better-off social groups did not experience hunger, but the negative impact of hard times was reflected in their finances.

But what was the human responsibility for these hydrometeors to claim so many victims? In the best tradition of the Anthropocene, the human actions that contributed to the extreme levels of these phenomena were closely linked to the great processes of deforestation and alteration of ecosystems in New Spain and Guatemala during the sixteenth and seventeenth centuries, as well as to the development of agricultural practices based on clearing, burning and long periods of recovery of vegetation cover; practices that in themselves were incapable of reversing the damage caused by meteorology and biological pests.

The Climate Aggravation of the Eighteenth Century

It is true that throughout the eighteenth century the inhabitants of the Captaincy of Guatemala and New Spain experienced different natural phenomena of great intensity; however, it was during the second part of that century when the conditions worsened (Florescano 1995: 46), so that during the period 1769–1811 both territories experienced the effects of numerous climatic oscillations. At that time, the climate and environmental conditions were distinguished by their instability and – especially – by the scarcity of humidity and the formation of biological pests. The documentation reveals a great variety of climatic events of limited temporal scale –weeks or months – but with sufficient intensity to cause shortages, famine, hunger, disease and death. Within this chronological horizon, three major droughts of the eighteenth century have been identified which, due to their impact and scope, are discussed in greater detail: the great drought of 1768–1773, which affected from the north of Costa Rica to the southeast of New Spain and was accompanied by summer heat and locust plagues that combined with numerous social, economic and political problems. The drought of 1785–1786 that provoked one of the best-known agricultural crises of the century – in the case of New Spain. Finally, the droughts of 1796–1797 and 1809–1811.

The Great Drought of 1768–1773

To speak of the great drought of 1768–1773 implies referring to a meteorological phenomenon that had the capacity to occur – with different intensities and times – throughout Mesoamerica and where climatic alterations and extreme natural phenomena predominated. In fact, its dimensions were so remarkable that they did not escape the reflections and comments of some witnesses of the time. For example, José Antonio de Alzate y Ramírez referred in the *Gacetas de literatura de México* that:

> since the earthquakes of 1768, which were felt here and continued in 1776, this country is no longer New Spain, the one that Cortés conquered; there is no year that looks like another; frosts out of season; dryness in the atmosphere, abundant rains in certain territories, and at the same time scarce in others: this is the dangerous result that the inhabitants of New Spain suffer […]. The year [1769] has been very strange, with respect to what is experienced here; in the months of November and December, the corresponding cooling has not been experienced, and in [these months] there has been an abundance of those flowers, which are only proper to spring: the trees have flourished in these months, and although this is not very rare in one or the other; but it is in the abundance that has been seen: the seeds have been scarce, principally those of Castile: the wheat of everybody knows that it was *achahuiztló*: the rains were in the times that do not correspond, and were lacking in the most necessary. (Alzate 1831: 280–281)

Some judges of the Royal Court of Mexico – such as Joaquín Benito de Medina y Torres – indicated that between 1769 and 1776 "the summer was too dry; the summer was unseasonably cold; the autumn excessively humid; and the winter was extremely unstable. This invention of temper led to almost total sterility in the fields, the death of livestock and the almost absolute loss of seeds" (Archivo General de Indias [AGI] 1777).

Similar opinions were developed and disseminated in the Captaincy of Guatemala, since the years 1768–1769 were considered a "catastrophic period" since the drought caused hunger and disease in many Indian villages, as revealed by the president of the Royal Court in 1769:

> Although most of the towns of this province (which, strained and sterilized by the droughts and plagues they have suffered and the delays they have experienced, either by the many deaths, or by the large number of absentees, and indeed by how heavily taxed they were […] last year of 1768) were surely unable to pay their taxes until today, without a growing failure […] and without having been able to give covered justifications. (Archivo General de Centroamérica [AGCA] 1769)

In Chiapas, Bishop Juan Manuel García de Vargas de Rivera (1769–1774) issued two cordilleras between 1769 and 1770 to promote agriculture among his parishioners, relieve their needs and contain food shortages; He also instructed his parish priests to draw up population counts, register the ravages of drought and apply contentious measures (Archivo General de Centroamérica [AGCA] 1769–1770; Archivo Histórico Diocesano de San Cristóbal de Las Casas [AHDSC] 1770–1771a; AHDSC 1770–1771b). In Guatemala, Archbishop Pedro Cortés y Larraz (1767–1779) insisted on attending to parish emergencies and learning about the consequences of the drought on the tithe accounts indicated by the reports of his pastoral visit. For example, the notes from the parishes of Santa Ana Malacatan indicated that the "harvests were reduced to maize, with a great deal of scarcity. [...] and still barely enough for sustenance." In the meantime, the descriptions of the Huehuetenango parish warned that "in the towns of this parish there are very few people, because with the scarcity of harvests, many go to the provinces of San Antonio and Tabasco [in New Spain] to look for a living." The books of the Cofradía de Nuestra Señora del Carmen de la Ermita (province of Sacatepequez) reveal in their accounts of livestock a progressive decrease between 1769 and 1770 "due to the death of many of these cattle because of the scarcity of water during the winter" (Archivo Histórico Arquidiocesano de Guatemala [AHAG] n.d.; see also Cortés and Larraz 2001: 367–378, 409–410).

These stories show the extent of the drought and its effects on towns and cities. Despite the fact that these episodes lasted for several years, specialized historiography has paid little attention to them. Perhaps the exception is the research of Enrique Florescano and Virginia García Acosta, who noted the effects of these climatic anomalies in the central region of New Spain and their preponderant role in the agricultural crisis of the 1771–1772 biennium. The categorization as a "minor agricultural crisis" was a major factor in generalizing the scope of the drought in Mesoamerica and has recently led several scholars to analyze its effects in Yucatan, Campeche, Tabasco, Oaxaca, Chiapas, Guatemala and San Salvador (see García Acosta, Molina del Villar, and Pérez Zevallos 2003; García Acosta 1988; for the case of Chiapas, see Obara Saeki and Viqueira 2017). (see García Acosta, Molina del Villar and Pérez Zevallos 2003; García Acosta 1988; for the case of Chiapas, see Obara Saeki and Viqueira 2017; for Guatemala and San Salvador see Arrioja Díaz-Viruell 2019; González Alzate 2015).

The effects of this severe drought were exacerbated by high temperatures, whirlwinds, locust and rodent infestations, the drying up of aquifers, epizootics and the devastation of crops. In some regions of Chiapas, Yucatan, Guatemala, Honduras and Nicaragua, these scenes were accompanied by cycles of hunger, disease and death. In Yucatan, for example, nearly 70,000 deaths were recorded (Campos Goenaga 2001; Peniche Moreno 2010). In Chiapas and Guatemala, several towns experienced – in only three years – a considerable reduction in their tax registration, such is the case of San Juan Chamula, San Andrés Ixtacolcot, Santa María Tolotepeque, Santiago Huistan, San Miguel Pinula, San Andrés Yagaguita, San Francisco de Moyos, Chiquimula and Chicumuselo where "many who have died of hunger and plague, or because they have been absent due to the many miseries they have suffered." In fact, the authorities of these towns refused to pursue the absent tributaries because they lacked the resources to search for them and, above all, the food to sustain them at the time of their repatriation. Both Spanish and indigenous authorities agreed that this panorama was the result of the "great drought that has come since

1769 until today [...], and which has caused much hunger, illness and poverty [...], to the extent that the towns have neither utensils nor beasts since they have sold all their belongings" (AGCA 1772; AHDSC 1770).

It should be noted that these atmospheric conditions were explained by the climatic oscillations of the LIA and a series of regional factors that aggravated the effects of the climate. Proof of this was the soil management in some regions of Mesoamerica, where land clearing practices and poor crop rotation changed food chains and exposed green areas to the proliferation of locust pests, the origin of which was climatic alterations. In this regard, it is known that one of the factors that made the spread of these pests possible was the scarcity of rain and the increase in temperature during the period 1768–1773; these phenomena disrupted the endocrine system of the insects, favored their reproductive periods, allowed them to accumulate thermal energy (thermotropism and phototropism), abandon their isolated and inoffensive state, and reach longer reproductive cycles. There was also another less visible and less documented fact that contributed to the gestation of these pests: human displacement and, therefore, the vacating of land due to droughts, eruptions, extreme rains or epidemics; therefore, many agricultural and livestock lands became wastelands and, over time, served as receptacles for the reproduction and propagation of the acridids. This gave way for the insect population to increase and reach its gregarious condition. This experience was common in northern Costa Rica, the provinces of Nicaragua, western and central San Salvador, the coastal plain and highlands of Guatemala, the central depression of Chiapas and the Yucatan peninsula (Arrioja 2019: 115–189; Retana 2000: 76–77).

Other Mesoamerican regions such as Veracruz, Oaxaca, Tabasco, Campeche and Yucatán also felt the severity of this great drought, which increased with the arrival of locust swarms that took over the evergreen swampy and jungle areas (West, Psuty, and Thom 1987: 21; Ruz Abreu 2005; Nancy Farriss 1992). A dramatic situation occurred in Yucatan, where drought and famine led the population to consume horses, donkeys and dogs, and even encouraged infanticide, since

> in addition to the fact that many infants had disappeared and relics of them were found in various stews, on which proceedings were followed, there were mothers who, in order to free their lives and those of their children, ate one of them, without having been able to free themselves from the havoc, even with such extraordinary and cruel diligences, more than sixty thousand people, according to a prudential calculation, died of necessity. (AGI 1770)

Church sources reveal that the Church deployed a number of spiritual and material resources to combat the drought between 1770 and 1772. Parishioners, religious hierarchs and political authorities participated in the rogations that were encouraged by the cathedral councils, requested by the political authorities and materialized through solemn masses, sermons, public processions and novenaries, to implore divine help, rainfall, crop prosperity and the extinction of hunger. From the providential perspective, "to turn to God in great needs, to invoke his help in the midst of tribulation, to put our trust in his omnipotence and to beg him to look with mercy on our misfortunes, is prescribed by religion, commanded by morality and demanded by the character of Christians" (Fortea 1809: f. 3). For this reason, in 1770, the city council of Guatemala asked Archbishop Cortés y Larraz for a public rogation *for rain* – with the intercession of Our Lady of Help – for the provinces affected by the drought (AGCA 1770; AHDSC 1770–1771c). In Yucatan, these liturgical resources were also implemented. Some epistles indicate that several rogations were held, some subsidized by the governor himself, although the most remembered was the one called by Bishop Antonio Alcalde in 1769 to promote rains and extinguish the locust plague (AGI 1770: f. 3018).

These rogations were accompanied by other religious resources such as *novenarias* (a Catholic practice of a set of prayers that is repeated for nine days, usually directed towards God or Virgin Mary) and sermons, to make the parishioners aware of the divine burden of natural phenomena, but also to find in providentialism the causes and remedies for such threats. Hence, these resources urged individuals to "acknowledge sins, confess crimes, ask for mercy and trust in obtaining it. These were the objectives of the supplications and sermons: to appeal for clemency and hope that God's wrath would be appeased. God's justice frightens us, his mercy encourages us." (Iwasaki 2018: 98–99).

Droughts, Frosts and Famine: 1785–1789

In the decade 1780–1789, climatic conditions in Mesoamerica were a little more benign with 4 droughts, as opposed to 1770–1779 which doubled the number with 9 (Florescano 1995: 46); which did not mean that the aftermath was any less stark. The effects of the aerosols released by the eruption of the Laki volcano (Iceland) in 1783 were visible in several Mesoamerican areas since 1784 and – above all – were accompanied by a series of adverse meteorological conditions: cold summers, intense frosts and scarce rainfall (García Acosta et al. 2003). Undoubtedly, the effects of this eruption are also related to the extemporaneous droughts and frosts that occurred between 1785 and 1786, which gave way to one of the best-known agricultural crises of the eighteenth century and which has filled several pages of Mexican and Central American historiography. News from the Archivo General de la Nación de México and the Archivo General de Centro América reveal the ravages caused by frost and lack of humidity in the New Spain provinces of Nueva Galicia, Zacatecas, Durango, Guanajuato, Michoacán, México, Puebla and Veracruz (Florescano 1981); Likewise, in the Guatemalan provinces of Chiapas, Totonicapan, Quetzaltenango, Chimaltenango, Escuintla and Zacapa (Arrioja 2019).

In the case of New Spain, Luis Chávez Orozco and Enrique Florescano were the first to explore the consequences of these extreme phenomena (Chávez 1953; Florescano 1969), so that the agricultural crisis of the years 1785–1786 became, *par excellence*, the topic of study for regional economic, agrarian, political, fiscal, etc. research (see also Florescano 1971; Florescano 1981; Florescano 1995; Florescano, Sacho y Cervera, and Pérez-Gavilán 1987; Valle Barbosa et al. 2000; Carbajal López 2010; Talavera Ibarra 2015; Espinosa Cortés 2016; Cahuich Campos 2012; Argumaniz Tello 2013). A detailed review of the effects of droughts and frosts in New Spain shows a horizon where seed shortages, higher food prices, lack of pasture and fodder for animals, the destruction of agricultural areas, human displacement in search of food, the increase of poor and beggars in the cities, the cessation of work in mines and haciendas, and the multiplication of riots and robberies were common.

In contrast, in the Captaincy of Guatemala these meteorological problems occurred between 1785 and 1788, and were most evident in the wheat and corn producing areas of Quetzaltenango, Sacatepequez and Chimaltenango and in the provinces of Cartago, Alajuela and San José of the governorate of Costa Rica. The aftermath of these disturbances led to grain shortages, food shortages, deterioration of agricultural markets and the proliferation of diseases among the population. Faced with these setbacks, the Guatemalan authorities did not hesitate to promote measures and palliatives to contain the misfortune, instruct the population to promote crops, prohibit the hoarding and monopoly of seeds, regulate sales prices, prosecute usury and greed, and contain food shortages in cities and towns. The situation was so extreme that the Guatemalan church allowed its parishioners to consume animal protein during Holy Week of 1786, while the authorities of the Royal Audiencia exempted several towns affected by the frosts from the annual payment of taxes (AGCA 1785a; AGCA 1785b; AGCA 1786; ANCR 1786). The New Spain clergy, for their part, deployed similar measures: they condemned the hoarding of grains from the pulpit; they authorized the consumption of meat in 1785 and 1786; they promoted – together with the civil councils – the construction of public works in cities such as Guadalajara and Mexico City to avoid begging and public disorder (Florescano 1981).

The core of these problems were the droughts and frosts that impacted Mesoamerica, although with greater intensity in the temperate and cold lands that were dedicated to the cultivation of corn and wheat. The situation was so complex that many towns in the provinces of Mexico, Puebla, Michoacán, Nueva Galicia and Guanajuato were left without food. Probably the only regions that escaped these threats were the north and northwest, the plains of the Gulf of Mexico and the Yucatan Peninsula. However, they suffered from the measures adopted to alleviate the crisis in the viceroyalty; they were forced to save their seeds and move them to the most affected areas (see also Chávez Orozco 1953; Pastor 1981; Arrioja Díaz-Viruell 2013; Campos Goenaga 2011; Endfield 2004).

These droughts also broke trophic chains, so predatory animals proliferated and species that served as a barrier against biological threats succumbed. As a result, agricultural fields in the province of Guanajuato suffered from the exponential reproduction of rodents and worms that ruined the vegetation cover. Something very similar happened with the herds of small cattle in the province of Mexico, where a good part of them were attacked by ticks *(Riphicephalus microplus*) and infected with *babesiosis*, which caused a great mortality and serious problems in the meat supply. In addition, the scarcity of rainfall restricted the multiplication of fruits, plants, roots and tubers that complemented the diet of the population (Florescano 1969: 149–152; see also García Torres 2017; Garza Merodio 2017).

The drought was followed by frosts and with them came numerous diseases which, in turn, led to epidemic outbreaks. Regarding the latter, we would like to point out that a good part of these climatic alterations helped a series of bacteria and microorganisms to proliferate in spaces where they did not have an environment conducive to their reproduction in the past. Given this, it was no coincidence that after the passage of droughts and frosts a series of diseases emerged among populations that –by force of circumstance– were poorly nourished and lacked defenses (Behringer 2010: 96–97). The consequence of this was the death of around 500,000 people throughout the viceroyalty of New Spain; meanwhile, in the Captaincy of Guatemala we are still awaiting an investigation to expose the human devastation caused by this two-year period of drought, frost and disease. David J. Robinson has pointed out that death by disease was the first demographic variable of the referred crisis, but it was not the only one. It is known that the aftermath of these climatic pulses also caused many marriages to be postponed, birth rates to fall, many potential mothers and fathers to die and – above all – thousands of children to disappear from the age pyramids (Robinson 2005).

Another horizon that testified to this extreme climatic situation had to do with the agricultural structure that existed in much of the territory of New Spain and with the exacerbation of the economic differences of the colonial system. A system where most of the population had access to farmland with very limited agricultural capacities, with very traditional crop options (corn, beans, squash and chili) and which was dependent on stable weather conditions; It was also a system that allowed a small group of landowners and ranchers – creoles and peninsular Spaniards alike – to control a large part of the agricultural production, to encourage extensive monocultures, promote monopolistic schemes and lack the necessary strategies to face sudden and abrupt changes in climatic conditions. Indeed, these natural threats revealed many of the weaknesses of the colonial system and the predominant agricultural structure in Mesoamerica.

In short, we can say that this great drought manifested itself in many ways: abandonment and disappearance of towns, hunger, disease, mortality, famine, scarcity and outbreaks of discontent among the population. These situations were impossible to alleviate by the authorities in office, since, year after year (1768–1773), the shortage of moisture prevented the reactivation of agriculture and, therefore, of the economy.

The Droughts of 1796-1797 and 1809-1811

In the last decade of the eighteenth century and the first decade of the nineteenth century, a series of atmospheric disturbances continued to occur in the Mesoamerican region. In New Spain and Guatemala, droughts continued to be the dominant note and thus the main cause that ruined fields, collapsed economies, encouraged usury and food hoarding, and caused the death of people and animals.

In the case of New Spain, the lack of precipitation was present in 1796–1797 and 1809–1811. It is worth remembering that in the rural areas of the viceroyalty there were neither granaries nor grain stores to protect grains and resist bad weather, much less authorities – civil or religious – to render the effects of a drought or any other extreme climatic phenomenon less impactful (Florescano 1969: 144–146).

Regarding the drought of 1796–1797, existing sources reveal that the main area affected was the southeast of New Spain and – specifically – the provinces of Oaxaca, Veracruz, Tabasco and Yucatán; areas with rugged geographies, predominantly indigenous populations and agricultural activities oriented to subsistence and production of vegetable fibers and natural dyes. In addition to the agricultural devastation, the drought served as a prelude to activate – once again – the endocrine system of millions of acridids that, after several months, grouped together, left behind their inert condition and formed one of the most devastating plagues that impacted the viceroyalty. Thus, after the problems in agriculture came the setbacks of a plague that remained active until 1806. The stories are crude, dramatic and pessimistic, as the chain of droughts and plagues caused numerous problems. In some Yucatecan and Oaxacan towns these events transcended time and were captured in written memory under premises of fear, desolation and disease (Arrioja Díaz-Viruell 2012; Arrioja Díaz-Viruell 2019; see also O'Hara and Metcalfe 1994).

As for the experience in the Captaincy of Guatemala, the sources indicate that this drought was as extreme as the one that occurred twenty years earlier, but with the peculiarity that the impacted area stretched from Nicoya (Costa Rica) to Ciudad Real (Chiapas) (Guevara-Murua 2018). The first symptoms of the "water shortage" became evident between July and October 1796, when the political authorities of Costa Rica and Nicaragua reported the ruin of numerous corn, rice, indigo and cocoa crops, and the detection of famine and outbreaks of disease in the provinces of Granada, León and Cartago (Gazeta de Guatemala 1797; Archivo Nacional de Costa Rica [ANCR] 1797). Reports revealed that the drought had spread to other provinces of the Captaincy, and, in only ten months, its effects were felt as far as the highlands of Guatemala. In response to these events, the councilors of the town council of Guatemala located the provinces that had corn and wheat in order to undertake a program of collection and redistribution of grains in cities, towns and villages that lacked them. In addition, they asked the cathedral chapter for rogations in honor of the Virgin of La Merced due to the "notable shortage of water and the great harm that comes to the public with the sowing of grains for the supply" and called for a general collection to raise funds to pay for processions, masses and rogations to the image of Our Lady of the Rosary of Santa Cruz to alleviate the drought (AGCA 1796a; AGCA 1796b; AGCA 1797).

The ministers of the archbishopric of Guatemala took action to address the disaster and meet the needs of the population, asking their parish priests and parishioners for information on the state of the crops and the possible remnants of grain accumulated in the storehouses and bins. They invited the settlers to proclaim a permanent vigil and to publicly repent of their sinful conduct, because – from the spiritual perspective – these aroused the divine wrath and propitiated the presence of calamities, such as drought:

> a scourge with which the Lord usually manifests his anger, and it is the awakening that his divine majesty uses for the wise designs of his most high providence, alternating them or gathering them together as the ungrateful correspondence of men increases; and if in the present time we experience this, it is because ingratitude has now reached such an extreme that we need such a painful reminder. (AHAG 1797a; AHAG 1798)

In response to this, the authorities of the Royal Court compiled information on the geographic and economic scope of the drought and issued *cordilleras* (inspection visits) and *bandos* (proclamations, ordinances, and other government provisions) to warn the population. Between 1797 and 1798, the news revealed that the drought positioned itself and acted – gradually in all the provinces of the Captaincy. In León, for example, royal officials noted that "to the few harvests achieved" was added another calamity: locusts. For this reason, the shortage of seeds became present, and corn prices went from 8 to 36 reales per bushel in a short period of time. In San Salvador, the indigo crops suffered a considerable decrease "due to the lack of water in the best weather." In Cartago, the drought forced the authorities to prohibit the extraction of grains and to control their trade in the markets. Meanwhile, in Comayagua they requested support from the Royal Court to import flour from New Spain to alleviate hunger (Gazeta de Guatemala 1798a; Gazeta de Guatemala 1798b; Gazeta de Guatemala 1798c; ANCR 1798; AGCA 1798).

The atmospheric conditions of the years 1799–1800 continued to be just as extreme throughout the Captaincy, to the extent that the effects of the drought extended to the Chiapas intendancy and reached the New Spain provinces of Tabasco and Yucatán. Although the drought precipitated on vegetation cover, it also had a direct impact on social groups and institutions. Even during this period, a good part of its effects was evidenced through popular religiosity and economic hardships.

Above the religious displays, the processions aimed at dispelling the effects of the weather stood out. These practices responded to two fundamental elements of providentialism: the stance that explained the transgression of Christian conduct and the perspective that obliged men to repent of their behaviors and honor the heavenly power (García Torres 2013: 99–116). Everything seems to indicate that between 1797 and 1802, large processions were held throughout the length and breadth of the Captaincy to contain the ferocity of the weather. The forms assumed by these ceremonies were very diverse, although the general principles were well recorded by Domingo Juarros in his *Compendio de la historia de la ciudad de Guatemala:*

> The affliction that these plagues and droughts caused to its inhabitants is well known in the many prayers that were made, since there was almost no image of veneration that was not taken out in procession to obtain from God the remedy for these calamities. Our Lady of Sorrows of the Hill was taken in procession to the nuns' convents on June 15 and 16, after having made a novena in the parish of Candelaria. A novena was held for Our Lady of Mercy in the cathedral, which concluded with a general procession. Jesus Nazareno de la Candelaria also had a novena, and on the last day, June 9, he was taken out in a penitential procession through all the churches of the city. Likewise, the churches of Our Lady *del Coro de San Francisco,* Our Lady of Help, Our Lady of Manchén, San Sebastián, San Serapio and lately the image of Ecce Homo from the town of San Gaspar was brought to the temple of Calvario to be prayed for nine days. (Juarros 1818: 231–232)

Another element that exposes the extent of this drought are the reports related to the economic setbacks in the countryside. The experience of the Guatemalan *mitre* (area under jurisdiction of a bishop) is worth mentioning since between 1796 and 1802 it suffered considerable losses in its finances, especially in the areas of tithes and alms. In Escuintla, for example, the accountant of the tithe reported that during the years 1794–1795 in that province the privilege to collect the tithes was auctioned at 2,000 pesos and that the result of the tax collection was in excess of this sum; however, from 1796 to1797 and from 1798 to1799 the auctions ranged between 1,100 and 1,300 pesos, while the sum from the collections did not reach 700 or 800 pesos due to the misery experienced in the countryside. Something similar was expressed by the private tax collector (the *arrendatario*) of Suchitepequez, who under the argument of "perpetual ruin" asked the church authorities for a reduction in the auction of the right to collect tithes since the fruits and livestock of the tithe experienced a "devaluation of 75 percent […] which destroys the basic agreement of any auction for having to pay excessive expenses […] that are not recovered by the royal collection." The *arrendatario* of Zacapa indicated in 1797 that, due to the "extreme storms of 1796, many sugarcane fields, water sources and livestock were lost […], and with the scarcity of water in 1797, the crops have been lost" (AHAG 1802a; AHAG 1797b).

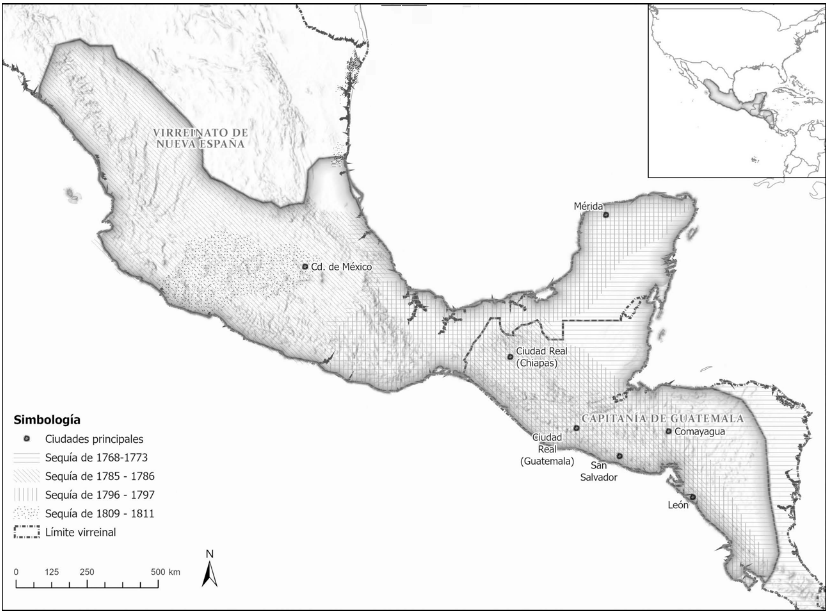
On the other hand, a group of traders from New Guatemala – Domingo Viruela, Joseph Izazi and Francisco Pacheco – asked the Royal Board of Tithes for authorization to buy the 2,000 bushels of corn that were stored in the collection office of Petapa and Pinula to sell them in the city and help with the shortage of grains suffered by the population. These problems also had an impact on the resources of the city's archconfraternities and confraternities, for at "such calamitous times as the present" they were unable to raise the costs of wax, flowers and oils for the solemnity of the Sacred Corpus Christi. From the cathedral chapter's perspective, this shortage was due to the ruin of the farms and alms:

> the former [the farms] destroyed by the catastrophe […] and in the latter [the alms] it is noted that the unsuccessful de Corpus collection alone amounted to 800 pesos and did not go below 500 pesos (before that pitiful period), but last year these alms, previously so abundant, were reduced to 13 pesos. (AHAG 1800; AHAG 1802b; AHAG 1802c; AHAG 1802d)

Everything seems to indicate that the climatic conditions of the Captaincy underwent a series of changes between October 1802 and September 1803, which made possible the arrival of precipitation to the agricultural and cattle-raising regions. This natural remedy was crucial for the survival of many villages and the revival of farming activities. On the other hand, this humidity was also a determining factor for biological threats to increase their destructive capacity and expand their radius of influence, as was the case with the locust plague that hit several provinces. In addition, during these years, a series of volcanoes became active in the provinces of Nicaragua, San Salvador and Guatemala; facts that – together – revealed the force of nature, the progressive changes in the climate and the recurrent disturbances in the vegetation cover.

As for the drought of 1809–1811, it is known that it considerably affected the central and northern portion of New Spain, and served as a prelude to the emancipation movement of the priest Miguel Hidalgo. According to sources, this natural threat manifested itself in May 1809 with a delay in the first rains of the agricultural cycle, which made it impossible for the seeds to germinate and the corn, bean, squash and chili plants to mature. In addition, during the second half of the year there were several frosts and hailstorms, which ruined the existing crops. As far as we can observe, the most serious consequences of the drought were felt in the provinces of Guanajuato, Mexico, Michoacán, San Luis Potosí and Querétaro, and resulted in grain shortages and price increases (Florescano and San Vicente 1985). In other provinces, such as Durango, Zacatecas and Saltillo, the drought caused a shortage of pastures and a reduction of water sources, which led to livestock mortality. In the cases of Guanajuato and Zacatecas, this loss of animals had a direct impact on mining, commercial and agricultural activities. The shortages caused by these climatic phenomena were catalogued by the New Spain authorities as "bad" and in some places "disastrous." To the aforementioned, we must add the problems that emerged with the development of the insurgent struggle. Incidentally, one of the setbacks that is rarely referred to in history and which is closely related to climatic fluctuations and the independence movement is the spread of a typhoid epidemic, a disease that affected physiologically weakened societies with marginal living conditions; likewise, that the main vectors of contagion were the insurgent troops, while the causes of propagation were anchored in the scarcity of water and food; factors that – as a whole – had an impact on the population, hygienic conditions and the natural environment (Florescano and San Vicente 1985; see also Molina del Villar 2010; Alberola Romá and Arrioja Díaz-Viruell 2019; Alberola Romá and Arrioja Díaz-Viruell 2020).

Map 1 shows the main droughts of the eighteenth century in colonial Mesoamerica: 1768–1773, 1785–1786, 1796–1797, 1809–1811.



Map prepared by Marco Antonio Hernández Andrade, based on Kirchhoff 1960: 5.

Thus, we can say that most of the climatic pulses that occurred in the late eighteenth century refer to a cooling process that was accompanied by a shortage of precipitation, disruptions in solar luminosity, an increase in volcanic activity and in the consequent dispersion of aerosol particles in the atmosphere. Undoubtedly, these events had a direct impact on Spanish and New Spain geography. In some places, certain seeds were no longer sown, some fruits became extinct, animal species succumbed and a series of biological pests were suffered; in other places new plants were introduced, animal migrations took place and – above all – some products underwent an adaptation to new environmental conditions, as happened with coffee in Mexico and Central America, and with Opuntia *Opuntia* and grana cochineal in the Canary Islands.

Conclusions

Throughout this chapter we have drawn a panoramic view of the climatic conditions in the Mesoamerican area during the sixteenth, seventeenth and eighteenth centuries; likewise, we have shown that during these years there were a series of climatic anomalies that influenced the history of many provinces of the viceroyalty of New Spain and the Captaincy of Guatemala. In this regard, we have pointed out that the droughts were the result of very complex atmospheric processes: decrease in global temperatures, cooling of air currents, shortage of humidity, oscillations in ambient temperatures, distortions in solar luminosity, changes in the chemical composition of the atmosphere, and so on. We have also shown that these droughts occurred in very diverse geographies, at different times and with unequal intensities. As we have suggested, these droughts were distinguished by their precise timing, their own dynamics and – above all – by generating a series of effects on flora and fauna. In this sense, they can be considered as atmospheric phenomena severe enough to have disrupted agricultural cycles, food chains, erosion processes, environmental conditions and the interests of many social groups. Regarding the latter, the evidence shows that these droughts impacted both, the material base of the most well-to-do men and the nourishment of the most marginalized groups. Obviously, Indian villages were the places where droughts were synonymous with scarcity, hunger, desolation, disease, migration and death. Meanwhile, in the towns and cities, these phenomena were the cause of shortages, famine, begging, disease and social unrest. In addition, we have highlighted the way in which extreme events can have greater effects when combined with human actions or practices that modify ecosystems, vegetation cover or food chains; actions that, over time, become processes that accumulate vulnerabilities and build risk situations.

In general terms, the droughts studied and their atmospheric contexts reveal a series of climatic extreme events that marked the history of Mesoamerica during three centuries; events that should be studied with greater precision through research in Mexican and Central American collections, relying on the methods and tools provided by historical climatology and proposing explanatory arguments from the field of social history. Thus, to the extent that a research horizon between social sciences and environmental sciences can be established, there will be possibilities of having a better understanding of those historical processes that concern the climate as well as social groups and institutions.

Translated by Omar Sierra Cháves.

References

Acuña-Soto, Rodolfo, David W. Stahle, Malcolm Cleaveland, et al. 2002. "Megadrought and Megadeath in 16th Century Mexico." *Emerging Infectious Diseases* 8, no. 4: 360–362.

Alberola Romá, Armando. 2014. *Los cambios climáticos. La Pequeña Edad de Hielo en España.* Madrid: Ediciones Cátedra.

Alberola Romá, Armando, and Luis Alberto Arrioja Díaz-Viruell. 2019. "Clima, medio ambiente y plagas de langosta en la península Ibérica y América Central en el último tercio del siglo XVIII. Una aproximación comparativa." *Anuario de Estudios Atlánticos* 65: 379–421.

———. 2020. "Climatic Extremism and Crisis on the Iberian Peninsula and New Spain (1770–1800). Notes for a Comparative Study." In *Peoples, Nature and Environments: Learning to Live Together*, ed. Ana Cristina Roque, Cristina Brito, and Cecilia Veracini, 55–66. Newcastle upon Tyne: Cambridge Scholars Publishing.

Archivo General de Centroamérica [AGCA]. 1769. *Comunicación del Presidente de la Real Audiencia de Guatemala*. [A3, leg. 2843, February 5].

———. 1769–1770. *Los nativos de Yajalon piden providencias para la destrucción de las plagas de langosta* [A1.22.8, leg. 1, exp. 10].

———. 1770. *Solicitud de Rogativa para Nuestra Señora del Socorro* [A.12-3, leg. 9, exp. 215].

———. 1772. *Informes sobre la situación que enfrentan los pueblos de Chiapas* [AI.I0,648.42].

———. 1785a. *Providencias del ayuntamiento de la ciudad de Guatemala para el abasto de granos* [A1.2.20-1101, leg. 41, exp.58].

———. 1785b. *Comunicación del ayuntamiento de la ciudad de Guatemala sobre el desabasto de trigo y maíz* [A1.2.20-1012, leg. 41, exp. 61].

———. 1786. *Sobre la compra de trigo en las provincias de Guatemala* [A1.2.20-1013, leg. 41, exp. 62].

———. 1796a. *Solicitud del ayuntamiento de la ciudad para llevar a cabo una rogativa pro pluvia* [A1, leg. 2841, exp. 25404].

———. 1796b. *Solicitud de regidores y particulares para convocar limosnas y oraciones en beneficio de los cultivos* [A1, leg. 2841, exp. 25415].

———. 1797. *Los regidores del ayuntamiento de Guatemala sobre el abasto de granos* [A1.2, leg. 42, exp. 1053].
———. 1798. *Para intensificar los cultivos en Comayagua y la importación de harinas* [A3.6, leg. 1840, exp. 29139].
Archivo General de Indias [AGI]. 1770. *Informe del cabildo secular sobre el estado de la provincia de Yucatán* [México, 3057/México, 3018].
———. 1777. *Carta de Joachín Benito de Medina y Torres, propietario de cámara de la Real Audiencia de Nueva España* [Carta núm. 4., México, 2103, August 14].
Archivo Histórico Diocesano de San Cristóbal de Las Casas [AHDSC]. 1770. *Solicitud de la Real Audiencia de Guatemala para que el obispo de Chiapas no realice la visita a su diócesis* [Family Search, San Cristóbal de las Casas, Cofradías y cordilleras, 1702–1771, leg. 2].
———. 1770–1771a. *Cordillera para que los curas animen a los feligreses a fomentar sus sementeras* [Fondo diocesano, carpeta 3690, exp. 9].
———. 1770–1771b. *Informe de Marcos Novelo sobre el hambre y peste que sufren los pobladores de Palenque* [Fondo diocesano, carpeta 1678, exp. 1].
———. 1770–1771c. *Expediente formado a raíz de la hambruna que están padeciendo los indios de la provincia de Chiapas por la escasez de granos* [Fondo diocesano, carpeta 3965, exp. 31].
Archivo Histórico Arquidiocesano de Guatemala [AHAG]. n.d. *Libro de la cofradía de Nuestra Señora del Carmen de la Ermita* [Archivo Parroquial de Nuestra Señora de Candelaria, f. 12].
———. 1797a. *Providencias del arzobispo de Guatemala sobre las conductas de los feligreses y la presencia de sequías y viruelas* [Secretaría de gobierno, Providencias, leg. 17, exp. 192, ff. 1–3v].
———. 1797b. *Sobre el remate de diezmos en el partido de Zacapa* [Cabildo, Diezmos, libro 47, f. 71].
———. 1798. *Propuesta de don Ignacio Rodríguez para sembrar peces en la laguna de Amatitan* [Secretaría de gobierno, Providencias, leg. 17, exp. 15].
———. 1800. *Sobre archicofradías y cofradías* [Fondo cabildo, Libro VI de actas capitulares, f. 110–110v].
———. 1802a. *Sobre el remate de diezmos en el partido de Escuintla* [Fondo Diocesano, Diezmos, Escuintla, tomo 16, f. 361–361v].
———. 1802b. I*nforme del contador de diezmos de Escuintla* [Fondo Diocesano, Diezmos, Escuintla, tomo 16, f. 361–361v].
———. 1802c. I*nforme del arrendatario de diezmos en Suchitepequez* [Fondo Diocesano, Diezmos, Suchitepequez, tomo 28, f. 186–186v].
———. 1802d. *Solicitud para la compra de granos en Petapa y Pinula* [Fondo cabildo, Libro VI de actas capitulares, f. 135].
Archivo Nacional de Costa Rica [ANCR]. 1786. *Bando del gobernador de Costa Rica sobre la escasez de semillas* [Serie Guatemala, exps. 806, 823].

———. 1797. *Bando del gobernador de Costa Rica para exterminar la presencia de langosta* [Centroamérica, signatura 1095].

———. 1798. *El alcalde mayor de Cartago informa sobre la sequía y la plaga que afecta la provincia* [Cartago, exp. 1095].

Argumaniz Tello, Juan Luis. 2013. "El lapso de sobremortalidad de 1785–1786 en Guadalajara y sus alrededores. Un vistazo a la conformación regional y al comportamiento diferencia entre distintas poblaciones durante la crisis." In *Epidemias y rutas de propagación en la Nueva España y México (siglos XVIII–XIX)*, ed. Mario Alberto Magaña Mancillas, 178–210. Mexicalli: Gobierno del Estado de Baja California Sur/UAG.

Arrioja Díaz-Viruell, Luis Alberto. 2012. "'Enjambres' y 'nubarrones' en el campo oaxaqueño: las plagas de langosta de 1802 y 1853." *Revista Relaciones. Estudios de Historia y Sociedad* 129: 161–213.

———. 2013. "Guatemala y Nueva España: historia de una plaga compartida, 1798–1807." *Revista de Historia Moderna. Anales de la Universidad de Alicante* 33: 309–324.

———. 2019. *Bajo el crepúsculo de los insectos: clima, plagas y trastornos sociales en el Reino de Guatemala (1768–1805)*. Zamora de Hidalgo: El Colegio de Michoacán.

Alzate, José Antonio de. 1831. *Gacetas de literatura de México*. Vol. 2. Puebla: Hospital de San Pedro.

Barriendos, Mariano. 2005. "Variabilidad climática y riesgos climáticos en perspectiva histórica. El caso de Catalunya en los siglos XVIII–XIX." *Revista de Historia Moderna* 23: 11–34.

Barriendos, Mariano, y Llasat, Carmen. 2003. "The Case of Malda Anomaly in the Western Mediterranean Basin (AD 1760–1800): An Example of a Strong Climatic Variability." *Climatic Change* 61: 191–216.

Brázdil, Rudolf, Petr Dobrovolný, Jürg Luterbacher, et al. 2010. "European Climate of the past 500 years: New Challenges for the Historical Climatology." *Climatic Change* 101: 7–40.

Brooke, John L. 2014. *Climate Change and the Course of the Global History. A Rough Journey.* Cambridge: Cambridge University Press.

Cahuich Campos, Martha Beatriz. 2012. "La hambruna de 1785–1787. Reconstrucción geográfica de una crisis climática." *Cuicuilco. Revista de Ciencias Antropológicas* 80: 135–156.

Campos Goenaga, María Isabel. 2001. *Entre crisis de subsistencia y crisis colonial: la sociedad yucateca y los desastres en la coyuntura 1765–1774*. Mexico City: CONACULTA/INAH/ENAH.

Carbajal López, David. 2010. "Los años del hambre en Bolaños (1785–1786). Conflictos mineros, escasez de maíz y sobremortalidad." *Relaciones* 21, no. 121: 57–81.

Chávez Orozco, Luis. 1953. *La crisis agrícola novohispana de 1784–1785*. Mexico City: Publicaciones del Banco Nacional de Crédito Agrícola y Ganadero.

Claxton, Robert H. 1986. "Weather-Based Hazards in Guatemala." *West Georgia College Studies in the Social Sciences* 25: 139–163.

Cortés y Larraz, Pedro. 2001. *Descripción geográfico-moral de la diócesis de Goathemala hecha por su arzobispo el Ilustrísimo señor don Pedro Cortés y Larraz del Consejo de su Majestad. En el tiempo que visitó y fue desde el día 3 de noviembre de 1768 hasta el día 1 de julio de 1769, desde el día 22 de noviembre de 1769 hasta el día 9 de febrero de 1770 y desde el día 6 de junio de 1770 hasta el día 29 de agosto de 1770*. Ed. Julio Martín Blasco and Jesús María García Añoveros. Madrid: Consejo Superior de Investigaciones Científicas.

Crutzen, Paul J. 2002. "Geology of Mankind." *Nature* 415: 23.

Endfield, Georgina. 2004. "Drought and Disputes, Deluge and Dearth: Climatic Variability and Human response in Colonial Oaxaca, Mexico." *Journal of Historical Geography* 30: 249–276.

Espinosa Cortés, Luz María. 2016. "'El año del hambre' en Nueva España, 1785–1786: escasez de maíz, epidemias y 'cocinas públicas' para los pobres." *Diálogos. Revista Electrónica de Historia* 17, no. 1: 159–180.

Eriksdotter, Gunhild. 2013. "Did the Little Ice Age Affect Indoor Climate and Comfort?: Re-theorizing Climate History and Architecture from Early Modern Period." *Journal for Early Modern Cultural Studies* 13, no. 2: 24–42.

Fagan, Brian. 2009. *El gran calentamiento. Cómo influyó el cambio climático en el apogeo y caída de las civilizaciones*. Barcelona: Gedisa.

Farriss, Nancy. 1992. *La sociedad maya bajo el dominio colonial: la empresa colectiva de la supervivencia*. Madrid: Alianza.

Florescano, Enrique. 1969. *Los precios del maíz en México*. Mexico City: El Colegio de México.

———. 1971. *Origen y desarrollo de los problemas agrarios de México, 1500–1821*. Mexico City: Era/SEP.

———, ed. 1981. *Fuentes para la historia de la crisis agrícola de 1785–1786*. 2 vols. Mexico City: AGN.

———. 1995. *Breve historia de la sequía en México*. Xalapa: Universidad Veracruzana.

Florescano, Enrique, and Victoria San Vicente. 1985. *Fuentes para la historia de las crisis agrícolas (1809–1811)*. Mexico City: UNAM.

Florescano, Enrique, Jaime Sacho y Cervera, and David Pérez-Gavilán. 1987. "Las sequías en México: historia, características y efectos." *Comercio Exterior* 30, no. 7: 747–757.

Fortea, Manuel. 1809. *Sermón que en las rogativas por la guerra contra Francia, dijo el doctor don Manuel Fortea, el 19 de marzo con asistencia de ambos cabildos en la Santa Iglesia Catedral de Valencia*. Madrid: Imprenta de Álvarez.

Fuentes y Guzman, Francisco Antonio. 1882. *Historia de Guatemala o Recordación florida. Escrita en el siglo XVII por el capitán Francisco de Fuentes y Guzmán, natural, vecino y regidor perpetuo de la ciudad de Guatemala que publica por primera vez con notas* *e ilustraciones Don Justo Zaragoza*, 3 vols. Madrid: Luis Navarro Editor. Orig. pub. 1690.

García Acosta, Virginia, América Molina del Villar, and Juan Manuel Pérez Zevallos. 2003. *Desastres agrícolas en México. Catálogo histórico. Tomo I. Época prehispánica y colonial (958–1822)*. Mexico City: Fondo de Cultura Económica/CIESAS.

García Acosta, Virginia. 1988. *Los precios del trigo en la historia colonial de México.* Mexico City: CIESAS.

García Torres, Adrián. 2017. "La religiosidad popular frente a la sequía en la ciudad de México (1700–1760)." *Temas Americanistas* 38: 32–56.

Garza Merodio, Gustavo. 2017. *Variabilidad climática en México a través de fuentes documentales (siglos XVI al XIX)*. Mexico City: UNAM.

Gazeta de Guatemala. 1797. "Granada de Nicaragua." *Gazeta de Guatemala* 31.

———. 1798a. "León." *Gazeta de Guatemala* 74.

———. 1798b. "León." *Gazeta de Guatemala* 89.

———. 1798c. "San Vicente." *Gazeta de Guatemala* 87.

González Alzate, Jorge. 2015. *La experiencia colonial y transición a la independencia en el occidente de Guatemala. Quezaltenango: de pueblo indígena a ciudad multiétnica, 1520–1825*. Mexico City: UNAM.

Guevara-Murua, Álvaro, Caroline A. Williams, Erica J. Hendy, et al. 2018. "300 Years of Hydrological Records and Societal Responses to Droughts Floods on the Pacific Coast of Central America." *Climate of the Past* 14: 175–191.

Iwasaki, Fernando. 2018. *¡Aplaca, Señor, tu ira! Lo maravilloso y lo imaginario en Lima colonial*. Lima: Fondo de Cultura Económica.

Kirchhoff, Paul. 1960. "Mesoamérica, sus límites geográficos, composición étnica y caracteres culturales." *Suplemento de la revista Tlatoani* 3: 1–12.

Juarros, Domingo. 1818. *Compendio de la historia de la ciudad de Guatemala, escrita por el bachiller don Domingo Juarros, presbítero secular y examinador sinodal de este arzobispado. Tomo II contienen un cronicón del reino de Guatemala*. Guatemala: Ignacio Beteta.

Le Roy Ladurie, Emmanuel. 2017. *Historia humana y comparada del clima*. Mexico City: CONACYT/FCE.

Molina del Villar, América. 2010. "Santa María de Guadalupe, Atlacomulco, ante los aciagos años de principios del siglo XIX: conflictos locales, crisis agrícolas y epidemias, 1809–1814." *Revista Relaciones. Estudios de Historia y Sociedad* 31, no. 121: 109–136.

Lutz, Christopher H. 1982. *Historia sociodemográfica de Santiago de Guatemala, 1541–1773*. Antigua Guatemala: CIRMA.

O'Hara, Sara y Metcalfe, Sara. 1994. "On the Arid Margin: The Relationship Between Climate Humans and Environment. A Review of Evidence from Highlands of Central Mexico." *Chemosphere* 29: 965–981.

Obara Saeki, Tadashi, and Juan Pedro Viqueira. 2017. *El arte de contar tributarios: provincia de Chiapas, 1560–1821*. Mexico City: El Colegio de México.

Parker, Geoffrey. 2013. *El siglo maldito. Clima, guerras y catástrofes en el siglo XVII*. Barcelona: Planeta.

Pastor, Rodolfo. 1981. "Introducción." In *Fuentes para el estudio de la crisis agrícola de 1785–1786*, ed. Enrique Florescano, 29–63. Mexico City: AGN.

Peniche Moreno, Paola. 2010. *Tiempos aciagos. Las calamidades y el cambio social del siglo XVIII entre los mayas de Yucatán*. Mexico City: CIESAS.

Pfister, Christian. 1989. "Fluctuaciones climáticas y cambio histórico. El clima en Europa central desde el siglo XVI y su significado para el desarrollo de la población y la agricultura." *Geocrítica. Cuadernos críticos de geografía humana* 82: 5–41.

———. 2005. "Weeping in the snow: The Second Period of the Little Ice Age-type Impacts, 1570–1630." In *Culture Consequences of the Little Ice Age*, ed. Wolfgang Behringer, Hartmut Lehmann, and Christian Pfister, 31–74. Gottingen: Vandenhoeck and Ruprecht.

Religioso de San Franciso. 1772a. *Novena al glorioso San Cristóbal, abogado contra los temblores y muertes repentinas. Dispuesta por un religioso de la Orden de Nuestro Seráfico Padre San Francisco*. Guatemala: Oficina de Don Antonio Sánchez Cubillas.

———. 1772b. *Novena de la Gloriosa Virgen y Mártir Santa Irene, natural de Nabancia, Portugal, especial patrona de la honra, cuyo cuerpo se conserva maravillosamente incorrupto en un precioso sepulcro fabricado por los ángeles en lo profundo del río Tajo. Escrita por un religioso de Nuestro Señor Padre San Francisco, predicador y misionero apostólico del Colegio de Cristo Crucificado de Guatemala*. Guatemala: Imprenta de Joaquín de Arévalo, impresor de los Tribunales Eclesiásticos.

Remesal, Antonio de. 1932. *Historia general de las Indias occidentales, y particular de la gobernación de Chiapas y Guatemala, escrita juntamente los principios de la religión de nuestro glorioso padre Santo Domingo y de las demás religiones al Conde de la Gomera del Consejo del Rey Nuestro señor presidente y capitán general por el presentado fray Antonio de Remesal de la orden de predicadores de la provincia de España*. 2 vols. Guatemala: Centro América.

Retana, José Alberto. 2000. "Relación entre aspectos climatológicos y el desarrollo de la langosta centroamericana Shistocerca piceifrons piceifrons en el Pacífico Norte de Costa Rica durante la fase cálida del fenómeno El Niño-Oslación Sur (ENOS)." *Tópicos meteorológicos y oceanográficos* 7, no. 2: 73–87.

Robinson, David. 2005. "1785–1786, el año de hambre en México colonial." *Ciencia y Técnica Administrativa* 4, no. 22.

Ruz Abreu, Mario Humberto. 2005. "Plagas, epidemias y muerte en el puerto de Villahermosa, siglo XVIII." In *Tabasco: antiguas letras, nuevas voces*, ed. Mario Humberto, 141–148. Mexico City: UNAM.

Stevenson, David S., Carol E. Johnson, Eleanor J. Highwood, et al. 2003. "Atmospheric impact of the 1783–1784 Laki eruption: Part I. Chemistry modelling." *Atmospheric Chemistry and Physics Discussions* 3: 551–596.

Talavera Ibarra, Oziel Ulises. 2015. "La crisis de los años 1785–1786 en Michoacán: ¿El gran hambre o las grandes epidemias?." *Tzintzun. Revista de Estudios históricos* 61: 83–129.

Valle Barbosa, María Ana, Javier E. García de Alba García, Guadalupe Vega López, et al. 2000. "Defunciones masculinas de 1786, en el Hospital Real de San Miguel de Belén de la ciudad de Guadalajara." *Cirugía y Cirujanos* 68, no. 1: 32–35.

Vázquez, Fr. Francisco. 1937. *Crónica de la provincia del santísimo nombre de Jésus de Guatemala de la Orden de Nuestro Seráfico Padre San Francisco en el reino de la Nueva España, compuesta por el reverendo padre fray Francisco Vásquez*. 6 vols. Guatemala: Tipografía Nacional.

Wagner, Sebastian, and Eduardo Zorita. 2005. "The Influence of Volcanic, Solar, and CO_2 Forcing on the Temperatures in the Dalton Minimum (1790–1830): A Model Study." *Climatic Dynamics* 25: 205–218.

West, Robert Cooper, Norbert P. Psuty, and Bruce G. Thom. 1987. *Las tierras bajas de Tabasco en el sureste de México*. Villahermosa: Gobierno del Estado de Tabasco.

Wortman, Miles L. 1982. *Goverment and Society in Central America, 1680–1840*, New York: Columbia University Press.

Ximénez, Francisco. 1930. *Historia de la provincia de San Vicente de Chiapa y Guatemala de la orden de predicadores, compuesta por el reverendo padre predicador fray, hijo de la misma provincia*, 3 vols. Guatemala: Centro América.

Climate Change in the Caribbean during the Colonial Period

Climate and Tropicality in the Caribbean Islands

Reinaldo Funes Monzote

Climate change has become one of the most pressing issues worldwide in the early twenty-first century. While its impacts are felt everywhere, places like the Caribbean islands are often among those most at risk from rising global temperatures. Because they are surrounded by water, these lands face increased threats from sea-level rise – something already evident on many beaches and coasts – but they also deal with other climate-related challenges. These include more tropical diseases, stronger hurricanes and longer droughts, less land available for farming, and greater risks to food security.

Examining the history of the Caribbean through the lens of contemporary climate change discussions presents several compelling reasons for scholarly interest. The Caribbean was among the first regions integrated into post-Columbian globalization, serving as a crucial source of capital and raw materials that contributed to the onset of the Industrial Revolution and, consequently, the fossil fuel era. The swift transformation of its landscapes – primarily due to the establishment of plantations based on slave labor – and the relatively small size of many islands resulted in the early manifestation of adverse anthropogenic impacts on local ecosystems.

Secondly, the region is frequently impacted by meteorological phenomena such as hurricanes and droughts, leading to loss of life, significant infrastructure damage, and both immediate and long-term socioeconomic effects. The area also has a longstanding history of managing these events; however, current trends indicate that such occurrences may grow in severity and destructive capability over time.

This chapter opens with an overview of the regional climate, followed by an examination of two aspects of the historical interaction with climate in the insular Caribbean, spanning from the arrival of Europeans to the early nineteenth century. The first aspect is material and concrete, providing a concise review of natural phenomena affecting the region that may escalate into social and economic disasters. Notably, tropical storms, cyclones, and hurricanes are prominent, while droughts of varying duration are also common occurrences at the other end of the spectrum of extremes. Floods associated with these climatic events are likewise considered.

The second dimension is less tangible and concerns the prevailing conceptions of climate among European settlers and colonizers, as well as those articulated within the philosophical and theoretical works of prominent intellectuals of the era. Accordingly, significant emphasis will be placed on the notions of tropicality and their evolving application within the context of the expansion of the African slave trade and the predominance of slavery as the principal labor system on Caribbean agricultural plantations during this timeframe.

Climate of the Antilles

The Antillean arc is situated north of the Equator, spanning latitudes from 10° N to the Tropic of Cancer (23° 27' N). If the Bahamian group – located north of Cuba and west of Florida – is included, the arc's reach extends nearly to 27° N. Longitudinally, it ranges from approximately 59° W, where Barbados lies in the Atlantic, to 85° W at Cuba's western extremity. This region encompasses numerous islands within the Caribbean Sea that fall outside the Greater and Lesser Antilles classifications, including most of the Bahamas, Trinidad and Tobago, and islands positioned north of Venezuela. Additionally, several islands along the margins of the western Caribbean are part of this area, ranging from those adjacent to the coastlines to more distant locations such as San Andrés and Providencia, which are territories of Colombia.

The climate history of the region shows significant variations over geological time, with fluctuations between dry and wet periods. In the late Pleistocene and early Holocene, dry and relatively cold conditions prevailed. Towards the mid-Holocene, an increase in humidity and an expansion of forested areas occurred, followed by another drier period in the late Holocene that may have contributed to the extinction of mammal species (Newson and Wing 2004: 13).

Given its location in the tropics, the climate of the insular Caribbean is characterized as warm and humid, under the direct influence of the northeast trade winds that carry moisture from the Atlantic into the region. The mean annual temperature is around 25°C, with a small variation of about 2.5°C between the wettest and driest months in Puerto Rico, Jamaica, the Lesser Antilles, and the islands north of Venezuela, and a variation of 2.5°C to 5°C in northern Hispaniola, Cuba, and the Bahamas. Generally, the Antilles are considered to have a predominantly subtropical climate, while a truly tropical climate is found on the islands located below 15° N latitude. Average rainfall across most of the region is between 1,000 mm and 2,000 mm per year.

However, the climate across the islands is not homogenous and is influenced by factors such as island topography and orographic effects. Typically, the northern and eastern aspects of higher elevations experience greater rainfall compared to the southern and western slopes. In mountainous regions, annual precipitation generally ranges from 1,500 mm to 2,500 mm, though certain locations may receive even higher amounts. In contrast, islands with lower elevations and areas situated at lower altitudes tend to receive between 750 mm and 1,000 mm of rainfall annually. The size of the islands and seasonal rainfall influenced by additional phenomena, such as convection, also contribute significantly to these climatic variations.

Across the region, characterized by its tropical and subtropical climate, two distinct seasons are typically observed: the rainy season and the dry season. The length of these seasons, however, varies according to several factors and specific locations within the Caribbean. As a result, researchers have identified at least five climate types based on the duration of wet and dry periods. The humid climate, defined by two or fewer dry months, stretches from the mountains of eastern Cuba through much of Hispaniola, northern Jamaica, northern Puerto Rico, and most of the Lesser Antilles. Regions experiencing two to five dry months are predominantly situated in the western parts of the Caribbean, including much of Cuba as well as western Hispaniola and Jamaica; some districts here also experience extended droughts lasting six to seven months. Conversely, the islands situated north of Venezuela exhibit eight to ten dry months annually, with certain areas classified as semi-desert or desert climates enduring eleven or twelve dry months (Watts 1987: 23–25).

The distribution of rainfall significantly shapes the composition of plant communities in the insular Caribbean. Based on the Holdridge bioclimatic classification system, forest ecologists have identified thirteen distinct life zones or ecosystems within the region (Newson and Wing 2004: 20). It is estimated that nearly half of the forested area consists of tropical and subtropical dry forests, which are notable for their elevated bird density and diversity. Various forms of tropical and subtropical moist and wet forests are also present, particularly in mountainous regions. Additionally, local soil characteristics play a crucial role in determining vegetation types, influenced by their differing capacities to retain moisture. For instance, savanna or natural grassland vegetation is considered to be more closely associated with soil properties than with climatic conditions.

Upon the arrival of Europeans in the Caribbean, the region's vegetation demonstrated significant adaptation and endemism within insular ecosystems. Plant species were distributed according to local humidity or aridity conditions and exhibited resilience to extreme climatic events. For example, palm trees possess trunks capable of withstanding strong tropical storm winds, while mangroves serve as protective barriers between sea and land. These plants provided important resources for the earliest inhabitants and later became highly sought after as the colonies integrated into international trade networks.

Prior to 1492, Indigenous communities practiced localized agriculture and resource management tailored to the Caribbean environment, most notably through the introduction of cassava from South America. However, European colonization catalyzed a radical transformation of regional ecosystems. This shift prioritized large-scale forest exploitation and the establishment of commercial plantations. The majority of these crops – including sugarcane, coffee, bananas, rice, ginger, citrus, and mango – were introduced species that demonstrated exceptional adaptation to the Neotropical climate and soil (edaphic) conditions. During the Columbian Exchange of flora and fauna, climate adaptation in the insular Caribbean was a critical factor for both Old World species and those newly introduced from other regions of the Americas. Presently, secondary vegetation dominates much of the area, and its ecosystems have been extensively altered by anthropogenic activity. A similar pattern is evident with domestic animals, predominantly originating from Eurasia and Africa, with the exception of certain pets such as parrots and songbirds. The process of acclimatization to local conditions was complex, influenced by environmental phenomena including tropical storms and droughts – both defining aspects of the Caribbean climate.

Between Hurricanes and Droughts

Tropical storms and periodic droughts are the most intense weather events in the insular Caribbean. While the region's hurricanes – classified by their power – were unfamiliar to European colonizers, they had faced strong storms back home near the Mediterranean and North Atlantic. Droughts were more common in the southern and western parts of the Iberian Peninsula, and less so in northern European territories that started colonizing the Caribbean from the seventeenth century. In contrast, Indigenous populations were better equipped to handle these climate extremes, owing to their agricultural practices, plant choices, and architectural styles. Early Europeans depended on local knowledge to understand the timing, frequency, and prediction of hurricanes – a word derived from the Carib or Taíno languages: Huricán or Juracán – as noted by scholars (Schwartz and Mulcahy 2022: 193–194).

Among the natural phenomena impacting the Caribbean region – such as earthquakes and volcanic activity – tropical storms are the most prevalent. The frequency of these events fluctuates in extended cycles influenced by climatic patterns, including El Niño and La Niña, which originate in the Pacific Ocean and alternate every two to seven years or longer. El Niño periods are characterized by warmer and drier conditions, resulting in a reduced number of hurricanes, though their intensity remains unaffected. In contrast, La Niña periods bring increased humidity and precipitation, along with a higher incidence of hurricanes. These cycles enable the identification of phases with greater or lesser storm activity, typically occurring from June to November. Generally, it is uncommon for tropical storms to be entirely absent during this period, and in seasons of heightened activity, more than ten storms may develop.

The Saffir-Simpson scale, established in 1969, categorizes storms based on wind intensity and barometric pressure, ranging from Category One (winds between 119 and 153 km/h) to Category Five (winds exceeding 252 km/h). There is ongoing discussion regarding the adequacy of assessing hurricanes solely by wind speed, as numerous additional variables affect their overall impact. Notably, rainfall contributes to significant flooding and frequently represents the primary cause of casualties and property damage. The spatial extent of each storm, which may surpass diameters of 600, 800, or even 1,000 km, is also a critical factor. Despite its limitations, the scale remains valuable for retrospective analysis of storm characteristics (Schwartz 2018).

Prior to the twentieth century, hurricanes were not assigned formal names but were instead identified by reference to the Catholic calendar of saints. The practice of naming hurricanes with female names commenced in the United States in 1953, and, beginning in 1979, the World Meteorological Organization and the U.S. National Weather Service established protocols to alternate between female and male names. Accordingly, during the period discussed in this chapter, storms were neither measured for intensity nor provided with official names, and their occurrence or approach could not be forecasted as reliably as has been possible since the mid-nineteenth century, particularly due to technological and meteorological advancements in recent decades.

The historical analysis of Atlantic hurricanes and their socio-environmental effects have seen significant scholarly advancement in recent years. Stuart Schwartz's works (2015 and 2018) represent the most thorough examinations, evaluating the role of hurricanes as a central influence in shaping the social, economic, political, and environmental history of the Greater Caribbean region from European colonization through Hurricanes Katrina and Maria. Additional contributions include Mulcahy's (2008) study of hurricanes within the British Greater Caribbean between 1629 and 1783, Sherry Johnson's (2011) research on the connection between climatic phenomena and revolutionary movements in the Caribbean during the late eighteenth century, as well as Eleonora Rohland's (2019) 300-year hurricane history of New Orleans, which also includes a wider perspective on the Caribbean.

These investigations integrate the history of hurricanes in the Caribbean with prominent themes such as colonization, plantation societies, and the military conflicts undertaken by European monarchies to secure territories in the region. Christopher Columbus was among the earliest Europeans to encounter tropical storms, notably during his second voyage along the coast of Hispaniola in June 1495 (Mulcahy 2005: 14). Subsequently, during his fourth voyage, Columbus's prior experience may have prompted him to advise the authorities in Santo Domingo in July 1502 to delay the departure of a convoy of thirty ships for Spain amid adverse weather conditions. His warning, however, was not heeded; the fleet suffered extensive losses, with most vessels destroyed and approximately 500 crew members lost. Only three or four ships survived, including one that transported Columbus's personal treasure (Schwartz 2015: 10–11).

From that point forward, understanding storms became essential in Caribbean geopolitics and navigation. It's likely that the Spanish treasure fleet system (Carrera de Indias), set up from the 1560s, was influenced by the timing of Atlantic hurricane seasons. In 1569, authorities distinguished between the fleets heading to Veracruz, New Spain in April, and those traveling to Tierra Firme (such as Cartagena, Nombre de Dios, or Portobelo) in August. On their return journeys, all ships had to regroup in Havana before departing for Spain, aiming to leave around August. However, a regulation put in place in 1573 stated that if any fleet was delayed and could not leave before October, they had to wait until the most dangerous part of hurricane season was over (De la Fuente 2008: 52). As nautical science progressed, these types of rules were made more precise and later adopted by other European colonial powers operating in areas prone to tropical cyclones.

Similarly, many military campaigns in the Caribbean conducted by competing crowns strategically avoided periods characterized by storms and heavy rainfall, influenced not only by environmental conditions but also by the increased prevalence of diseases such as yellow fever and malaria – at a time when their mosquito-borne transmission was not yet understood (McNeill 2010). These choices were informed by practical experience rather than scientific understanding of hurricane dynamics. Consequently, explanations rooted in providential interpretations, including notions of divine retribution, dominated this era. Schwartz notes the significant influence of the church, especially through the Eucharist and prayers addressing climatic events such as cyclones and droughts, as documented in early chronicles and contemporary accounts.

During the eighteenth century, advancements in statistical methods and systematic weather record-keeping led to an improved understanding of hurricane dynamics (Schwartz 2015). Colonial authorities and church officials documented storm-related damages, compiling valuable information on hurricane characteristics. By the end of the century, the introduction of the barometer – an invention from the prior century – likely contributed to enhanced forecasting capabilities regarding hurricane arrivals. This development was noted in the Havana press following the Hurricane of San Agustín on August 27–28, 1794 (Johnson 2015), which is now classified as moderate intensity, or Category 2, according to the Saffir-Simpson scale (González and Ramos 2019).

The early 1620s marked a significant shift as European powers, competing with Spain, began to conquer various Caribbean islands. Soon after, slave-based plantation systems, focused on the export of sugarcane and other tropical or subtropical crops such as coffee, indigo, cacao, and cotton, were established throughout these territories. Consequently, many of the Lesser Antilles – including British Barbados, Antigua, St. Kitts (which was shared with France), Nevis, Montserrat, and the French islands of Guadeloupe and Martinique – experienced rapid deforestation.

Throughout the following century, this development extended to the larger islands under imperial control. Notable examples include Jamaica, taken by the British from the Spanish in 1655, and Saint-Domingue (now Haiti), which became a French colony after being ceded by the Treaty of Ryswick in 1697. The greater availability of resources and land on these islands enabled expanded production, positioning them as the principal slave plantation societies in the Atlantic world during the eighteenth century (Burnard and Garrigus 2016).

The expansion of slave-driven plantation agriculture throughout the islands introduced new vulnerabilities to storms. Specifically, sugar production necessitated extensive deforestation to establish larger sugarcane fields, correlating with increased numbers of enslaved individuals and growing production units. This widespread loss of forest cover combined with ongoing cultivation heightened soil compaction, promoted flooding, and reduced natural barriers against strong winds. Cultivation of crops such as coffee, frequently located at higher altitudes, further intensified erosion, triggered landslides, and exacerbated river flooding. Beyond environmental consequences, climatic events also had substantial social impacts, disproportionately affecting both enslaved populations and planters while increasing risks of famine and heightening concerns over potential uprisings.

The expansion of plantation colonies led to an increase in the construction of urban infrastructure, administrative centers, residential areas, ports, religious institutions, and planters' mansions. Nevertheless, a significant proportion of the population comprised enslaved African laborers who resided in basic *bohíos*, as well as the most impoverished inhabitants whose homes were often located in vulnerable areas such as floodplains or mountain slopes. An illustrative example of the impact of hurricanes on Caribbean slave societies can be found in the 1780 hurricane season, which occurred during one of the most active periods of cyclonic activity between the 1760s and 1780s.

Between October 10th and 16th, the Great Hurricane impacted several Lesser Antilles islands. The storm, which originated in the Atlantic, exhibited wind speeds and destructive capacity consistent with the highest classification on the Saffir-Simpson scale. In Barbados, reports indicate that nearly all structures and trees were destroyed, resulting in at least 4,500 fatalities, though some estimates suggest a higher toll. The hurricane claimed the lives of 2,000 enslaved individuals, with population statistics indicating a decrease of approximately 5,000 between that year and the next. In Saint Lucia, about 6,000 residents lost their lives and in Kingstown, Saint Vincent, only six out of 600 houses remained intact. On the French territories of Martinique and Guadeloupe, fatalities numbered around 9,000 and 6,000, respectively, while in Dutch St. Eustatius, deaths ranged from 4,000 to 5,000. Overall, the Great Hurricane of 1780 is recognized as the deadliest hurricane in Caribbean history, with total fatalities estimated between 22,000 and 30,000, along with significant animal casualties and extensive material damage (Schwartz 2015: 93–97).

In October 1780, the Solano Storm swept across western Cuba between the 15th and 22nd, sinking several of the sixty Spanish armada ships under Admiral Solano on their way to Pensacola and resulting in the loss of half of their 4,000 crew members. The following month, the Savanna-La-Mar hurricane hit western Jamaica before moving across central-eastern Cuba. On Jamaica, this hurricane was likened to the catastrophic 1692 earthquake that destroyed Port Royal, leaving widespread devastation to both the sugar industry and essential crops like plantains. This series of storms during the decade severely disrupted Jamaica's sugar production, which had been steadily growing since the 1750s.

Efforts to rebuild after the hurricanes of the 1780s highlight both immediate and lasting effects these events had on the Caribbean islands. Researchers examining this period note actions such as raising relief funds in the colonial metropolises, direct government aid, tax breaks, and temporary openings of trade to import food from neighboring foreign colonies. While the initial destruction from wind and rain may have been widespread, social inequalities soon emerged in the recovery phase; for instance, planters often received the majority of the assistance. As Schwartz (2015: 101) observes, social and racial hierarchies became increasingly apparent during post-hurricane recovery efforts.

One notable detail about the hurricanes of 1780 is how island size impacted their effects. On smaller islands, areas near the storm's eye could devastate the entire territory, a situation that happened less often in the larger Greater Antilles. The aftermath raised serious worries about food shortages and the risk of famine threatening social stability. In response, commercial exchanges with rivals and cooperation between colonial administrations from various European powers sometimes became acceptable. Not all consequences of these storms were negative, however; the rainfall often replenished water supplies in regions typically prone to scarcity, ending frequent droughts and helping restore soil fertility.

Although hurricanes often receive greater attention due to their immediate destructive effects, the impact of droughts on Caribbean islands is less frequently discussed. This tendency may be influenced by prevailing perceptions of the tropics as perpetually lush and idyllic. However, the regional climate is marked by alternating rainy and dry seasons of varying lengths. Extended periods of dryness within a single year, as well as recurring dry conditions over consecutive years, are common in the area. The cumulative consequences of these droughts can surpass those of tropical storms, leading to prolonged crises in agriculture and food security.

Droughts come in various forms – meteorological, hydrological, agricultural, and climatic – and these categories do not always overlap. Here, it is important to note that both meteorological and socioeconomic factors play equally significant roles in causing droughts. Drought may result from insufficient rainfall, the fact that most precipitation is concentrated in a few summer months (accounting for 70 to 80 percent of the annual total), or phenomena like El Niño. Socioeconomic factors, such as the amount of agricultural land and the accessibility of drinking water – which can be scarce on some islands – also matter. Additionally, human activities including deforestation, crop types, water management projects, trade policies, and social inequality greatly shape how droughts impact communities. Unlike hurricanes, droughts give us more time and flexibility to make decisions that can reduce their most serious effects.

Schwartz and Mulcahy (2022: 216–228) argue that, during the modern era, droughts in the Caribbean may have produced more significant economic effects than other natural disasters, potentially leading to famines and long-term increases in mortality due to food shortages. For instance, between 1647 and 1650, Barbados lost approximately 20 percent of its population to drought and disease. Similarly, Saint-Domingue experienced a nearly 50 percent decline in plantation production during the late 1770s, while the severe drought of 1775–1776 is believed to have contributed to the deaths of an estimated 30,000 enslaved persons. These extreme outcomes often coincided with major political or economic events, such as the Seven Years' War (1756–1763) and the American Revolution (1775–1783), when dry cycles overlapped with disruptions in the supply of essential goods. In Jamaica, the combined effects of hurricanes and droughts resulted in reports of roughly 15,000 enslaved individuals dying from hunger and disease during this period (Mulcahy 2020: 77).

The convergence of prolonged drought conditions with disruptions stemming from the slave plantation system and wartime circumstances was particularly pronounced on the island of Antigua (281 km²), which experienced significant rainfall shortages between 1775 and 1780. During this period, Antigua operated 300 sugar plantations across 220 km² and held the position as the principal exporter within the Lesser Antilles. Economic and political authority resided with a minority population of 2,500 white inhabitants, whereas the workforce predominantly comprised 37,000 Africans and their descendants. By the mid-eighteenth century, the island's annual intake through the transatlantic slave trade approached approximately 2,000 individuals.

A prolonged drought resulted in insufficient water supplies for both human and animal consumption, exacerbated by the increased presence of British troops. The ongoing conflict disrupted imports of essential food items, including salted meat, corn, and wheat. These adverse conditions led to widespread famine and a shortage of potable water, which subsequently contributed to an outbreak of dysentery. This epidemic claimed approximately 20 to 25 percent of the enslaved population – between 7,500 and 7,900 individuals – as well as additional losses among those of European descent (Berland 2018: 222).

The rapid deforestation of the Lesser Antilles, primarily for plantation development, intensified the impact of droughts in these regions. Consequently, during the eighteenth century, there were increasing calls to address and mitigate environmental degradation on the smaller islands. Additionally, human activities were increasingly identified as contributing factors to local climate changes, particularly in connection with widespread deforestation. The resulting effects included accelerated soil erosion, reduced soil fertility, increased incidence of forest fires, diminished water retention capacity, and a decline in biodiversity.

Scholars have observed that environmental issues in the tropical island colonies of the Caribbean, Asia, and Africa led to innovative actions that are considered foundational to modern environmentalism. These included establishing botanical gardens, forest reserves, and protected zones. Notable early examples are the founding of the Botanical Garden in Saint Vincent in 1765 and, a few years later in 1791, the creation of the King Hill Forest Reserve on the same island. This forest reserve was established to protect forests, conserve timber resources, and help maintain rainfall (Grove 1995).

By the time conservation measures were implemented in many regions, the extended period of slave-based plantation agriculture had already caused substantial environmental degradation, adversely affecting productivity. Notable outcomes included diminished soil fertility and a significant shortage of timber for both manufacturing and fuel. Initially, island deforestation was viewed as essential to enhancing natural conditions and improving air quality, with plantations believed to be transforming the islands into cultivated gardens. Commercial agriculture was thus perceived as advantageous for both the land and climate (Carey 2011: 134). Over time, however, these perspectives shifted toward concern regarding the detrimental impacts of hurricanes, droughts, pests, and diseases.

This growing apprehension led to advocacy for the preservation and regeneration of forests, aimed at mitigating anthropogenic climate change and protecting the viability of plantations. In the late eighteenth century, these concerns were further exacerbated by the emergence of abolitionist movements. Plantation owners increasingly posited that only enslaved Africans possessed the resilience needed to endure the intense heat, humidity, and disease prevalent in the Caribbean environment.

Climate and Slavery

Debates surrounding changes in the Caribbean's climatic conditions – whether from natural or anthropogenic causes – are inseparable from the major themes of slavery, the African slave trade, and tropicality. This connection partly dates back to classical antiquity when the world's regions were differentiated into five major areas: two polar or frigid zones, two temperate zones, and the torrid zone. Authors like Aristotle considered that only the temperate climate could be inhabited by humans, while others linked skin color to different latitudes. The use of these geo-climatic categories marks the birth of environmental determinism and maintained significant influence in the following centuries. However, they are far from representing the modern idea of the tropics, which is both a product of European imperial expansion since 1492 and the evolution of scientific knowledge about the regions between the equidistant parallels of the Equator, known as the Tropic of Cancer (23° 27' north latitude) and the Tropic of Capricorn (23° 27' south latitude).

The arrival of Columbus in the Americas marked a significant turning point in the European intellectual and material understanding of tropical regions. With this event, extensive new territories were incorporated into the scope of the known world, later defined by natural scientists as the Neotropics. Due to its pivotal role in Western European colonization from the sixteenth to eighteenth centuries, the Caribbean emerged as a prominent area within this region and played a consequential part in shaping Eurocentric perspectives.

While the tropical zone includes vast deserts, savannas, and even glaciers, its conventional image is largely associated with Caribbean-island environments. These are typically characterized as low-lying, warm, and humid regions dominated by palm and coconut trees – areas often perceived as paradisiacal, with abundant vegetation believed to readily provide for human needs. During the period of European expansion, the concept of "tropicality" became linked to the agricultural and forest commodities that were significant in international trade but unavailable in metropolitan centers due to climatic constraints. Such goods included sugarcane, coffee, cacao, bananas, and valuable timbers like mahogany (Sutter 2014). Notably, until the early nineteenth century, the Caribbean islands served as primary sources for many of these products. Consequently, the theory of comparative advantage was employed to justify the notion that colonies within the tropics were inherently suited to supply metropolitan markets with climate-dependent exports, defining their position within the emerging global capitalist economy.

The perceived natural advantages of the Caribbean islands in supplying European markets with tropical goods were paralleled by arguments that the region's climate justified the use of enslaved African labor. These factors played a critical role in establishing the slave-based plantation system, which became a significant driver of profit and capital accumulation. While associations between skin color and slavery existed prior to the colonization of the Americas, it was the development of the plantation economy in the insular Caribbean that solidified the inseparable connection between the two.

"Tropicality" functioned as a powerful ideological tool that persisted even after the formal abolition of forced labor. It served as a pretext to claim that only "inferior races" possessed the biological constitution required for agricultural labor in hot, humid climates. This logic was foundational to a strand of modern European thought, consolidated in the seventeenth century, that categorized non-white and non-European peoples as "primitive" or "childlike." By framing these groups as inherently less developed, this discourse naturalized human inequality and justified continued exploitation under the guise of environmental determinism (Müller 2021).

While climatic arguments existed during the early Spanish colonization of the Americas, Eleonora Rohland (2020) argues that the justification for enslavement of Africans was initially rooted in biblical tradition, Greek mythology, and the historical Muslim presence in Africa rather than environmental theory. According to Rohland, skin color was not a prerequisite for slavery until the late sixteenth century. The specific notion that white Europeans were biologically incapable of (forced) labor in the "Torrid Zone" only solidified with the rise of British and French plantation economies in the seventeenth and eighteenth centuries. This transition established a persistent European *topos*: the claim that Africans were uniquely suited for tropical labor due to their physiology, while simultaneously asserting that the tropical climate exerted a "morally degrading" influence on human character (Rohland 2020: 38). This ideological shift coincided with the emergence of "race" as a primary category for human classification.

In his examination of climate theory and the emergence of environmentalism, Urteaga (1993) illustrates that deterministic perspectives regarding environmental influence were prevalent in both European natural and social science disciplines, though alternative viewpoints were also present. One example he discusses is the Count of Buffon (Georges-Louis Leclerc de Buffon, 1707–1788), who attributed the 'black color' of Africans' skin primarily to the effects of heat rather than heredity. Regarding the Indigenous inhabitant, Buffon claimed he was "a weak man in a hostile environment," lacking body and facial hair, as well as sexual ardor. In contrast, in temperate climates were found "the most beautiful and well-proportioned men: the true color of man and the authentic standard of beauty" (Urteaga 1993).

Urteaga discusses the work of Baron de Montesquieu (Charles Louis de Secondat, 1689–1755), noting that his seminal publication, The Spirit of the Laws (1748), espoused a distinct form of environmental determinism. Montesquieu argued that climatic variations accounted for differences in politics, religion, culture, temperament, and customs among various populations. Although he morally condemned slavery, Montesquieu justified the enslavement of Africans using the climatic argument: "There are countries where the heat enervates the body and so weakens courage that men are led to perform a painful duty only through the fear of punishment; in these countries, slavery is less contrary to reason" (Urteaga 1993).

Parallel to the expansion of slavery in the New World, two pervasive European myths emerged regarding tropical labor. The first asserted the biological "unsuitability" of white Europeans for physical exertion in intense heat and humidity. The second proposed the myth of "tropical exuberance" – the belief that the region's natural abundance rendered subsistence effortless compared to the rigors of temperate climates. This dual narrative framed the tropics as a space where labor was both a biological impossibility for the "civilized" and a task made redundant by nature's bounty for the "savage." For instance, Montesquieu wrote that "fertile soils sustain weak peoples," while "barren and mountainous lands produce strong and warlike peoples" (Urteaga 1993). These perceptions also forged a negative stereotype of the Creole population. While Creoles were credited with a degree of biological immunity to tropical hazards, they were simultaneously maligned as lascivious, promiscuous, and indolent. This characterization served a dual purpose: it acknowledged their environmental adaptation only to weaponize it as evidence of moral and physical degeneration caused by the "Torrid Zone." Paul Sutter (2014) describes this perspective as "negative tropicality," which became prominent in discourse surrounding these regions, characterizing them as areas where nature predominated over civilization. The belief that the tropics were detrimental to Europeans was accompanied by the argument that Africans were more capable of adapting to New World plantations within the tropical belt – a common justification among eighteenth-century proponents of the African slave trade. As Rohland notes, this idea contributed to the widespread perception of individuals from tropical regions (with darker skin) as ideal laborers for plantations in the Americas. Consequently, "the evolution of the concept of race and racism cannot be properly understood without appreciating the role of the 'environment' in its changing meanings" (Rohland 2020: 63).

The expansion of the plantation system in British, French, and other Northwestern European Caribbean territories contributed to an association between the islands' tropical climate and African slavery. This relationship was present during the early stages of colonial development, as evidenced by the initial plantation model implemented in Hispaniola near Santo Domingo from 1520 to 1580 (Rodríguez Morel 2012). Nonetheless, the scale of the African slave trade was particularly extensive in these regions, often referred to as "islands of sugar and slaves." Historical estimates indicate that approximately 4.6 million Africans were transported to the Caribbean through the transatlantic slave trade, accounting for nearly half of all enslaved individuals brought to the Americas. Of this total, around 18 percent arrived in the Spanish Caribbean, mainly to Cuba in the nineteenth century, while the remaining 82 percent – primarily directed to British and French colonies (comprising 70 percent combined) and the territories of the Netherlands, Denmark, and Sweden – underscores the significance of these regions in the broader context of the slave trade (Richardson 1992: 63–65).

The islands' tropical climate, characterized by warmth and humidity, served as a significant justification for the implementation of forced labor. Additional environmental factors, such as hurricanes and droughts, further increased the perception of risks associated with permanent European settlement in the region. Tropical diseases – including yellow fever and malaria – were especially prevalent within plantation settings, creating conditions that facilitated their spread and established them as major concerns among colonists. The modes of transmission for these illnesses remained unidentified until the late nineteenth century; however, their increased occurrence during the rainy summer months underscored the adverse health conditions of the tropical climate and acted as a deterrent to European immigration (McNeill 2010).

These climatic arguments served as a convenient veil for the true drivers of African enslavement: the pursuit of profit, the monopolization of land by planter elites, and the extreme social stratification inherent to the plantation system. The persistent claim that only those of African descent were biologically equipped for labor in the Caribbean – and even in non-tropical North American colonies – marks the genesis of modern environmental racism. As defined by Johnston (2020: 262), this involves the systematic justification for subjecting specific groups to hazardous environments based on the fallacy of a "phenotypic predisposition" to endure extreme conditions.

Attitudes toward the Caribbean climate, especially regarding physical work and permanent settlement, were not uniform and could shift depending on circumstances. Johnston points to Edward Long, who wrote A History of Jamaica in 1774 and criticized the widespread belief that the island's climate was unsuitable for Britons. Yet, only a few years later, Long claimed Europeans were incapable of working in the West Indies, thus – in his view – making forced African labor essential. This perspective aligned more closely with the planters' views as they faced increasing opposition to the slave trade and the rise of abolitionism in Britain.

Notably, those who opposed slavery seldom directly challenged the prevailing belief – articulated by Joseph Renny in his 1807 history of Jamaica – that enslavement was an inherent condition suited to populations from warmer climates (Rohland 2020: 38). Instead, their argument focused on the reality that, despite assumptions concerning the adaptability of Africans to Caribbean environmental conditions, the elevated mortality rates among enslaved individuals on plantations underscored the system's fundamentally inhumane and abusive nature (Johnston 2020: 283–284). This perspective had limited influence in the Spanish Antilles, where colonial authorities and Creole landowners began to look towards the plantation models employed by the British and French islands as a means to revitalize economies reliant on cash crops. Facilitating the large-scale importation of enslaved Africans became a central demand for realizing this economic transformation.

Another discursive variant regarding the climate of the islands pertains to the diversity of local landscapes. The low-lying plains, often chosen for plantation development alongside mangrove and swamp regions, were typically criticized for their higher temperatures and humidity levels. Conversely, mountainous areas were regarded as cooler and more conducive to good health. This distinction contributed to the Caribbean islands becoming a destination for individuals from colder climates seeking recuperation from illnesses such as tuberculosis, particularly during the drier months that coincide with the region's mild winters and in its elevated zones. As noted by Carey (2011: 132), the climate of the region was never understood in a reductive or uniform manner.

Despite negative associations with tropicality – arising from the legacy of the slave plantation system, recurrent natural disasters, and widespread epidemics or syndemics – the notion of the Caribbean as an Edenic paradise persisted. While plantations were often promoted as advancements over untamed nature, representing productive and efficient agricultural transformation, literary and artistic depictions simultaneously constructed an idealized, picturesque, and pastoral image of the islands. Such representations served to obscure the significant social and environmental challenges associated with plantation slavery (Dillman 2015).

Conclusions

Exploring the climate history of the insular Caribbean involves many perspectives and offers insight into the area's environmental challenges, especially regarding contemporary discussions around climate change and the Anthropocene. Any study must take into account both the region's tropical location and its island nature, as these are fundamental influences. However, it is even more essential to examine how human activities have altered the environment over time, as well as evolving perceptions of the tropical climate that have accompanied these changes.

Deforestation and other environmental impacts arising from the plantation economy did not fundamentally alter the prevailing climate patterns of the insular Caribbean; however, they did intensify the effects of climatic events such as hurricanes and droughts. It is important to acknowledge the limited capacity for predicting these phenomena and the insufficient understanding of their characteristics during a period prior to the development of meteorology and modern preventive technologies. Nevertheless, these natural occurrences significantly affected post-Columbian societies in economic, political, social, and cultural dimensions. For instance, they are considered to have contributed to changes within the colonial system by encouraging policies that diminished mercantile monopolies and favored local planters and colonists.

Nevertheless, these potentially catastrophic events did not fundamentally challenge the plantation system reliant on enslaved labor, nor did they undermine prevailing beliefs regarding the islands' suitability for tropical agriculture. Rather, such occurrences were occasionally invoked as justification – alongside interpretations of tropical climates as unsuitable for European labor – to support the large-scale importation of enslaved Africans. Consequently, this chapter has analyzed the relationship between climate narratives and race-based enslavement as a key factor shaping developments in the period from 1492 to 1810.

Concepts linking climate as a determinant of plantation systems and racialized labor in the intertropical zone persisted beyond the abolition of the African slave trade and slavery, which concluded at varying points throughout the nineteenth century. Barry Higman (1996) observes that, when professional historians began documenting Caribbean history in the early twentieth century, environmental determinism – particularly climatic determinism – was highly influential; thus, the connection between climate and labor in tropical regions was a central theme in their analyses. This perspective posited that manual labor on plantations was influenced by climatic conditions considered unsuitable for individuals of European descent, resulting in the assumption that indigenous populations were better adapted to the heat and humidity and therefore responsible for performing such work.

These perspectives began to be critically examined within academic circles from the 1940s onward, with contributions by Ortiz (1940), Thompson (1941), and Williams (1944), although some ecological determinisms persisted. Subsequent developments, including the decolonization movement following the Second World War, the Cuban Revolution of 1959, and the decolonization of the British Caribbean from 1962, provided significant challenges to longstanding myths originating from European and U.S. colonial systems. The particular myth under consideration – associating slavery and physical labor with the tropical climate – proved especially influential in legitimizing colonialism and white supremacy for centuries, supported by prominent Western theorists. Its longevity underscores the importance of its examination as a means to counter reductive views that attribute contemporary environmental crises solely to global warming.

References

Berland, Alexander J. 2018. "Drought and Disaster in a Revolutionary Age: Colonial Antigua during the American Independence War." *Environment and History* 24: 209–235.

Burnard, Trevor, and John Garrigus. 2016. *The Plantation Machine. Atlantic Capitalism in French Saint Domingue and British Jamaica*. Philadelphia: University of Pennsylvania Press.

Carey, Mark. 2011. "Inventing Caribbean Climates: How Science, medicine and Tourism Changed Tropical Weather from Deadly to Healthy." *Osiris* 26: 129–141.

De la Fuente, Alejandro. 2008. *Havana and the Atlantic in the Sixteenth Century*. Chapel Hill: The University of North Carolina Press.

Dillman, Jefferson. 2015. *Colonizing Paradise: Landscape and Empire in the British West Indies*. Tuscaloosa: The University of Alabama Press.

González-Ramírez, Carlos M., and Luis E. Ramos Guadalupe. 2019. "Cronología de las tormentas tropicales que han afectado a La Habana." *Revista Cubana de Meteorología* 25, no. 3.

Grove, Richard. 1995. *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600–1860*. Cambridge: Cambridge University Press.

Higman, Barry. 1996. "Ecological Determinism in Caribbean History." In *Inside Slavery. Process and Legacy in the Caribbean Experience,* ed. Hilary McDonald Beckles, 52–76. Canoe Press/The University of West Indies.

Johnson, Sherry. 2011. *Climate and Catastrophe in Cuba and the Atlantic World in the Age of Revolution*. Chapel Hill: The University of North Carolina Press.

________. 2015. "The History and Science of Hurricanes in the Greater Caribbean." In *Oxford Research Encyclopedias: Latin American History.* Oxford: Oxford University Press.

Johnston, Katherine. 2020. "Endangered Plantations: Environmental Change and Slavery in the British Caribbean, 1631–1807." *Early American Studies: An Interdisciplinary Journal* 18, no. 3: 259–286.

McNeill, John. 2010. *Mosquito Empires. Ecology and War in the Greater Caribbean, 1620–1914*. New York: Cambridge University Press.

Mulcahy, Matthew. 2008. *Hurricanes and Society in the British Caribbean, 1629–2008*. Baltimore: Johns Hopkins University Press.

________. 2020. "'Miserably Scorched'. Drought in the Plantation Colonies of the British Greater Caribbean." In *Atlantic Environments and the American South*, ed. Thomas B. Earle, and A. Johnson, 65–83. Athens: University of Georgia Press.

Müller, Christian. 2021. "Bringing order to an unorderly mankind: The savage stages of mankind and the concept of time." In *Civilization – Nature – Subjugation. Variations of (De-) Colonization,* ed. Christof Haar, Matthias Kauffman, and Christian Müller. Berlin: Peter Lang.

Newson, Lee A., and Elizabeth S. Wing. 2004. *On Land and Sea: Native American Uses of Biological Resources in the West Indies*. Tuscaloosa: The University of Alabama Press.

Ortiz, Fernando. 1940. *Contrapunteo cubano del tabaco y el azúcar. Advertencia de sus contrastes agrarios, económicos, históricos y sociales, su etnografía y su transculturación*. Havana: Jesús Montero.

Richardson, Bonham. 1992. *The Caribbean in the Wider World, 1492–1992. A Regional Geography*. New York: Cambridge University Press.

Rodríguez Morel, Genaro. 2012. *Orígenes de la economía de plantación de La Española*. Santo Domingo: Editorial Nacional.

Rohland, Eleonora. 2019. *Changes in the Air. Hurricanes in New Orleans from 1718 to the Present*. Berghahn Books.

________. 2020. *Historia entrelazada y el medio ambiente. Transformaciones socioambientales en el Caribe, 1492–1800*. Bielefeld: Kipu-Verlag.

Schwartz, Stuart B. 2015. *Sea of Storms. A History of Hurricanes in the Greater Caribbean from Columbus to Katrina*. Princeton: Princeton University Press.

________. 2018. *Mar de tormentas. Una historia de los huracanes en el Gran Caribe desde Colón hasta María*. San Juan, Puerto Rico: Ediciones Callejón.

Schwartz, Stuart B., and Matthew Mulcahy. 2022. "Natural Disasters in the Early Modern Caribbean." In *Sea and Land. An Environmental History of the Caribbean,* ed. Philip Morgan, John R. McNeill, Mathew Mulcahy, and Stuart B. Schwartz. New York: Oxford University Press.

Sutter, Paul S. 2014. "The Tropics: A Brief History of an Environmental Imaginary." In *The Oxford Handbook of Environmental History*, ed. Andrew C. Isenberg. Oxford: Oxford University Press.

Thompson, Edgar T. 1941. "The Climatic Theory of Plantation." *Agricultural History* 15, no. 1: 49–60.

Urteaga, Luis. 1993. "La teoría de los climas y los orígenes del ambientalismo." *Geo Critica* 18, no. 99.

Watts, David. 1987. *The West Indies. Patterns of Development, Culture and Environmental Change*. Cambridge: Cambridge University Press.

Williams, Eric. 1944. *Capitalism and Slavery*. Chapel Hill: The University of North Carolina Press.

From the Mid-Nineteenth Century to 1950

Source: Fernando Efrén Sandoval Herrera (2021)

Introduction: Climate Change and the Anthropocene in Latin America from the Mid-Nineteenth Century to 1950

Anthony Goebel McDermott, Virginia García Acosta, Eleonora Rohland, Javier Taks

Several decades ago, environmental historian Donald Worster, a precursor of this historiographic subdiscipline, articulated that its fundamental objective is to deepen "our understanding of how humans have been affected by their natural environment over time and [...] perhaps more importantly in the face of the global concern of our time, how humans have affected the environment, and with what results" (Worster, cited by Castro 2019: 13). Although recent times have seen some qualifications to the concepts mentioned in the definition just quoted, particularly regarding the separation between humans and the non-human world, the notion of the biophysical environment as both an object and subject of anthropogenic transformation, and simultaneously as a conditioner of such transformation, remains fully valid.

In this context, we regard climate as one of the most evident manifestations of this dual path, encompassing its complexity and the various dimensions of socio-environmental relations from a historical perspective. Considering the significant role of climate as an influencing factor, its connection to the material complexities of societies, and the consequent development of increasingly unsustainable interactions with the natural biophysical environment, it is essential to recognize the colonial period as more dependent on and affected by natural climate variability. Conversely, the period known in the Global North as the Great Acceleration (from 1950 to the present) represents the culmination of Latin America's "anthropocenic" contribution to global Climate Change.

While generally valid, the statement may overlook the specific characteristics of Latin America in contributing to the Anthropocene and its global climate interactions. This series of Handbooks aims to address these aspects through complexity, multidimensionality, and multiscalarity.

Considering the above, if we define a "long 19th century" in Latin America and the Caribbean (1810–1950) as a period marked by structural dependence on the natural climatic variability of colonial societies and the emergence of anthropogenic Climate Change during the Great Acceleration of the Global North, several crucial research questions emerge: What were the specific characteristics of Latin American climate transformations? And what were the social, economic, and cultural implications of natural climate variability during this intermediate period between the dominance of climate as a conditioner and climate as a determining factor?

Considering the "long 19th century" in Latin America and the Caribbean (1810–1950), which lies between the colonial dependence on natural climate variability and the later anthropogenic Climate Changes driven by the Global North's Great Acceleration, it is important to explore the region's unique role in the climatic changes of this apparently intermediary period and what were its social, economic, and cultural impacts.

The authors of this section of the volume have made significant contributions by offering tentative answers from diverse analytical perspectives, methodologies, and interpretative paradigms.

Regarding the major socio-environmental changes in Latin America during the long nineteenth century and their connection to anthropogenic Climate Change, it should be noted that the temporal boundary (1810 to 1950) introduced by this Handbook in itself is a hypothesis to be tested. This aligns well with what we might refer to as the "great transformation" prior to the Great Acceleration, introducing nuances to the applicability and relevance of the Great Acceleration specifically for the Latin American context.

It is important to highlight that, from the political independence of Spanish colonies in America during the early nineteenth century until the consolidation of Latin American liberal states later in the same century, there was a period of "downward adjustment" in the environmental history of Latin America, as conceptualized by Castro (1996). Unlike the "environmental novelties" that followed the conquest and colonization of Latin America, and the significant productive reorganization of the territory in the eighteenth century, the oligarchies of the region tended to reinforce traditional forms of social domination and exploitation of natural resources. In essence, the socio-political dynamics implied by the emergence of nascent states did not correlate with changes in the socio-environmental dimension or the economic sphere. This stagnation is largely attributable to the initial success of political conservatism, which, as noted by Tulio Halperin (1993), hindered the growth expectations of Creole elites. Consequently, the technological backwardness, social disorganization, and political instability following the independence processes seem to have been decisive factors contributing to this period of minimal change in socio-environmental relations in Latin America.

By the mid-nineteenth century, after the relative consolidation of Latin American nation-states and their formal insertion into an articulated global market, new socio-productive dynamics with a clearly modern imprint began to give a new face to the socio-environmental profile of the region, although with notable differences between countries. The end of the nineteenth century and the first decades of the twentieth century saw the consolidation of the liberal oligarchies and the regimes of "order and progress" (*orden y progreso*) developed by them. From our perspective, this was the period of greatest socioeconomic, cultural and environmental transformations since the arrival of Europeans in the region and the consequent imposition of a quasi-colonial environmental regime, which, although not exempt from diverse cultural and ecosystemic resistances, ended up becoming dominant in our subcontinent.

It is essential to remember that during the European conquest and colonization of Latin America, significant environmental transformations occurred. This period generated the foundations of a "rapacious economy," characterized by a predatory relationship with nature, which aimed at converting natural resources into exportable commodities. This approach disregarded the intricate methods of working with nature that had been meticulously developed by indigenous populations prior to European arrival (Castro 1996).

From the last third of the 19th century, a significant duality began to shape the environmental history of Latin America that persists to this day. On one hand, Latin America emerged as the most "modern" of the New Europes (Crosby 1999), with an economy characterized by exploitation defining the relationship between society and nature. On the other hand, it became a region where conflicts arose from the opposition of various social sectors and ethnic and cultural groups to economic demands, social models, and relationships with nature that were largely imposed upon them. This opposition has been a constant feature up to the present time.

In summary, during the early to mid-nineteenth century to 1950 period, the foundations (both material and symbolic) of Latin America's current status as a globalized periphery were established from a socio-environmental perspective. This era is characterized by neoliberal capitalism and the ensuing expansion of capital exploitation frontiers through the imposition of large-scale, unsustainable development models. These models often link extraordinary profitability with the destruction of territories and the dispossession of populations (Svampa 2019: 43).

It is important to note that this period marked Latin America's entry into the fossil fuel era, which resulted in significant changes in many extractive processes while introducing and promoting new ones previously unknown in the region. These extensive anthropogenic transformations contributed to increased emissions of CO_2 and other greenhouse gases (GHGs), giving a specific character to Latin America's role in the production of the Anthropocene and its relation to global Climate Change.

During this period, the modernization of agriculture significantly accelerated across the region, though it varied both within and between countries. This acceleration was driven by the expansion of export crops such as coffee, bananas, sugar cane, and tobacco, as well as the early stages of productive intensification. This intensification was facilitated by an increasing reliance on external energy inputs, predominantly from fossil sources, including machinery, agrochemicals, and pesticides. These developments were aligned with the principles of the "Green

Revolution," which served as the paradigm for agricultural industrialization. This period witnessed significant changes in subsistence agriculture within the region, with traditional agricultural practices being increasingly displaced. Despite their modern agroecological designs suited to the socio-productive organization of various indigenous communities, these practices were characterized by notable territorial focus, maintenance of nutrient cycles, and high energy efficiency. Concurrently, there was a modernization of long-standing extractive activities. Beef cattle ranching, for instance, underwent a substantial process of liberalization and capitalization throughout Central America, marked by the introduction of grazing, fencing, and new cattle breeds. This set the stage for the cattle boom experienced by the isthmus and other regional countries, whose impact on the regional socioecological profile and the development of unsustainable agro-extractivist practices has often been underestimated, particularly in countries not traditionally associated with cattle ranching (Van Ausdal and Wilcox 2018; Urrego-Mesa, Infante-Amate, and Tello 2019).

Mining was another sector with structural persistence in the region that underwent significant capitalist modernization. With the rise of liberal "order and progress" regimes in Latin America, and during the agro-export boom, mining played an integral role in foreign investment, particularly from Europe and the U.S., in various sub-regional areas. In some instances, the substantial influx of foreign capital enabled the resolution of chronic issues, such as technical limitations and lack of capital. Consequently, there was a notable increase in the exploitation of both metallic and non-metallic minerals. This growth was strongly supported by new applications, such as the mass consumption of electrical appliances emerging since the early twentieth century, along with the traditional luxurious consumption of gold and silver. Technological advancements, along with the relative scarcity of various minerals in a globally growing demand context, led to the development of a new mining model that was more extensive than traditional underground mining: open-pit metallic mega mining (Svampa, Bottaro, and Sola Álvarez 2009). Following its initial development during the period under consideration, this model expanded in different regions during the 1980s and 1990s, both in traditionally mining-oriented countries such as Mexico and Chile, and in other relatively new mining frontiers in Central America and the Greater Caribbean. This expansion has been predominantly driven by Canadian and U.S. companies, and more recently by Chinese enterprises (Funes 2018).

The extensive deforestation in Latin America to accommodate high-demand productive and extractive activities, particularly for markets in the Global North, such as commercial agriculture, cattle ranching, and mining, has been an ongoing issue in the region. The commercial exploitation of forest products evolved significantly with the modernization processes that occurred between the mid-nineteenth century and 1950.

During this period, many Latin American countries experienced a shift in their forestry industry. The focus moved from the extractive exploitation of a limited number of species yielding "precious woods" for the luxury consumption of North Atlantic elites to the sale of "cheap" woods, which previously had no market value. Additionally, the industry saw growth in forest crops or tree plantations – a new and profitable mode of forest exploitation – driven particularly by the substantial demand from the American middle class for housing construction materials and the need for pulp in paper manufacturing within a rapidly globalizing publishing sector (Goebel 2022). These are just two representative examples of the emerging demands and global interconnectedness of forest products. The expansion of the forest commodity frontier has significantly increased the pressure on the region's forests. This pressure arose not only from the elimination of the forest and the consequent social and cultural exclusion of its inhabitants but also from the transformation of a naturally chaotic, biodiverse, and complex ecosystem into a uniform, simplified, and comprehensible one (Scott 1998). This process has led to the loss of many ecological functions of the forests, as well as their essential contributions to human life and sustenance (Martínez Alier 2004: 150–152).

The activities briefly described here, along with many others not included in this introduction but covered in other volumes of the Handbook, appear to have undergone significant socio-environmental transformations between the mid-nineteenth century and 1950. These transformations underpin the economy of dispossession characteristic of neoliberal capitalism in most Latin American countries. This extensive transformation, as discussed herein, highlights some specific aspects of Latin America's role in the production of the Anthropocene as a critical threshold, as conceptualized by Svampa (2019: 33). This period was marked by substantial changes in the regional anthropogenic contribution to global Climate Change, which increased as the commodity frontiers of extractivism expanded (Bosma and Vanhaute 2021: 9). These expansions nevertheless displayed significant intra-regional differences, driven by rising demand from the Global North for both new and existing raw materials, as well as final goods extracted directly from local ecosystems or produced through their reorganization for commercial purposes. In the context of the construction and initial consolidation of commercialization chains and the international division of labor within capitalism, the linkage of different Latin American countries to the world market was strengthened through a series of ecologically unequal exchanges. These exchanges were expressed in the trade of extracted products, which are difficult or impossible to replace, for rapidly manufactured products (Martínez Alier 1993: 31–32).

It is important to note that, from a structuralist perspective, socially exclusive and environmentally unsustainable societies are strongly linked to urban growth and industrial development processes in certain countries within the region. Additionally, the industrialization of agriculture (Infante-Amate, Urrego-Mesa, and Tello

Agaray 2020; Soluri 2005; Infante-Amate and Picado 2018; Zarrilli 2001), the extractive exploitation of biotic and abiotic natural resources, and the capitalization and liberalization of large-scale livestock farming (Van Ausdal and Wilcox 2018: 183–204; Castro Herrera 2006: 151–177; Funes Monzote 2019; Goebel McDermott et al. 2023) represent significant driving forces of socio-environmental change in Latin America. These changes are propelled by the increasing demand for raw materials and finished goods from the Global North. Therefore, understanding the anthropogenic impact on Climate Change in Latin America requires considering these processes, as the historical significance of this period is undeniable and cannot be overlooked.

Commercial agriculture with a tendency toward monoculture, which advanced significantly during the period under discussion, not only led to a loss of energy efficiency in agroecosystems and a reduction in agrobiodiversity but also caused the degradation of ecosystems associated with and surrounding farms. This practice resulted in substantial climatic changes, particularly through increased CO_2 emissions from slash-and-burn methods used to develop permanent and annual crops and new export cycles of certain agricultural commodities, contributing to global warming (Viales and Urquijo 2024). Additionally, the process of agricultural modernization produced other, sometimes overlooked, effects on global Climate Change. The increasing demand for external energy inputs derived from fossil fuels, a consequence of agricultural industrialization particularly towards the end of this period, fostered the development of highly polluting industries. These industries significantly impacted global Climate Change through the generation of greenhouse gas (GHG) emissions. Notable examples include the manufacture of agricultural machinery such as tractors and mowers, the production of organochlorine pesticides with DDT being the most notable, and various types of agrochemicals which became prevalent following the mandates of the "Green Revolution." However, the adoption of these technologies varied among different countries and subregions (Cushman 2017).

The impacts of anthropogenic Climate Change due to the expansion of cattle herds, territorial growth, and the modernization of capitalist activities in various countries of the region are significant. A notable example is Central America, where between 1850 and 1950, cattle ranching advanced steadily over the semi-deciduous forests of the Central American Pacific, facilitated by the widespread introduction of African pastures (Van Ausdal and Wilcox 2018; Edelman 1998). This development laid the groundwork for what has been conceptualized after 1950 as the "hamburger connection," characterized by extensive deforestation of Central American forests and its association with the increasing demand for meat products by the fast-food industry in the United States, as well as the decrease in South American beef exports due to foot-and-mouth disease (Myers 1981).

One of the primary socio-environmental impacts of extensive livestock farming in relation to Climate Change is its significant contribution to methane levels, as well as carbon dioxide emissions resulting from deforestation through slashing and burning methods used to create pasturelands. The global impact of pollution generated by livestock is substantial, with the FAO estimating in the early 2000s that the livestock sector emitted more greenhouse gases – 18 percent, measured in carbon dioxide (CO_2) equivalent – than the transport sector itself (Steinfeld et al. 2006). This evidence strongly suggests that the period discussed here was not only preparatory for the climatic impacts of the Latin American cattle boom post-1950 but also contributed significantly to anthropogenic global Climate Change. This is especially apparent when considering the profound qualitative and quantitative differences between modern, capital-intensive cattle ranching and its colonial counterpart, where practices such as the raising of semi-wild cattle did not require large-scale forest destruction and often integrated small-scale agriculture within the hacienda system. In the context of mining, it is important to underscore the socially exclusive and environmentally damaging characteristics of the activity. These issues are expected to escalate with the expansion of open-pit mining megaprojects as the predominant model in subsequent decades. This evolution has led to numerous social conflicts arising from both the environmental impacts of production processes and their consequences on human health. Furthermore, there is increasing economic, social, and ecological marginalization caused by these companies. Issues include the commodification of water and minerals, and competition for land and water use with agricultural production, among others (Guzmán López 2016).

From a climatic perspective, it is important to highlight that many mining operations, whether subterranean or open-pit, necessitate the systematic removal of large areas of forest. Unlike activities such as agriculture and livestock rearing, this deforestation is not offset by other forms of biomass. Instead, it is replaced by a technified mining landscape that is energetically unproductive, degraded, and lacking in biodiversity.

This results in the reduction of carbon sinks, significant changes to the regional hydrological cycle, and the production of GHGs. Additionally, mining activity has historically been and continues to be highly dependent on fossil energy (coal and oil) for its extraction and processing, which is associated with anthropogenic Climate Change.

This large-scale extractive activity significantly alters the composition and structure of an ecosystem following a disturbance or succession of disturbances. It directly impacts the "availability of surface and groundwater resources, affecting ecosystems, their retention and regulation capacity, and the consequent provision of water as a good and service that allows the development of productive activities and the very life of the population and living beings" (Garay Salamanca 2013: 94). Deforestation for the productive reorganization of land was a primary factor in Latin America's anthropogenic contribution to global Climate Change during this period. It is important to highlight that commercial logging, whether through extractive methods or the development of forest plantations, also played a significant role in generating GHGs. The main GHGs include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Under normal conditions, plants absorb excess carbon dioxide, but when forests are burned or cleared, the accumulated carbon dioxide is released into the atmosphere. Consequently, deforestation is directly linked to the greenhouse effect, not only from converting forests into croplands or pastureland but also from the expansion of the forest product commodity frontier. Therefore, the substantial increase in deforestation had a direct impact on Climate Change and global warming between the mid-nineteenth century and the first half of the twentieth century.

The emphasis placed in this introduction on climate as a subject of anthropogenic transformation does not imply that its fundamental role in shaping human material activity has ceased. However, it is necessary to highlight that the distinction between natural climatic variability and anthropogenic Climate Change is becoming increasingly blurred during this period. This blurring occurs due to the accumulation of vulnerability and risk (García Acosta 2004), resulting from climatic events that are progressively influenced by socioeconomic modernization processes and the consequent transformation of regional socioecological profiles, as previously described in general terms.

The modernization of agriculture, the expansion of livestock, new expectations in mining, and the commodification of the forestry business have impacted the global climate, while simultaneously being increasingly influenced by it. This highlights the inextricable relationship between climate variability and various dimensions of production in the Anthropocene from Latin America. Although there is a relative scarcity of studies specifically addressing the interconnections between these activities and Climate Change within the context of the "great transformation" discussed here, other volumes of the Handbook provide detailed coverage of these issues.

Therefore, considering climate as a conditioning factor, it is important to note that from the mid-nineteenth century to the early twentieth century, the Little Ice Age (LIA) came to a close. As highlighted in the general introduction of this volume, this period resulted in significant socio-environmental impacts, including agricultural transitions, flooding, prolonged droughts, epidemics, epizootics, and recurring agricultural crises. These factors destabilized human health, led to elevated mortality rates and led to shortages, scarcity, and rising prices of basic goods.

However, the end of this global climatic anomaly did not mean the cessation of droughts, frosts, heavy precipitation, floods, and other events associated with the El Niño-Southern Oscillation (ENSO), or hurricanes, tropical waves, and other hydrometeorological phenomena characteristic of interannual climatic variability related to the oscillation of the Intertropical Convergence Zone (ITCZ). These events continued to affect Latin American societies. Their social and human impacts increased due to anthropogenic actions on ecosystems, while various social actors developed different adaptation and coexistence strategies in response to these events. Some of these strategies are observable over the Braudelian *longue durée*, and others have a clear modern influence (Mora Pacheco 2016).

It is important to note that this period marked significant advancements and the institutionalization of meteorology in the region, although progress was uneven among different countries. The establishment of meteorological institutes and observatories played a crucial role in the growing influence of modern science in Latin America, which was closely tied to the urgent need to understand climatic patterns essential for the rapidly expanding commercial agriculture sector. The introduction of new instruments and an increasing number of meteorological stations facilitated the documentation of both dominant climatic characteristics and the impact of various phenomena and climatic anomalies (Amador 2002), through systematic measurement and collection of meteorological data. This is important for understanding, from a synchronic perspective, the relationships between climate and the social construction of scientific knowledge around it. It also aids in reconstructing, diachronically, the general patterns of the climate of the past, its changes, and the characteristics of anomalies that have impacted and continue to impact societies. This climate-science-society relationship is evident in some of the contributions of this section of our volume on Climate Change.

The impact of climatic anomalies, such as the Mega Niño event of 1877–1878, which recorded a warming of over 2°C and is considered the most intense episode of that century for Costa Rica (Amador 2002: 71), cannot be overlooked. This event has been associated with the locust plague that affected the Central American Dry Corridor during those years (Díaz Bolaños, Alfaro Martínez, and Leitón Gutiérrez 2019; Arrioja 2019).

Additionally, it is important to recognize the significant influence of non-meteorological phenomena on regional and global climates during this period. One notable example is the 1883 eruption of Krakatoa, which led to a worldwide temperature drop. The volcanic ash and dust were expelled into the upper troposphere, impacting incoming solar radiation and altering the earth's climate for years (Amador 2002: 71).

The impacts on Latin American societies from climatic phenomena and anomalies, as well as the social, institutional, political, and cultural responses to climatic crises, are integral to the contributions for this period. These phenomena illustrate numerous intersectional spaces between natural climatic variability and anthropogenic Climate Change.

In this section, various authors from different analytical perspectives, disciplines, and methodologies have significantly contributed to understanding the climate-society relationships during one of the periods marked by significant anthropogenic changes in the socio-environmental relations of Latin America and the Caribbean. This period also saw the establishment of "neoliberal plunder," which continues to create enduring social, environmental, and human impacts across many countries in the region.

References

Amador, Jorge A. 2002. "Some aspects of climate in Costa Rica using historical data from the XIX century." *Tópicos meteorológicos y oceanográficos* 9, no. 2, 64–74.

Arrioja Díaz-Viruell, Luis A. (2019). *Bajo el crepúsculo de los insectos. Clima, plagas y trastornos sociales en el Reino de Guatemala (1768–1805)*. Mexico City: El Colegio de Michoacán-Universidad de San Carlos – FLACSO – Universidad Autónoma de Honduras.

Bosma, Ulbe, and Eric Vanhaute. 2021. "Frontiers, regimes and learning from history." In *Handbook of Critical Agrarian Studies,* ed. A. Haroon Akram-Lodhi, Kristina Dietz, Bettina Engels, and Ben M. McKay, 9–14. Chettenham: Edward Elgar.

Castro, Guillermo. 1996. *Naturaleza y Sociedad en la Historia de América Latina,* Vol. 1, Panamá: Centro de Estudios Latinoamericanos (CELA).

———. 2006. "El agua y la tierra en el país del tránsito Panamá 1903–2003." In *Los tormentos de la materia: Aportes para una ecología política latinoamericana,* ed. Héctor Alimonda, 151–177. Buenos Aires: CLACSO.

———. 2019. Naturaleza y Sociedad en la Historia de América Latina. San José, Costa Rica: EUNED.

Crosby, Alfred W. 1988. *Imperialismo ecológico. La Expansión biológica de Europa, 900–1900*. Barcelona: Crítica.

Cushman, Gregory T. 2017. "Guano, Intensive Agriculture, and Environmental Change in Latin America and the Caribbean." *Oxford Research Encyclopedia of Latin American History,* 1–44. https://doi.org/10.1093/acrefore/9780199366439.013.113.

Díaz Bolaños, Ronald E., Eric J. Alfaro Martínez, and Leninger Leitón Gutiérrez. 2019. "La plaga de langostas Schistocerca sp. (Orthoptera: Acridae) y su relación con el Mega Niño de 1877–1878 en Costa Rica." *Cuadernos de Investigación UNED* 11, no. 2: 54–74.

Edelman, Marc. 1998. *La Lógica del Latifundio: las grandes propiedades del noroeste de Costa Rica desde finales del siglo XIX*. San José, Costa Rica: Editorial de la Universidad de Costa Rica/Standford University Press.

Funes Monzote, Reinaldo. 2018. "The Greater Caribbean and the Transformation of Tropicality." In A Living Past: Environmental Histories of Modern Latin America, ed. John Soluri, Claudia Leal and José Augusto Pádua, 45–66. New York: Berghahn.

———. 2019. *Nuestro viaje a la luna. La idea de la transformación de la naturaleza en Cuba durante la Guerra Fría.* La Habana: Fondo Editorial Casa de Las Américas.

Garay Salamanca, Luis J. 2013. *Minería en Colombia. Fundamentos para superar el modelo extractivista.* Colombia: Contraloría General de la República.

García Acosta, Virginia. 2004. "La perspectiva histórica en la antropología del riesgo y del desastre. Acercamientos metodológicos." *Relaciones. Estudios de historia y sociedad* XXV, no. 97: 124–142.

Goebel Mc Dermott, Anthony. 2022. "Land and Climate. Natural Constraints and Socio- Environmental Transformations." In *The Oxford Handobook of Central American History,* ed. Robert H. Holden, 27–56. Oxford: Oxford University Press.

Goebel Mc Dermott, Anthony, Andrea Montero Mora, Ronny Viales Hurtado, and Juan Infante Amate. 2023. *Las huellas de la ganadería vacuna en Costa Rica: transformaciones socioecológicas y cambios del paisaje en Guanacaste (1890–2014).* San José, Costa Rica: Universidad de Costa Rica, Centro de Investigaciones Históricas de América Central.

Guzmán López, Federico. 2016. "Impactos ambientales causados por megaproyectos de minería a cielo abierto en el estado de Zacatecas, México." *Revista de Geografía Agrícola* 57: 7–26.

Halperin Donghi, Tulio. 1993. *Historia contemporánea de América Latina.* Madrid: Alianza Editorial, 280–355.

Infante-Amate, Juan, Alexander Urrego Mesa, and Enric Tello-Agaray. 2020. "Las venas abiertas de América Latina en la era del Antropoceno: un estudio biofísico del comercio exterior (1900–2016)." *Diálogos Revista Electrónica de Historia 21,* no. 2: 177–214.

Infante Amate, Juan, and Wilson Picado. 2018. "Energy Flows in the Coffee Plantations of Costa Rica: From Traditional to Modern Systems (1935–2010)." *Regional Environmental Change* 18: 1059–1071.

Martínez Alier, Joan. 1993. "Temas de Historia Económico-Ecológica." *Ayer* 11: 19–48.

———. 2004. *El ecologismo de los pobres. Conflictos ambientales y lenguajes de valoración.* Barcelona: Icaria Antrazyt – Flacso.

Mora Pacheco, Katherine G. 2016. "Adaptación de sociedades agrarias a la variabilidad climática. Sabana de Bogotá, Andes Orientales colombianos, 1690–1870." PhD diss., National University of Colombia.

Myers, Norman. 1981. "The Hamburger Connection: How Central America's Forests Become North America's Hamburgers." *Ambio* 10, no. 1: 2–8.

Scott, James C. 1998. *Seeing Like a State. How Certain Schemes to Improve the Human Condition Have Failed.* New Haven: Yale University Press.

Soluri, John. 2005. *Banana Cultures. Agriculture, Consumption, and Environmental Change in Honduras and the United States.* Austin: University of Texas Press.

Steinfeld, Henning, Pierre Gerber, Tom Wassenaar, Vincent Castel, Mauricio Rosales, and Cees de Haan. 2006. *Livestock's Long Shadow. Environmental Issues and*

Options. Roma: Food and Agriculture Organization of the United Nations (FAO)/ Livestock, Environment and Development Initiative (LEAD).

Svampa, Maristella. 2019. "El Antropoceno como diagnóstico y paradigma. Lecturas globales desde el Sur." *Utopía y Praxis Latinoamericana* 24, no. 84. https://doi.org/10.5281/zenodo.2653161.

Svampa, Maristella, Lorena Bottaro, and Marian Sola Álvarez. 2009. "La problemática de la minería metalífera a cielo abierto: Modelo de desarrollo, territorio y discursos dominantes." In *Minería transnacional, narrativas del desarrollo y resistencias sociales*, ed. Maristella Svampa, and Mirta Antonelli, 29–50. Buenos Aires: Biblos.

Urrego-Mesa, Alexander, Juan Infante-Amate, and Enric Tello. 2019. "Pastures and Cash Crops: Biomass Flows in the Socio-Metabolic Transition of Twentieth-Century Colombian Agriculture." *Sustainability* 11, no. 117: 1–28.

Van Ausdal, Shawn, and Robert W. Wilcox. 2018. "Hoofprints: Cattle Ranching and Landscape Transformation." In *A Living Past: Environmental Histories of Modern Latin America*, ed. John Soluri, Claudia Leal, and José Augusto Pádua, 183–204. New York: Berghahn.

Viales-Hurtado, Ronny J. and Pedro S. Urquijo-Torres. 2024. "Land Use in Mesoamerica from the Mid-Nineteenth Century to 1950. Historical-Environmental Processes." In *Land Use – Handbook of the Anthropocene in Latin America*. Vol. I, ed. Olaf Kaltmeier, María F. López Sandoval, José A. Pádua, and Adrián G. Zarrilli, 257–279. Bielefeld: CALAS/Bielefeld University Press.

Zarrilli, Adrián G. 2001. "Capitalism, ecology, and agrarian expansion in the Pampean region, 1890–1950." *Environmental history* 6, no. 4: 561–583.

Climate Change in the Southern Cone from the Mid-Nineteenth Century to 1950

Global Climate Change in the region. Background, Debates, and Impacts

Facundo Rojas and Osvaldo Sironi

The following chapter addresses antecedents and debates, since 1810, linked to the current discussions on Climate Change, Global Change and the Anthropocene in the extreme south of South America. During the nineteenth century and – to a greater extent – throughout the first half of the twentieth century, there are antecedents that describe and interpret socio-environmental processes where the static role of societies in relation to ecosystem changes at different spatial scales, including the global scale, is questioned. Buffon's ideas about the possibility that societies could intervene in the climate are well known (Glacken 1976). Also, around the same time – mid-eighteenth century – European explorers warned about the possible climatic problems that massive deforestation could bring about in the Caribbean (Grove 1997). During his trip to the Americas, between the eighteenth and nineteenth centuries, Humboldt proposed, in a somewhat more systematic way, the link between deforestation and climate variations, since they are co-produced by anthropic action: what we now call climate change (Cushman 2011). In a different but related vein, and already anticipating the nineteenth-century tension between culture and nature, José Martí argued: "There is no battle between civilization and barbarism, but between false erudition and nature" (Castro Herrera 2004: 4).

Based on a re-reading of a wide range of research literature, we problematize existing interpretations of material changes and socio-cultural practices associated with categories labeled "natural," "climatic," or "ecosystemic" from a historical-environmental and strongly interdisciplinary perspective. We also draw connections between these interpretations and a review of the critical economic history of the region under study in this chapter. It is important to note that already during the late eighteenth and early nineteenth century, arguments and evidence began to accumulate, which understood the strong link between production and consumption systems and processes of environmental degradation on a scale and with intensities unknown in the previous history of Latin America. Several authors point out that during the nineteenth century the increase in the cheap production of goods and the increase in cheap labor becomes evident (Patel and Moore 2018). This has been described as one of the main causes of the Anthropocene, and although Jason Moore (2017) considers that the reduction in the price of raw materials, energies and commodities has come to an end during the twenty-first century, it was far from being the norm during our study period (Silva et al. 2023). During the nineteenth century, the Southern Cone as a major exporter of raw materials, was incorporated, into the "free-trade capitalist stage" (Ansaldi and Giordano 2012) – or in what, from a productive perspective, would coincide with the "first industrial revolution." Moreover, since the beginning of the twentieth century, the Southern Cone has been added in a dependent and peripheral role to what Ansaldi and Giordano (2012) call the "imperialist monopolistic stage," coinciding with the second industrial revolution that was based on the exploitation of cheap hydrocarbons. Ansaldi's and Giordano's "stages" are mainly characterized by the export of different commodities, in large quantities and at a relatively low price, always in relation to the industrial production of the moment.

Enlightenment thinking and projects strongly influenced the South American elites in the early nineteenth century. Philosophical and academic production would consequently be accompanied by expeditions of naturalists, such as that of Malaspina or those of Humboldt himself (on trips to the north of the Southern Cone, except Lima). While some "voyages" or "raids" predated 1810, these were highly influential and inspiring, as travel grew exponentially after 1810 and especially after 1820. The resulting accounts by European naturalists, travelers and explorers about South America created strong imaginaries about its culture-nature relations and showed a strong colonial and Eurocentric bias (Pratt 2010).

The present chapter unfolds between two interpretative lines. First, it proposes a re-reading of certain milestones within the processes in which the great technological and political changes of the nineteenth century were intertwined to produce nature. And, secondly, it offers a long-term perspective on key points associated with the collective imaginaries that promoted – or confronted – such technological and political modernizations. In order to present these two perspectives, we investigated the extractive cultures that justified the exploitation of human and non-human labor power (Davis and Todd 2017; Haraway 2015, 2019) and, in a kind of counterpoint, we highlight other visions that disputed these meanings and proposed alternative paths.

The text is organized on the basis of a periodization that divides it into three sections and includes discussions of extreme weather events and of climatic variability, as well as examples of land use change, more linked to what we know today as Global Change. In all cases, we include processes located at the end of the eighteenth century (prior to our actual period of analysis), since we consider it important to incorporate and reinforce explanations that imply a certain continuity between the colonial and republican periods.

Despite our periodization, the most abundant finds begin in the mid-nineteenth century. During this period, there was a considerable increase in the environmental effects of the economic production models that increasingly began to take hold in Chile, Argentina, Uruguay, Paraguay and southern Brazil. All these models were oriented towards the export of "nature" on a large scale. This export boom, dated around circa 1850, is cited as a period of high economic growth for several territories, but it was also an interval of very strong intervention into "natural resources" that only relented in some areas during the First World War. After 1914, not only did the political arrangements of the nineteenth century gradually change, but along with other technologies, the liberal economic consensus changed as well, becoming increasingly protectionist, nationalist, and, with variations, substituting for industrial imports. This changing consensus and reformulation of nation states, of migrations and of the dominant political arguments about the place of nature and labor, did not result in a considerable reduction of the societal footprint on "non-humans." Rather, in the case of South America, authors such as Isaiah Bowman, George Mc Bride, Alan Ogilvie, Mark Jefferson, Max Sorre, Pierre Denis, Preston James, Juan Bialet Massé, Carl Sauer and Elisée Reclus portrayed profiles of landscapes and territories with very high levels of environmental deterioration, poverty and poor development.

Socio-Environmental Changes in the First Half of the Nineteenth Century

From 1808 onwards, a series of autonomous government juntas emerged in Latin America that were the germ of subsequent independence from the domination of the Iberian Monarchies. The economic impact of the wars of independence was intense, even extended, in some regions, during the first half of the nineteenth century (due to subsequent civil wars). As a consequence, many economies of the resulting new states and certain regions did not recover quickly or remained stagnant during those first decades. Therefore, the environmental impacts that resulted from agricultural and mining exploitations diminished between 1810 and 1820. There were other effects derived from the armed confrontations (Castro 2022), which lasted until the middle of the nineteenth century. However, based on the Assadourian interpretive model (1982), we believe that the progressive destructuring of the colonial patterns of production and/or the first independent stage of the countries of the region did not imply a sudden substitution of productive forces or of the modes and means of production, consumption and use of nature. This situation was intensified especially in territories that became the epicenter of the battlefields or where the supply of the armies was focused, regions such as Upper Peru or the Argentine Northwest.

Other territories recovered more quickly from the wars for independence, and from the economic changes derived from decolonization, as in the case of the city of Buenos Aires, which did not fall back to Spanish power after 1810. The number of hides exported to Spain had increased from 1782 onwards, both from Buenos Aires and from the so-called Banda Oriental (present-day Uruguay), and although this was impeded in the first decade of the nineteenth century, it was, however, one of the activities that most quickly recovered after the independence and civil wars. This development was observable especially around the rural areas adjacent to the port of Buenos Aires, which took advantage of the high demand for hides and salted meats by industrialized countries (Bushnell 1991: 120). This livestock, cattle and sheep production was developed in the "Pampas pastures" or simply in the "Pampas" and in the savannah ecoregion that extends throughout Uruguay and in the Atlantic Forest of southern Brazil. Figure 1 shows the main biomes or ecoregions of the Southern Cone. Towards the end of the nineteenth century, these regions became one of the largest cattle-raising regions in the world (Giberti 1961; Osório 2007; Goularte 2015). In recent decades, attention has been drawn to the environmental impacts derived from emissions (greenhouse gases) from livestock farming (Fernández Cirelli 2007).

The production of nature from the Uruguayan prairie – or savanna – shared several processes in common with the Pampas plain and the Brazilian south. The proliferation of European cattle had a strong antecedent in the political order dictated by *Hernandarias* in the seventeenth century (1611–1617), consisting of the release of herds of cattle and horses in the lands east of the Uruguay River, called "*lands without any profit*" (Reyes Abadie et al. 1974, Lanfranco et al. 2022, authors' emphasis). The beneficial ecological characteristics of the wide grasslands allowed these herds to reproduce rapidly, causing modifications of native flora and fauna, and giving rise to the so-called "*mines of flesh and leather*" (Abadie et al. 1974, authors' emphasis). This even strengthened the idea, in traditional Uruguayan historiography, that the "*cattle preceded the settler*" (Campal 1962, authors' emphasis), making invisible the role of the country's Indigenous and creole population.

This view of the agrarian landscapes of Uruguay is based on the dominant livestock orientation of the Pampas soils, which some authors link with the influence of the internal markets of the Guaranitic-missionary space since the seventeenth century (Moraes 2012, Sagrilo 2015). These socio-natural processes gave rise to territories inhabited by *Gauchos* (peasants of these plains identified with livestock and pastoral activity), who recognized themselves as central to the imaginaries and sociocultural representations that have been disputed in the narratives about regional and national identities. It was precisely the role of livestock and its rural actors linked to this activity that were the focus of strong symbolic and material disputes in the second half of the nineteenth century, when the processes of organization of Nation-States were established.

It is also important to note that, towards the end of the eighteenth century, specifically in 1778 already under the dominion of the Viceroyalty of the Río de la Plata, the Free Trade Regulation was established, which influenced the advance of new techniques for the exploitation of livestock, taking advantage of leather, meat, tallow and antlers. During the nineteenth century, specifically between 1836–1843, the main raw materials for export (leather, wool and *tasajo* or dried meat) experienced a strong expansion, as the heads of cattle and sheep increased significantly and, consequently, the number of salters distributed throughout the Uruguayan territory. This increase had a strong impact on the national economy, since towards the end of that century the prices of beef products in the international market rose, and it positioned itself as one of the nations that exported the most per capita (Reyes Abadie et al. 1974; Moraes 2012).

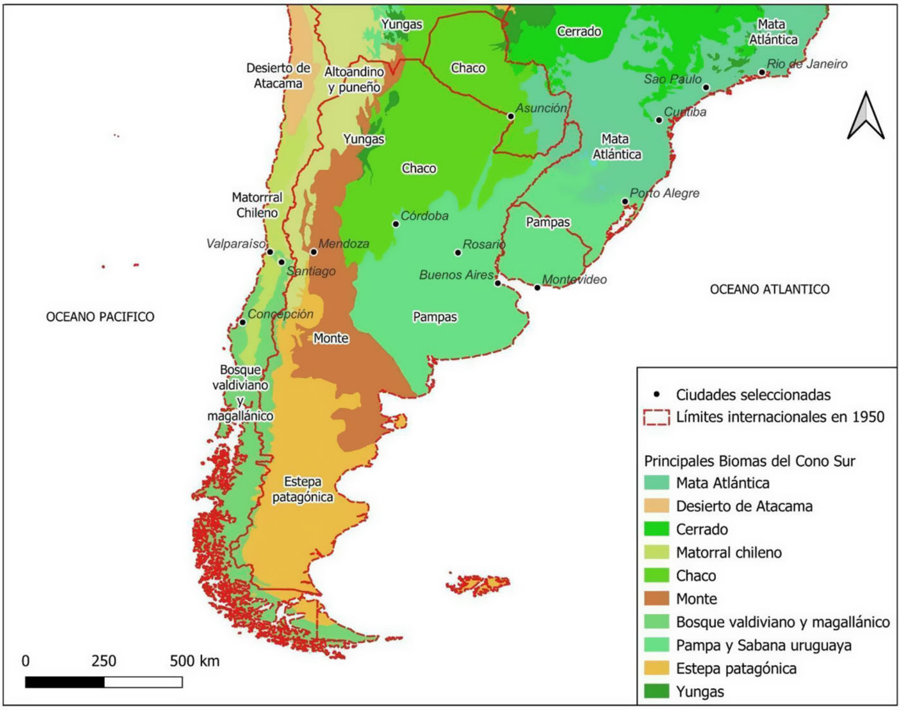
As for the climate of the Southern Cone, various studies lead us to think that its variability presented greater extreme oscillations since the last quarter of the eighteenth century, increasing the recurrence of droughts. On the one hand, there are indications that the Thermal Lift was perceived on a broad regional scale at this time (Gascón 2014). For example, in the case of northwestern Argentina, intense droughts occurred in 1780–1781 and 1783–1784, around Tucumán (López de Albornoz 1997). Other authors argue that, in an incipient way, the impact of societies on the amount of greenhouse gas emissions, or the decrease in capture due to deforestation and changes in land use, could have been felt in some type of climate variability (Villalba 1994; Del Puerto et al. 2013; Córdoba et al. 2015; Morales et al. 2020; Grau and Foguet 2021).

By the end of the eighteenth century, an increase in temperatures was recorded in the Chaco-Pampas region, along with a decrease in rainfall (Herrera et al. 2011): "The traditional economy of hunting maroons and raising and fattening cattle was affected by the lack of rainfall" (Gascón 2014: 55). However, at the beginning of the following century, during 1805, great floods of the Paraná River were recorded, evidenced by Prieto (2007), who highlights its relationship with the El Niño episodes (ENSO) that had begun in 1803 (García-Herrera et al. 2008). Prieto and Rojas (2015) have shown an increase in large floods of the Bermejo River since 1800 – a river that has its headwaters in Bolivia and runs through a large part of the Argentine section of the Chaco. This is linked to studies that point to an increase in more extreme ENSO events and more frequently as a result of higher greenhouse gas emissions (Cai et al. 2015), as well as the influence of various forcings (Gergis and Fowler 2009). The floods in the Paraná River and other rivers of the Chaco-pampean plain have been linked to the El Niño phenomena (which occur every 3 to 7 years), but also other forcings such as the North Atlantic Oscillation, the South Atlantic and Pacific Ocean Convergence Zone, respectively (Antico and Vuille 2022). It has been studied that El Niño (ENSO) significantly influenced the flow of the Paraná in 1876, 1940, 1983 and

2016, but not during the period 1941–1982, as these forcings became more extreme due to climate change (IPCC 2022).

In the same vein, the biogeographic history of the animal and plant lineages of present-day Argentina is strongly linked to climatic-environmental changes. The work of Tonni (2006) accounts for changes in the composition and distribution of biota, emphasizing two important events (the Medieval Thermal Maximum – MTM – and the Little Ice Age – LIA). Regarding this last event, the author states that in the east of the Pampas region, faunal records indicate, from the end of the eighteenth century to the second half of the nineteenth, semi-arid to arid conditions with lower temperatures than today.

Figure 1: Main biomes of the Southern Cone and contiguous regions, mentioned in this chapter.



Elaboration: Facundo Rojas 2023. Source: National Geographic Institute 2022; Brazilian Institute of Geography and Statistics 2020; and Dinerstein et al. 2017.

In addition to political changes, the Industrial Revolution significantly influenced nineteenth-century mining in the Southern Cone. It changed the sources of energy that were used for the foundries, and technology mutated in many aspects, including the use of electricity, which led to a profound change in labor Mining activity linked to the railroad drastically modified the scale and costs of production per unit of time. The railroads allowed certain places to access imported machinery. In addition, new technological methods allowed the separation of minerals (acids and oils) and towards the end of the nineteenth century the use of cyanide emerged, reaching a massive scale during the twentieth century. As a result, mercury amalgamation was abandoned throughout the nineteenth century and, in some cases, at the beginning of the twentieth century. It should be noted that new mines began to have a new centrality, such as Cerro de Pasco in Peru. Conversely, Potosí progressively declined its regional importance and influence (Brown 2012). The relationship between the larger scale of mining production and climate change during the period analyzed has not been studied, but it is assumed that in the Southern Cone emissions from smelters increased and catches decreased due to the growing deforestation (Richard and Tucker 1983; Camus Gayan 2004; Folchi 2005; Rojas 2013; Sironi 2022), as observed in the environmental history of mining in the Americas (Dore 2000; Studnicki-Gizbert and Schecter 2010).

In the early 1840s there was a growth in Peru's guano exports, as well as of silver from Chañarcillo and Tres Puntas (Copiapó-Chile), and shipments of wool from the Argentine pampas and from Uruguay to the European powers and the United States increased. The scale of increase in production and export is also important for Brazilian coffee. Although the main center for exporting coffee was concentrated in Sao Paulo, production progressively advanced to other territories, such as the State of Paraná (Gallero and Miraglia 2021; Nodari 2009). Around the same time, an increase in production also began with yerba mate – mainly in the Paraguayan jungle – however, its greatest boom only occurred towards the end of the nineteenth century (Glade 1991; Farinatti 2018; Gortari 2017).

In addition, around 1870 the export of Chilean copper experienced a period of decline. due to the fluctuation of international prices and the depletion of certain deposits in the Norte Chico. Pablo Camus Gayan (2004) has explored the environmental impact of mining on the forests of the Chilean Norte Chico during the nineteenth century, and has relativized the dominant view, that the deforestation and mining impacts were enormous. In his study, Camus takes up the traditional conflict between miners and farmers about the definition of the ownership of forests and land, which, in his view, generated an "exaggerated" discourse on the part of the farmers about the changes in vegetation, which were, however, less pronounced than they claimed. Mauricio Folchi Donoso (2005), on the other hand, disagrees with Camus and strongly attributes the degradation of forests and associated ecosystems to nineteenth-century copper mining. In any case, there is a marked increase in production in Chilean mining during the first half of the nineteenth century, including changes in land use due to an increase in cultivated area and population growth.

The meticulous studies carried out by Claudio Gay in the Norte Chico, where he describes the relationship between mining and deforestation, as well as the process of colonization and cutting and burning of forests in southern Chile (Gay 1838), are proof of a progressive degradation of the native forest that may have contributed to climate change.

On the other hand, it should be mentioned that the link between the volcanism and the climate variability has been disputed just for the last centuries and, specifically as a regional force in South America, it is even less studied (Paine et al. 2022).

Socio-Environmental Consequences in the Second Half of the Nineteenth Century until the First World War

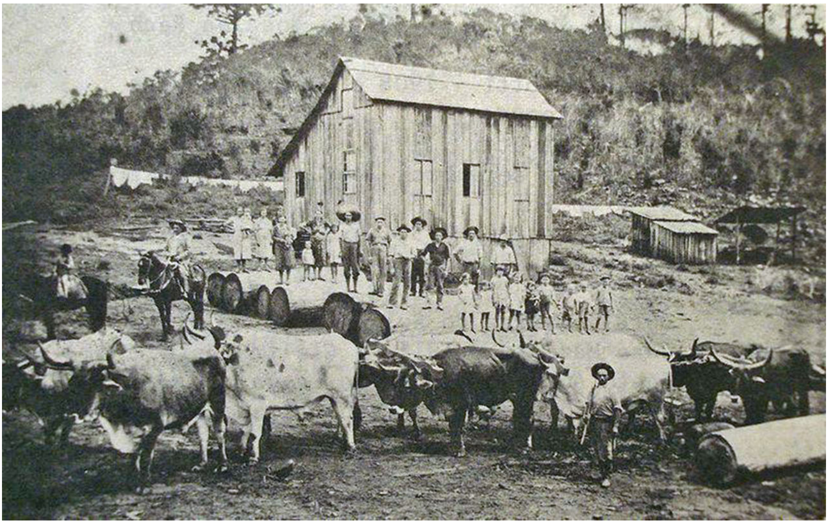
> The river (Paraná) tends to regularize. It would seem that the years make him judicious and sedentary. Before, it was already known: every twenty years a flood came that swept away the land, many leagues inland. In 58 there was one, colossal; in 78 another, no less formidable; another one was expected in '98, but it did not come. Will another twenty years of expectation pass in blank? Have the crops, the clearing of forests, the civilization that is gradually dominating the margins, tamed the old wild river? (Manuel Bernárdez on floods. La Nación en Marcha 1904 [Suárez 2021: 132])

During the second half of the nineteenth century, in the Southern Cone, the production of nature increased on scales and intensities unknown until then. The relationship between climate change, global change and social metabolism was studied, mainly, in regions of Europe but very little in the Southern Cone (Pengue 2023; González de Molina and Toledo 2014). However, there is no doubt that for the territorial region under study, a greater use of energy and materials as the result of the increase in economic production on a regional scale, is in itself a fact that implies higher greenhouse gas emissions. It is, therefore, an indicator of the socio-productive contribution to the increase in global temperatures, as postulated by the convergence of the World System Theory, research on global climate change and the different forms of ecological degradation (Wallerstein 2007). The contribution of each activity, depending on the historical moment analyzed, varies in relation to the overall input. Conversely, it is difficult to analyze the percentage of responsibility corresponding to climate change when assessing its impact on populations, and even more so for historical-environmental investigations.

Clear evidence of this has been the significant advance on the Brazilian Atlantic Forest (Dean 1996); the increase in livestock (for wool and meat) and the cultivation of cereals (such as wheat) in the Pampas region (Djenderedjian 2008) or the boom in vineyards of Chile (both in the Central Zone – with its *sclerophyllous* forests – or the arid Norte Chico – with its sub-desert scrub. The same is true of coal mines of the Bío Bío or the saltpeter mines in the Atacama Desert, as well as the unusual increase in the exploitation of guano on the coasts of Peru and Bolivia.

In different localities and regions, after 1850, an intense impact of economic modernization has been observed, which, in a different way and with different pulses, implied a scale of extraction and exploitation of natural resources that changed landscapes, the relations between societies and nature and the interaction between humans and non-humans. With certain exceptions, which begin earlier, such as the case of Potosí and other nuclei of colonial extractivism, such as Ouro Preto or the exploitation of sugarcane in the Brazilian Northeast (both cases, outside our area of study), it was only from the second half of the nineteenth century when the effects of societies on forests, water, and soils – and progressively also in the climate – became more and more evident. The following is a list of some of the most studied cases.

Figure 2: Forestry activity in Rio Grande do Sul at the end of the nineteenth century (Brazil).



Source: Dall'Alba (1984).

Italian immigration to southern Brazil began in the 1830s but increased markedly after 1871. In the case of migrants of Prussian origin, they began to arrive after 1824, but it was not until 1850 that their numbers increased exponentially. Eunice Nodari (2009) highlights that the arrival of European immigrants in addition to demographic changes, meant drastic reductions in the stocks of the Atlantic Forest due to new forms of production and a colonizing mentality, different from that of pre-existing Indigenous peoples (Figure 2). For Europeans who arrived in that region, the issues of preservation and reforestation were considered irrelevant (Nodari and Espíndola 2013: 168). This is related to climate change, since the increase in deforestation has a recognized effect on the greater availability of greenhouse gases in the atmosphere. Brandt & Moretto (2022) explain how, mainly during the first twenty years of the twentieth century, private agricultural colonization and logging activity devastated the forests of the Santa Catarina region, which also disintegrated the spaces of common use and generated the migration of the population called Caboclo.

In the Argentine Pampas, cattle ranching expanded in a way that impressed travelers and chroniclers of the time: "the sheep population of Argentina jumped from a couple of million at the beginning of the nineteenth century to about forty million in 1865, and to seventy-four million in 1895" (Van Ausdal and Wilcox 2019: 206). In 1862, cattle slaughter reached 850,000 head in Argentina and 500,000 in Uruguay (Lanfranco et al. 2022). The expansion of Pampas cattle and sheep ranching, and its consequent environmental impact in Argentina, prevailed until 1888, registering an incessant growth of agricultural land until 1937 (Vázquez Presedo 1971; Frontoms 2009). Regarding this environmental impact, nineteenth-century slaughterhouses and tanneries have been described as sources of intense pollution, either because of the discharges they threw into watercourses or because of their odors (Brailovsky and Foguelman 1991). Changes in land use with cattle ranching expansion led to deforestation, displacement of native flora and fauna and, in some cases, desertification, especially in the most arid edges of the Pampas to western Argentina and to the south, in extra-Andean Patagonia. Although there are no studies that show the value of livestock's contribution to the emissions responsible for Climate Change between 1850 and 1914, it is to be expected that the immense growth of the activity was correlated with a large increase in emissions. Some of these socio-environmental changes in Argentine rural areas are synthesized in França et al. 2022. Among some of the Great Plains we could mention how the fight against the locust (from 1890 onwards), implied in addition to the fight against a plague, the gradual change in the diversity of insects (and other species) and the broader task of integrating the Gran Chaco into the effective domain of the national government – and dominating the Indigenous people – in the Argentine border territories (McQuilkin 2022).

In the Atacama Desert, a historical process that has (re)configured the historical-social, political and environmental evolution of the peoples of the region focuses on the conflicts during and after the so-called War of the Pacific, in which territories were disputed between Chile, Bolivia and Peru in the period from 1879–1884. The main causes that triggered this armed conflict between the ruling classes of these countries centered on the interest in the exploitation of saltpeter and the export of guano from the coastal islands of Peru to the European markets and the United States, added to the imprecision of the border limits between Chile and Peru, a demarcation that came from colonial times (Bonilla 1974; Cushman 2018).

This socioeconomic profiling that was beginning to be established in these territories entailed environmental impacts of considerable magnitude. Guano – the excrement of seabirds from the coasts of Peru and Bolivia accumulated in their resting places – and saltpeter – a natural chemical product deposited in the expanses of the Atacama Desert known as sodium nitrate – began to be appreciated as fertilizers in agriculture and in the manufacture of gunpowder, in Western Europe and the United States. Both, fertilizer as well as gunpowder were needed to satisfy the growing food and productive requirements of the urban centers of the Industrial Revolution (Bermúdez 1963; Mitre 1981; Contreras Carranza 2012). Referring to the impact of guano on the Western economy, Jack Weatherford argues that the application of guano on European farms, from the mid-nineteenth century, inaugurated modern European agriculture, as this substance stimulated crop yields and, therefore, increased interest in fertilizer research and development (Weatherford 1988; Ceroni Galloso 2012). This is of utmost importance, because it implies that the export of guano facilitated increases in agricultural production, and, consequently, in energy consumption and environmental impacts related to climate change. Something similar happened with the exploitation of saltpeter, since although there are no quantitative studies that calculate the relationship between saltpeter production and climate change, qualitatively it is known that it implied a leap in the global social metabolism, due to the increase in agricultural and gunpowder production, which required greater energy deployment in its production and marketing (which necessarily implies higher emissions than those existing before said activity was massively produced). The so-called *Era of guano* marked the beginning of technological-agricultural modernization in reference to the use and application of synthetic fertilizers from the beginning of the twentieth century to the present day (Piel 1995; Spak et al. 2012; Cushman 2018). The decline of the extractivist monopoly of guano was eclipsed by the discovery of the "new" resource: saltpeter. The new territory conquered by the State of Chile contained high-grade saltpeter mineral deposits and, therefore, made it possible to modernize and replace saltpeter purification techniques that transformed the landscape of the Atacama Desert with the impressive "offices" for extracting the mineral (O'Brien 1982; Vilches et al. 2008). The contribution of these economic activities – the extraction of guano and saltpeter– have not been rigorously factored into anthropogenic climate change, however it is very likely that there is a significant effect. Considering for example the annual extraction of an average of 400,000 tons of guano between 1850 and 1879 on Chilean-Peruvian coasts (Coker 1908; Cárdenas 2022), as well as the demographic shift it enabled –and considering the destruction of forests during the saltpeter cycle (Zolezzi 1993; Castro

Castro 2020) – which brought with it numerous interconnected territories of towns and ports/coves in the plains of the current jurisdictions of Tarapacá and Antofagasta (Garcés Feliú 1999).

Simultaneously, there was a significant increase in deforestation in Argentina in the mid-nineteenth century, which is explained by several factors. Among them, the population increase for the second half of the aforementioned century stands out, concentrated in the large cities, mainly in the Pampas region, Mendoza and Tucumán.

Another significant cause of deforestation in the Chaco region was the appearance of the railroad and the spread of the use of tannin for leather tanning. Whether for forestry use for railway sleepers, for use as fuel for locomotives or for the extraction of tannin from *quebracho* trees. The excessive use of the quebracho *colorado* (red) in the Chaco region (10 million hectares deforested, according to Zarrilli 2016), has been abundantly cited as largely responsible for socio-environmental impacts of various kinds, including an impressive loss of forests that would contribute to anthropogenic climate change. There were up to thirty tannin extraction factories in Argentina that have received "well-founded criticisms from the economic, social and political realms as a true model of colonial enclave – emptying of cities, closure of industries and social repression" (Peri et al. 2021: 118). Gustavo Zarrili clarifies that, although the use of wood (roundwood) was more important during the nineteenth century, this was reversed in 1913 when the production of tannin became more important, in terms of the number of foresters involved.

Between 1870–1950, "the entire national railway system laid its tracks on rot-proof sleepers of a single species shared with Paraguay and Bolivia, the quebracho colorado santiagueño (*Schinopsis lorentzii*). The entire national tanned leather industry depended on tannin, a material processed from another red quebracho, the Chaco (*Schinopsis balansae*), and the entire fencing system of an agro-exporting country depended on two or three native trees, ñandubay (*Prosopis affinis*), quebracho and carob trees (*Prosopis alba, nigra, flexuosa, chilensis*)" (Zarrilli 2004: 257). In some of the territories cleared by the felling of the quebracho forests, cotton production was installed after 1920 "resulting in an unsustainable scheme, due to its direct social and environmental effects" (Zarrilli 2016: 59).

On the other hand, the socio-environmental consequences between 1850 and 1914 of the large-scale mining of the main deposits exploited at that time in Argentina (Famatina, Capillitas) were analyzed by Rojas (2013) who argues that these mining activities demanded a high consumption of native forest (carob trees) and that this modernization process was linked to deforestation also driven by the establishment of the railroad. In addition to mining and irrigated agricultural activity, in the Argentine province of La Rioja, extensive cattle ranching was combined with a forest market with highly extractive characteristics, absence of state control and poor working conditions for the Axe Makers (forestry workers), and without any local reinvestment. This generated serious social problems that have been described by different authors, mainly for the Plains of La Rioja (Gatica 1961; Natenzon and Olivera 1994; Olivera 2000).

From 1870 onwards, there was an immense growth of the agricultural oasis of Mendoza and San Juan (Argentina). This modernization of the wine industry was subsidized by the clearing of the carob trees in Cuyo (Abraham and Prieto 1999). At the beginning of the twentieth century, less water began to arrive in the lower basin of the Atuel River, west of the current province of La Pampa (Rojas and Prieto 2020; Rojas and Barbosa 2021). These processes of wine expansion were linked to the drying up of the Bermejo Swamp (Prieto and Rojas 2012) and the drying up of the Guanacache Lagoons (Abraham and Prieto 1991). Thus, in the arid west of Argentina, important deforestation has also been observed, since the mid and late nineteenth century, which has contributed to climate change, despite the fact that the levels of emissions that these forests could capture are not quantitatively estimated.

In the same region of Cuyo (Argentina), we have studied the relationship between hydrological drought processes and water scarcity due to socio-political causes (Rojas et al. 2023). Despite not having sufficient empirical elements to guarantee a direct relationship between these processes of scarcity and climate change, we were able to verify a management and guidance of various socio-political devices and intervention of social actors around the oversight of water resources during periods of climate variability in the provinces of Mendoza and San Juan during the nineteenth century and the first half of the twentieth century (Rojas 2021; Rojas et al. 2023). In this way, throughout the nineteenth and early twentieth centuries, socially constructed vulnerability has been linked to land ownership with irrigation rights (Rojas et al. 2023). This is due to the region's insufficient rainfall, snowpack, and glaciers (the latter characterized by longer-term dynamics) available in its mountain ranges for the development of various types of agriculture.

In this period of analysis, the case of the province of San Juan (Argentina) is an interesting example of the intensification of state practices to produce conditions that provide greater predictability to the use of water – "hydraulic missions" – and that these policies result in an expansion of irrigated territories based on agricultural modernization, mainly wine. However, similar to Mendoza, a strong social vulnerability to hydrometeorological extremes was observed when there was no ownership of land with the right to irrigation (Rojas 2021).

The lack of water, characteristic of years with water flow below average, is perceived, mainly, in years with normal or high flow, due to problems of access, distribution and quality of water. Thus, many disputes over the lack of water are prior to the years of low flow snowfall and continue when the flow is regularized, since they usually respond to social processes of longer duration than the years of hydrological drought. During the great drought of 1924, in Mendoza, the farmers expressed their anger at the lack of justice on the part of the State to distribute water and requested

> to proceed to a healthy and complete organization in the administration of water, so that it is distributed in the corresponding proportion and with absolute equity among the irrigators. They ask for justice and impartiality in the distribution of turns, banishing preferences and favoritism […] that have caused bloody incidents with fatal consequences. (Diario los Andes 1924: 5)

In contrast, until 1850 in San Juan, excess water due to rising rivers used to be more common and problematic than water scarcity. This means that despite being located in the so-called South American Arid Diagonal, a situated definition of Risk in an "arid zone" is relative to the place of territorial enunciation, the time scale, and the social sector (Rojas 2021).

As for Chile, the testimonies of Benjamín Vicuña Mackenna maintain that 1863 was a year of "complete and calamitous" drought in the center of the country (Vicuña Mackenna 1877). This great drought, which extended to 40°C, allowed the settlers of Puerto Varas and Puerto Montt to burn and clear 30,000 hectares of ancient Patagonian forests. In this process of clearing for agriculture, the oldest specimens in the region were burned (Elizalde Mac-Clure 1970). The 1863 SADA map shows extremely dry conditions in central Chile and northern Patagonia that persisted for the next 3 years (Morales et al. 2020). The main impacts of climate change on the Patagonian steppe (north-central Chubut) are detailed in González et al. (2018).

This drought had to do with a very strong episode of El Niño, which reached its peak during the South American summer of 1877 and 1878. Known for its immensely destructive nature in the Northern Hemisphere (Davis 2006); it also had a high impact in our study area. It generated intense droughts in the Andean Altiplano, accompanied by unusual and severe rainfall and flooding in the coastal areas of northern Peru, in central Chile and around the middle and lower part of the Paraná basin. As late as March 1878, the Paraná River was more than 6 meters above its average level in the city of Rosario (Argentina), and the associated floods were described as catastrophic by the *Diario de la Nación* of March 29 of that year (Aceituno et al. 2009: 406). The Paraguay River also rose considerably producing floods in different parts of Paraguay including the capital, Asunción. The heavy rains that affected central Chile during July 1877 caused dozens of deaths and extensive damage to infrastructure. On the eastern side of the Andes, the increased flow of the Mendoza River destroyed bridges in November of the same year (Aceituno et al. 2009).

Other evidence presented by Araki and Hidalgo Nunes explains an increase in temperatures for the State of Sao Paulo, in the last two centuries (Araki & Hidalgo Nunes 2009; Araki 2012).

Railroads played a key role in the modernization of the Uruguayan savannah between the end of the nineteenth century and the beginning of the twentieth, being an important factor in the national environmental history, since this means of transport, although it allowed the consolidation of the region as an important world exporter of wheat, beef and other products (Martínez-Díaz 1987; Brailovsky and Foguelman 1991), produced a series of considerable environmental problems that are reflected in the imposition of certain tree species on others, as well as the increase in forest-free areas.

In the southern part of the continent, during the second half of the nineteenth century, the Chilean State deepened its territorial power over larger Indigenous areas around Valdivia and advanced over large surrounding forested areas at a faster rate than was known so far (Solari et al. 2011; González Marilicán 2022). At the same time, the Argentine State also advanced on the territories of native peoples in present-day Argentine Patagonia. Thus, since 1865, there was already a presence of bighorn cattle near the Chubut River, and that same year a particular colonization of Welsh origin began in the valleys and coast of the current province of Chubut (Crovetto 2011; Mare 2019).

One of the main objectives of the military campaigns of the late nineteenth century was to expand the agricultural frontier in order to move sheep from the Pampas to less favorable lands (Bandieri 2009; Blanco 2010), at the cost of incorporating large territories inhabited by Indigenous peoples into the export system. Thus, most of the Argentine extra-Andean Patagonia specialized in sheep farming, which generated important processes of degradation and desertification due to overgrazing (Cepparo de Grosso 2001).

These military advances led to massacres of Indigenous communities, forced migrations, and favored the development of diseases that decimated the Mapuche and Tehuelche peoples. Those who survived were disciplined and subjected in various ways to forms of production typical of the large ranches or cattle states known as *estancias* (Delrio 2010). Mercedes Ejarque (2013) explains how the first problem of sheep production for Patagonian wool was connected with the First World War, when wool prices and international demand fell. Trade difficulties were aggravated by the economic crisis of 1930. Ejarque remarks that, only in the 1930s, the first mentions of overgrazing of Patagonian fields by cattle emerged. Subsequently, in the middle of the twentieth century, there was a relative stagnation of the livestock stock until its decline at the end of the 1970s. In Patagonia (present-day province of Santa Cruz, Argentina), the massive predation of the guanaco accelerated in the first quarter of the twentieth century. On this, Soluri states: "Hunting guanacos for commercial purposes began in the nineteenth century, when Indigenous hunters exchanged guanaco skins and *quillangos* – tunic-like garments made from the soft skins of baby guanacos – with travelers and settlers" (Soluri 2023: 41). Subsequently, for the same purposes of marketing meat and hides, it is visualized that, between 1931 and 1946, 2.5 million *guanaquitos* were exported to the United States (Soluri 2023).

The main causes of this stagnation are, on the one hand, the environmental difficulties mentioned above (desertification, soil erosion, loss of fodder and livestock reception capacity) and, on the other, the reduction of the international wool market due to competition with new raw materials: synthetic fabrics (Ríos 1958).

Forestry in Argentine Patagonia intensified during the twentieth century. In southern Patagonia in Argentina, we find data on intensive forestry since 1902 on the forest of *Nothofagus* and in 1918 in the Avellaneda Peninsula, covering an area of around 20 thousand hectares of forests (Peri et al. 2021).

Relations Between Economic Processes and Climate Change in the Southern Cone Between 1914–1950

It has been detected that the glaciers of the Southern Cone have shown an increase in the rate of retreat during the last 150 years, accelerating, mainly, during the twentieth century, and to a greater extent in the twenty-first. This shrinkage is usually explained by the contribution of anthropogenic greenhouse gas emissions that are affecting the climate (Aniya, et al. 1992; Rivera et al. 2021; Ruiz et al. 2022). Guerrido et al. (2014) hypothesize that the current oscillatory regime of the Perito Moreno glacier began during the early twentieth century and coincides with an increase in temperatures, which would be in tune with climate change. However, there is no further research of this type for our study period. In the near future it will be necessary to link such glaciological research with climate history and economic history in order to find some keys that have not been sufficiently studied so far.

Ricardo Pavetti (2010), citing Francisco Gaona (2007), details how, after the 1904 revolution in Paraguay, with the predominance of Anglo-Argentine capital, a strong extractivist cycle of the jungle began in order to obtain railroad sleepers, beams, posts, rolls and quebracho extract (*Schinopsis*) in Puerto María, Puerto Max, Puerto Sastre, Puerto Galileo, Jesús and Trinidad, among other locations. This cycle lasted intensely until 1915, although the export of wood would have already begun in 1879. By 1920 "Paraguay was in total dependence on the Argentine economy" (Pavetti 2010: 302).

In central Chile, since the beginning of the twentieth century, there has been a trend towards higher mortality and reduced radial growth of trees in the Mediterranean forest, caused by warmer and drier conditions, linked to climate change (Canales Cornejo 2020). In southern Chile, a significant negative trend has been detected in the annual rainfall accumulated since 1900 (Gonzalez-Reyes et al. 2017).

The years following 1917/18, at the beginning of the twentieth century according to the postulates of Eric Hobsbawm (1987), were moments of socio-environmental changes for South America and the Southern Cone, as they gradually saw transformations in their territories and the ways of interacting with "nature." The changes in South America are explained (in addition to the First World War, the Russian Revolution, the unstable and changing political situation between the European wars and the rise of American influence) by a series of regional political processes as well as the rise of popular and middle tiers of society to politics in Chile, Argentina and Uruguay especially. The social reforms of José Batlle y Ordóñez in Uruguay, Alessandri in Chile or Argentine governors such as Cantoni or Lencinas, were contemporaneous with the rise of other social demands from anarchism or socialism, often brutally repressed. Also, in the 20s and 30s there were revolutions (Revolution of 1923 in Rio Grande do Sul), coups d'état (1924 in Chile, 1930 in Brazil and Argentina, 1933 in Uruguay) and wars (Chaco War in 1932) that outlined new political, social and cultural orders that were further away from liberalism and closer to conservatism or the so-called "Latin American populisms."

Especially after the 1930s, agro-export models showed serious limitations, and states began to intervene in economies to, among other things, promote import-substitution industrialization. Thus, state intervention with a Keynesian perspective became the dominant paradigm. All of this had a strong imprint on nature policies. This can be seen, for example, in the increase in national protected areas, which in Argentina were used as national security zones in the face of possible conflicts with neighboring countries (Moreno 1902; Burkart and del Valle Ruiz 1994; Piantoni 2016). Although the Malleco National Reserve in Chile dates back to 1907, most of the protected areas of the Southern Cone are post-1914. In the case of Argentina, November 6 is celebrated as the day of the *National Parks* because Francisco P. Moreno, on that day in 1903, donated lands colonized by the government a few years earlier, under Indigenous domain and ceded to him for the formation of a park, which was only formally finalized during 1934.

This state model intervened in the regulation of markets, the creation and/or acquisition of its own companies, as well as regulated, directly or indirectly, the socio-environmental dimensions. An example of this is the valuable work of Fabiano Quadros Rückert (2021), who carries out a very detailed study of water management between the mid-nineteenth and early twentieth centuries, especially in the large cities of the State of Rio Grande do Sul, where water conflicts were resolved with greater state intervention. In the same region, Marluza Marques Harres (2021) analyzes the disputes over land and water since 1920 in a framework of economic protectionism, where rice cultivation progressively displaced livestock activity, with an increase in the construction of dams and the massive incorporation of mechanization. However, the water management monopolized by rice producers advanced, not only into the least touched environments until then (occupying wetlands and swamps), but also in parallel displaced peasants and other producers.

The growing process of urbanization and its complex environmental consequences in the Southern Cone emerged during the first half of the twentieth century. The urban population surpassed the rural population in Chile in 1940, while in Argentina that happened in 1914. These consequences are explained by Auyero and Swistun (2008) and Soluri et al. (2019), who state that the problems of hydrocarbon pollution in Greater Buenos Aires (Villa Inflamable) began around 1931 with the Shell Oil refinery. This has a precedent in the Argentine state oil company Yacimiento Petrolíferos Fiscales (YPF), created during the 1920s. Industrialization also produced high levels of lead contamination in Uruguay (Amorin 2001; Mañay et al. 2008). Other environmental effects of industrialization and regional urbanization can be found in the work of Reboratti (1989). This scenario would express that, although some economic activities slowed down their accelerating effect of climate change (such as the deforestation of the Chaco), a large amount of emissions are added to the equation, especially from large cities that sought to industrialize, and the large demographic increase generated higher levels of energy consumption.

An important dimension in the role of the Southern Cone in the Anthropocene is the growth of emissions due to the surprising urban growth of cities such as Santiago de Chile, Buenos Aires, Rosario, Montevideo and Porto Alegre (Hardoy 1978) since the mid-nineteenth century. Our area of analysis becomes one of the most urbanized regions on the planet by the middle of the twentieth century (Rivera 2016), and although urban emissions have not been calculated for the end of the nineteenth century, it would be important to estimate it in future work.

If we move to the rural area, we can mention a study that details and explains the construction of the local landscapes of the Yerbal basin, in Uruguay (Gautreau 2006). The same author states that during the first half of the twentieth century the consumption of woody generated by the production of charcoal gradually increased, doubling production in the area of the Yerbal valley by the 1950s. The processes were similar in the neighboring country "from the Second World War, when Argentina did not have foreign supplies of mineral fuels, it was mostly firewood and charcoal that replaced them, but at the cost of cutting down no less than 1,000,000 hectares annually" (Zarrilli 2007).

In addition, Reboratti makes comparisons between wet/dry cycles and agricultural cycles in the Province of Buenos Aires. A humid climatic cycle of the late nineteenth century that culminated in great floods in 1900, coincided with an agricultural cycle, the prolonged droughts between 1920 and 1935, favored the gradual decline of the previous cycle and the expansion of livestock, to be reversed again around 1970 with the current wet cycle that continues to this day and allowed the expansion of soybeans and the transfer of livestock to the edges of the Pampas (Reboratti 1989). These climatic cycles are shared with Uruguay, Southern Brazil and Paraguay, as they derive from the amount of rainfall in the South Atlantic. Climate change models predict that the wet cycle will continue, but its counterpart is increasingly recurrent droughts in central Chile and western Patagonia (dependent on the humid air masses of the South Pacific). It should be noted that, beyond the industrialization processes, South American economies continued to be highly dependent on agriculture. In this sense, it is worth highlighting a recent study that points to causality between the expansion of the agricultural frontier in the Chaco-pampean plain during the last forty years, and the increase in floodable areas within that same plain (Houspanossian et al. 2023). For the first half of the twentieth century, we do not have studies of this type, but it is likely that the behavior of the variables analyzed was similar to the previous decades of said analysis.

Different authors have focused their studies on the coasts of Chile, Argentina and Uruguay, emphasizing the history of fishing and indiscriminate hunting that took place in nineteenth-century marine environments, thus initiating the antecedents of the Anthropocene traces in the territorial seas of the Southern Cone (García 2009; Quiroz and Toledo 2014; Marín 2016; Mateo 2020).

If we refer to marine environments, during the twentieth century indiscriminate fishing grew considerably in different South American countries, between 1930 and 1940, with the capture of whales, tuna, and anchovy in northern Chile (Cunill Grau 1995) and on the Atlantic Patagonian coasts (Romero et al. 2022; Haller 2023).

Camus et al. 2022 studied the environmental conflicts between state expansion over maritime territory and artisanal fishermen at the beginning of the twentieth century. The production of nature and accumulation by dispossession did not diminish but increased with the advent of the new century. Favila Vázquez (2022) in her work for Mexico, develops, concepts and methodologies associated with the study of maritime cultural landscapes that would be highly recommended as a model to work with for other regions of the Southern Cone. The lack of studies on the subject is notorious. There are no studies that analyze the impact of fishing on Climate Change or the Anthropocene during the nineteenth or early twentieth century. There are valuable studies that studied the variability of fish populations before industrial fishing (Poulsen 2010; Schwerdtner Máñez and Poulsen 2016), although they are very focused on the northern hemisphere. Fishing had a negligible impact on the ichthyofauna of the open ocean in the pre-industrial fishing period ending by the Northern Hemisphere in the second half of the nineteenth century (Poulsen 2010). Between 1930 and 2010, Free et al. (2019) report a 4.1 percent decline in global productivity of marine fisheries. Some regions experienced losses of up to 35 percent. Among them, one of the regions most affected by a decline in marine fishing productivity is off the Chilean and Peruvian coasts.

It should be noted that studies on local perceptions of climate vulnerability and/or climate change in the Southern Cone are scarce, unlike the studies carried out in Mexico, Spain or Peru (Moseley 1981; Huertas 2001; Flores Galindo 1990; Carcelén Reluz 2010; Meseguer-Ruiz et al. 2022), which focus on analyzing Indigenous cosmovisions or Western religious manifestations as an indication of the search for stability in the face of climate variability and/or risks due to extreme weather events (Forero et al. 2014).

Conclusions

In 1972 the first version of the *Limits to Growth*, that hyper-cited modelling on a planetary scale where, based on computer models, with data from the year 1900, the evolution of five variables (natural resources, population quantity, pollution, per capita food and industrial production per capita) was calculated. It concluded in a scenario of collapse due to the progressive increase in all variables, except for the decrease in the availability of natural resources, which at some point would impact on a fall in the rest. That would happen, according to the report itself, during the twentyfirst century. Although criticisms, updates and debates on this model are not new, starting with the Latin American World Model (Herrera et al. 2004; Bardi 2014), it is true that a valuable aspect of such a report, and beyond the catastrophic tone, is the call to attention to the unexpected effects of an excessive growth in industrial activity and the use of natural resources. For similar problems, but from a different logic, Jorge Riechman (2014) took up Ugo Bardi's reflections asking whether a sustainable industrial society is possible. Riechman focuses on the system of production and consumption, and that is why we look for those traces and traces in the preceding pages.

Among the results of our review, we provide studies that help confirm that there has been a great South American acceleration since 1850 (in some cases since 1870 more precisely), almost entirely based on the very intense exploitation of natural resources. It is precisely during these years that the processes of formation and consolidation of nation states take place in Latin America (also for the Southern Cone). These processes included the consequent incorporation into the International Division of Labor, through the Agrarian Export Models that were based on the use of new lands to be exploited (Ansaldi and Giordano 2012).

Added to this was the use of hydrocarbons and their associated models, already during the twentieth century. This again means another leap in the scale of production, consumption and environmental impacts (McNeill and Engelke 2016) coinciding with the Great Global Acceleration (McNeill 2014).

Much has been reflected on nineteenth-century literature and science, which had marked influences of romanticism and positivism in Latin America. The elites, strongly influenced by Europeanized, Cartesian and Modern ontologies, justified the establishment and dissemination of productive systems with little awareness of social inequality, racism, and which were environmentally wasteful of natural resources. For the processes we study, it is necessary to mention those dominant imaginaries that fostered the processes of organization of nations by commemorating triumphs over "the natural." In the extreme south of the continent, there are abundant representations of exuberant, imposing and challenging landscapes, almost always empty of population, or occupied by supposedly "backward" inhabitants. Landscapes that were narrated as hostile, that "generated" "barbaric" Indigenous and creole cultures, within the framework of strongly deterministic visions. In the perspective of these elites, it was necessary to bend the nature that literally determined this type of society.

Thus, during much of the nineteenth century, the imaginaries linked to Iberian colonialism, with Christian roots, were at odds with lay and secular visions, which fought Christian metaphysics or Indigenous beliefs alike. Thus, for most of the century, the dominant confrontations were between conservatives and liberals. It was only towards the beginning of the twentieth century that anarchist and/or socialist visions became more common. There were then more harmonious experiences with the use of natural resources, with common goods and with different "non-human" agents, but arguably they came from territories not reached by capitalist modernization, and where sometimes Indigenous or creole cultures were preserved with communal forms of subsistence and low productive scale.

The rereading of sources and the rescue of alternatives to European-style progress and development that generated serious environmental problems (fostered Climate Change and impressive changes in land use) is of great importance, at least in two senses: on the one hand, on a material and practical level of complicating the historical explanation with regard to actors, actants and processes that have been made invisible, in order to better understand territories and societies. On the other, on a symbolic level that nourishes optimism and allows us to broaden horizons, in the crises and in the current challenges of socio-environmental subsistence.

Studies such as the ones that have served as secondary sources for this manuscript have experienced a sustained growth in recent decades. However, they focus on specific areas of the region and with often disciplinarily narrower views. Thus, research on economic history, environmental anthropology, geography or historical archaeology still does not tend to dialogue sufficiently with each other. Such dialogues would however be very timely to establish more precise connections regarding processes such as the Anthropocene, Global Change or Climate Change. Studies from environmental history have in some way corrected these shortcomings, but those that, either from historical climatology or other social dimensions of the processes associated with climate change, have an analytic perspective focused on the conjunction of social and environmental processes of medium and long duration are still incipient (Prieto et al. 2018). The main antecedents and thematic references stand out in Brazil, Argentina and the Pacific coast of South America (Peru and Chile). The quantitative representation of these studies in Paraguay, Bolivia and Uruguay is still scarce, but they have great analytical potential, especially if future analyses are carried out that go beyond national borders.

As highlighted by Leal et al. (2019) a characteristic of Latin America that is accentuated in the Southern Cone is the rise of middle classes during the twentieth century, largely defined by consumption (for example, meat, specific neighborhoods and leisure travel), in addition to governments that depend on natural rents to maintain their legitimacy and technological systems of high energy consumption.

Based on the compilation and analysis of the current discussions on Climate Change and the Anthropocene in the Southern Cone (1810–1950), we have thus attempted to provide a first synthetic perspective of this subject. As has been observed throughout the chapter, the systematic and in-depth approach to the impact of the Anthropocene (in quantitative-qualitative terms) is a pending debt that the academic field has towards the societies of the Southern Cone. The general tone of this chapter may have sounded very upbeat, but we allow ourselves to end with this reflection by Ezequiel Adamovsky:

> As if they were reminding us that good living will not come from the refuge of each one in the comfort of their private affairs, but from the vigor with which we sustain the collective. So much discomfort may then have a productive side. It may be from there that we will walk towards a future different from that other, gray and uncertain, that is announced to us today everywhere (2022: 365).

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References

Abraham, Elena, and María del Rosario Prieto. 1991. "Contributions of Historical Geography to the study of processes of landscape change: The case of Guanacache, Mendoza, Argentina." *Bamberger Geographische Schriften* 11: 309–336.

———. 1999. "Vitivinicultura y desertificación en Mendoza." In *Estudios de historia y ambiente en América I: Argentina, Bolivia, México, Paraguay*, ed. Bernardo García Martínez and Alba González Jácome, 109–135. Mexico City: El Colegio de México/IPGH.

Aceituno, Patricio, María del del Rosario Prieto, María Eugenia Solari, et al. 2009. "The 1877–1878 El Niño episode: Associated impacts in South America." *Climatic Change* 92, no. 3–4: 389–416.

Adamovsky, Ezequiel. 2022. *Historia de la Argentina*. Buenos Aires: Editorial Crítica.

Amorin, Carlos. 2001. *Plomo para toda la vida. La verdadera historia de una contaminación masiva*. Montevideo: Nordan Comunidad.

Aniya, Masamu, Renji Naruse, Masami Shizukuishi, et al. 1992. "Monitoring recent glacier variations in the Southern Patagonia Icefield, utilizing remote sensing data." In *International Archives of Photogrammetry and Remote Sensing: Committee of the XVII International Congress for Photogrammetry and Remote Sensing*, ed. Lawrence W. Fritz and James R. Lucas, 87–94. Washington, D.C.: International Society for Photogrammetry and Remote Sensing.

Ansaldi, Waldo, and Verónica Giordano. 2012. *América Latina. La construcción del orden: Tomo I de la colonia a la disolución de la dominación oligárquica*. Buenos Aires: Ariel.

Antico, Andrés, and Mathias Vuille. 2022. "ENSO and Parana flow variability: Long-term changes in their connectivity." *International Journal of Climatology* 42: 7269–7279.

Assadourian, Carlos. 1982. *El sistema de la economía colonial: mercado interno, regiones y espacio económico*. Lima: Instituto de Estudios Peruanos.

Auyero, Javier, and Débora Swistun. 2008. "Flammable: Environmental Suffering in an Argentine Shanytown." *American Sociological Review* 73, no. 3: 357–379.

Bandieri, Susana. 2009. *Historia de la Patagonia*. Buenos Aires: Editorial Sudamericana.

Bermúdez, Óscar. 1963. *Historia del salitre desde sus orígenes hasta la Guerra del Pacífico*. Santiago de Chile: Ediciones de la Universidad de Chile.

Bialet Massé, Juan. 1904. *Informe sobre el estado de las clases obreras en el interior de la República*. Buenos Aires: Imprenta y Casa Editora Coni.

Blanco, Graciela. 2010. "Estado Nacional y avance de la frontera productiva: propietarios y ocupantesen la Patagonia Argentina a fines del siglo XIX y primeras décadas del XX." Paper presented at the VIII Congreso Latinoamericano de Sociología Rural, Laboter – Laboratório de Estudos e Pesquisas das Dinâmicas Territoriais, Recife, November 15–19.

Bonilla, Heraclio. 1974. *Guano y burguesía en Perú: contrastes y paralelos en el marco de la región andina*. Lima: Instituto de Estudios Peruanos.

Bowman, Isaiah. 1924. *Desert Trails of Atacama*. New York: American Geographical Society.

Brailovsky, Antonio, and Diana Foguelman. 1991. *Memoria verde: historia ecológica de la Argentina*. Buenos Aires: Editorial Sudamericana.

Brandt, Marlon, and Samira P. Moretto. 2022. "The Caboclo Population of the Araucaria Forest of Santa Catarina: Common Use of Land, Expropriation and Marginalization." *Historia Ambiental Latinoamericana y Caribeña* 12, no. 2: 55–80.

Brown, Kendall. 2012. *A History of Mining in Latin America. From the colonial era to the present*. Albuquerque: University of New Mexico Press.

Burkart, Rodolfo, and Lucía del Valle Ruiz. 1994. *El Sistema Nacional de Áreas Naturales Protegidas de la Argentina. Diagnóstico de su patrimonio natural y su desarrollo institucional*. Buenos Aires: Administración de Parques Nacionales.

Bushnell, David. 1991. "La independencia de la América del Sur española." In *Historia de América Latina*. Vol. 5, *La independencia*, ed. Leslie Bethell, 75–123. Barcelona: Editorial Crítica.

Cai, Wenju, Agus Santoso, Guojian Wang, et al. 2015. "ENSO and greenhouse warming." *Nature Climate Change* 5: 849–859.

Camus Gayan, Pablo. 2004. "Los bosques y la minería del Norte Chico, S. XIX. Un mito en la representación del paisaje chileno." *Historia* 37, no. 2: 289–310.

Camus Gayan, Pablo, Rodrigo Hidalgo Dattwyler, and Enrique Muñoz Figueroa. 2022. “Microhistorias del mar: El Estado de Chile y la construcción burocrática de los espacios marítimos y litorales a inicios del siglo XX (1907–1929).” *Diálogo Andino* 67: 290–300.

Campal, Esteban. 1962. *Hombres, tierra y ganado*. Montevideo: Talleres Gráficos Treinta y Tres S. A.

Canales Cornejo, Camila. 2020. “Influencia de la variabilidad climática del último siglo sobre los patrones de crecimiento radial y mortalidad de un bosque de Nothofagus del Parque Nacional Radal Siete.” Master’s thesis, Universidad de Chile.

Carcelén Reluz, Carlos Guillermo. 2010. “La idolatría indígena como manifestación de la búsqueda de estabilidad ante la variabilidad climática en el centro del Perú, siglo XVIII.” *Diálogo Andino* 35: 57–68.

Cárdenas, Susana. 2022. “Más de un bicentenario entre el guano y el mar.” In *Desafíos y perspectivas de la situación ambiental en el Perú: en el marco de la conmemoración de los 200 años de vida republicana*, ed. Aída Castro and María Isabel Merino, 81–96. Lima: INTE-PUCP.

Castro, Joaquín. 2022. “El Costo de la Libertad. Un Acercamiento Metabólico a la Guerra de Independencia Chilena (1814–1817).” *Historia Ambiental Latinoamericana y Caribeña* 12, no. 2: 419–434.

Castro Castro, Luis. 2020. “El bosque de la Pampa del Tamarugal y la industria salitrera: el problema de la desforestación, los proyectos para su manejo sustentable y el debate político (Tarapacá, Perú-Chile 1829–1941).” *Scripta Nova. Revista Electrónica de Geografía y Ciencias Sociales* 24, no. 641: 1–37.

Castro Herrera, Guillermo. 2004. “José Martí: para una cultura latinoamericana de la naturaleza.” *Polis* 7: 1–6.

Ceroni Galloso, Mario. 2012. “Perú, el país de las oportunidades perdidas en ciencia: el caso de los fertilizantes.” *Revista de la Sociedad Química del Perú* 78, no. 2: 144–152.

Cepparo de Grosso, María Eugenia. 2001. “Southern Patagonia facing globalization.” In *Globalization and Marginality in Geographical Space*, ed. Heikki Jussila, Roser Majoral, and Fernando Delgado-Cravidao, 53–61. Aldershot: Ashgate.

Coker, Robert E. 1908. “Regarding the future of the guano industry and the guano-producing birds of Peru.” *Science* 28, no. 706: 58–64.

Contreras Carranza, Carlos. 2012. *La economía pública en el Perú después del guano y del salitre: crisis fiscal y élites económicas durante su primer siglo independiente*. Lima: Instituto de Estudios Peruanos.

Córdoba, Francisco, Lucía Guerra, Carolina Celeste Cuña Rodríguez, et al. 2015. “Una visión paleolimnológica de la variabilidad hidroclimática reciente en el centro de Argentina: desde la pequeña edad de hielo al siglo XXI.” *Latin American Journal of Sedimentology and Basin Analysis* 21, no. 2: 139–163.

Crovetto, Marcela. 2011. “Movilidad espacial, ocupación y empleo en el Valle Inferior del Río Chubut.” *Trabajo y Sociedad* 17: 363–380.

Cunill Grau, Pedro. 1995. *Las transformaciones del espacio geohistórico latinoamericano 1930–1990*. Mexico City: El Colegio de México/Fondo de la Cultura Económica.

Cushman, Gregory T. 2011. "Humboldtian Science, Creole Meteorology, and the Discovery of Human-Caused Climate Change in Northern South America." *Osiris* 26, no. 1: 19–44.

———. 2018. *Los señores del Guano. Una historia ecológica global del Pacífico*. Lima: Instituto de Estudios Peruanos.

Dall'Alba, João Leonir. 1984. *Os Dall'Alba: Cem anos de Brasil*. Porto Alegre: Editora da Universidad de Caxias do Sul.

Davis, Mike. 2006. *Los holocaustos de la Era Victoriana tardía. El Niño, las hambrunas y la formación del Tercer Mundo*. Valencia: Universitat de València.

Davis, Heather, and Zoe Todd. 2017. "On the Importance of a Date, or, Decolonizing the Anthropocene." *ACME: An International Journal for Critical Geographies* 16, no. 4: 761–780.

Dean, Warren. 1996. *A ferro e fogo: a história e a devastação da Mata Atlântica brasileira*. São Paulo: Cia. das Letras.

Del Puerto, Laura, Felipe García-Rodríguez, Roberto Bracco, et al. 2013. "Historia Ambiental y Dinámica Cultural para el Holoceno medio y tardío en el este del Uruguay." In *En clave inter. Procesos, contextos y resultados del trabajo interdisciplinario*, ed. Ximena Aguiar and Paula Cruz, 99–109. Montevideo: Mastergraf SRL.

Denis, Pierre. 1920. *La République Argentine, la mise en valeur du pays*. Paris: Armand Colin.

Delrio, Walter. 2010. *Memorias de expropiación. Sometimiento e incorporación indígena en la Patagonia 1872–1943*. Buenos Aires: Universidad Nacional de Quilmes.

Diario Los Andes. 1924. November 7, 5.

Dinerstein, Eric et al. 2017. An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm. *BioScience*, 67 (6), 534–545.

Djenderedjian, Julio. 2008. *Historia del capitalismo agrario pampeano: la agricultura pampeana en la primera mitad del siglo XIX*. Buenos Aires: Siglo Veintiuno/Editorial de Belgrano.

Dore, Elizabeth. 2000. "Environment and society: Long-term trends in Latin American mining." *Environmental History* 6, no. 1: 1–29.

Ejarque, Mercedes. 2013. "Reconstruyendo la historia ambiental de las tierras secas chubutenses (Argentina)." *Zonas Áridas* 15, no. 1: 169–187.

Elizalde Mac-Clure, Rafael. 1970. *La Sobrevivencia de Chile. La Conservación de sus Recursos Naturales*. Santiago de Chile: Ministerio de Agricultura.

Farinatti, Luis. 2018. "La Historia Agraria en el sur de Brasil: un panorama sobre los últimos avances historiográficos." *Boletín del Instituto de Historia Argentina y Americana Dr. Emilio Ravignani* 48: 174–206.

Favila Vázquez, Mariana. 2022. "Los paisajes culturales marítimos: aproximaciones desde la historia y la arqueología." In *Historia ambiental de América Latina. En-*

foques, procedimientos y cotidianidades, ed. Pedro Sergio Urquijo Torres, Adi Lazos, and Karine Lefebvre, 199–221. Universidad Nacional Autónoma de México, México.

Fernández Cirelli, Alicia. 2007. "La actividad ganadera: Vacas peligrosas." *Encrucijadas* 41: 1–7.

Flores Galindo, Alberto. 1990. "Buscando un Inca." In *Resistencia, rebelión y conciencia campesina en los Andes. Siglos XVIII al XX*, ed. Steven Stern, 187–202. Lima: Instituto de Estudios Peruanos.

Folchi, Mauricio. 2005. "Los efectos ambientales del beneficio de minerales metálicos – un marco de análisis para la historia ambiental." *Varia Historia* 33: 32–57.

Forero, Emma Lucía, Yolanda Teresa Hernández, and Carlos Alfonso Zafra. 2014. "Percepción latinoamericana de Cambio Cllimático: metodologías, herramientas y estrategias de adaptación en comunidades locales. Una revisión." *Revista de Universidad de Ciencias Aplicadas y Ambientales. Actualidad & Divulgación Científica* 17, no. 1: 73–85.

França, Ana Marcela, Juan Manuel Cerdá, and José Muzlera. 2022. "Las Transformaciones de los Espacios Rurales Argentinos: Paisajes Imaginados y Cambios Socio Ambientales (1880–1930)." *Historia Ambiental Latinoamericana y Caribeña* 12, no. 2: 20–54.

Free, Christopher M., James T. Thorson, Malin L. Pinsky, et al. 2019. "Impacts of historical warming on marine fisheries production." *Science* 363, no. 6430: 979–983.

Frontoms, Gabriel. 2009. "La economía argentina durante el ciclo de la lana." *Invenio* 12, no. 22: 61–66.

Gallero, María Cecilia, and Marina Miraglia. 2021. "Transformaciones ambientales de la Selva Paranaense (relicto de la Mata Atlántica) en la triple frontera de Brasil-Argentina-Paraguay entre 1810 y 2020." *Historia Ambiental Latinoamericana y Caribeña* 11, no. 1: 222–252.

García, Susana V. 2009. "El estudio de los recursos pesqueros en la Argentina de fines del siglo XIX." *Revista Brasileira de História da Ciência* 2, no. 2: 202–221.

García-Herrera, Ricardo, Henry Díaz, Rolando R. García, et al. 2008. "A chronology of El Niño events from primary documentary sources in Northern Perú." *Journal of Climate* 21: 1949–1962.

Gascón, Margarita. 2014. "Etnoclimatología en la Araucanía y las pampas. Clima y relaciones interétnicas entre los siglos XVI y XIX." *Dimensión Antropológica* 60: 37–60.

Gatica, Héctor David. 2003. "Memoria de los Llanos." In *Obras Completas*, Héctor David Gatica. Córdoba: EUDELAR. Orig. pub. 1961.

Gautreau, Pierre. 2006. "Relatos de crisis ambiental en el Río de la Plata. Una evaluación geográfica de 300 años de relatos de "destrucción" de los bosques uruguayos (siglos XVIII al XX)." PhD diss., Université des Sciences et Technologies de Lille.

Gay, Claudio. 1838. "Memoria sobre las causas de la disminución de los bosques en la provincia de Coquimbo." *El Araucano* 399: 2.

Gergis, Joëlle, and Anthony M. Fowler. 2009. "A history of ENSO events since A.D. 1525: implications for future climate change." *Climatic Change* 92: 343–387.

Giberti, Horacio. 1961. *Historia económica de la ganadería argentina*. Buenos Aires: Ediciones Solar.

Glacken, Clarence. 1976. *Traces on the Rhodian Shore*. Berkeley: University of California Press.

Glade, William. 1991. "América latina y la economía internacional, 1870–1914." In *Historia de América Latina*. Vol. 7, *América Latina: economía y sociedad, c. 1870–1930*, ed. Leslie Bethell, 1–49. Barcelona: Editorial Crítica.

González, Cinthya C., Magdalena Llorens, and Daniela Anabel Calderón. 2018. "Principales impactos esperados y actividades de adaptación propuestas frente al Cambio Global para el centro-norte del Chubut, Patagonia Argentina." *Naturalia Patagónica* 11: 43–58.

González de Molina, Manuel, and Víctor Toledo. 2014. *The Social Metabolism: A Socio-Ecological Theory of Historical Change*. New York: Springer.

González Marilicán, Matías. 2022. "De la crítica a la admiración. Cambios actitudinales de occidente hacia el bosque nativo de la Araucanía, Chile (1850–1900)." *Diálogo andino* 67: 269–279.

González-Reyes, Álvaro, James McPhee, Duncan A. Christie, et al. 2017. "Spatiotemporal variations in hydroclimate across the Mediterranean Andes (30°–37°S) since the early 20th century." *Journal of Hydrometeorology* 18, no. 7: 1929–1942.

Gortari, Javier. 2017. "'Maldita' Yerba Mate: explotación de la mano de obra en las minas yerbateras del Paraguay Colonial." In *Tareferos. Vida y Trabajo en los Yerbales*, ed. Daniel Ré, María Luz Roa, and Javier Gortari, 31–58. Posadas: Edunam.

Goularte, Gustavo. 2015. "Fronteira do Jaguarão: unidades produtivas e trabalho escravo na formação de um espaço fronteiriço, 1801–1835." Master's thesis, Universidade Federal do Rio Grande do Sul.

Grau, H. Ricardo, and Javier Foguet. 2021. "El legado de la urbanización europea en el cono sur sudamericano: Una aproximación a la historia de las teleconexiones sobre la ecología del territorio." *Ecología Austral* 31: 114–128.

Grove, Richard H. 1997. *Ecology, Climate and Empire. Colonialism and Global Environmental History 1400–1940*. Cambridge: White Horse Press.

Guerrido, Claudia, Ricardo Villalba, and Facundo Rojas. 2014. "Documentary and tree-ring evidence for a long-term interval without ice impoundments from Glaciar Perito Moreno, Patagonia, Argentina." *The Holocene* 24, no. 11: 1–8.

Haller, Sofia Clara. 2023. *Balleneros, Loberos y Guaneros en Patagonia y Malvinas. Una historia socioambiental del mar 1800–1914*. Buenos Aires: Editorial Sb.

Haraway, Donna. 2015. "Anthropocene, capitalocene, plantatio-nocene, chthulucene: Making kin." *Environmental Humanities* 6, no. 1: 159–165.

———. 2019. *Quedarse con el problema: hacer parientes en el Chthulucene*. Bilbao: Editorial Consonni.
Hardoy, Jorge E. 1978. "La construcción de las ciudades de América Latina a través del tiempo." *Problemas del Desarrollo. Revista Latinoamericana De Economía* 34: 83–118.
Herrera, Amílcar O., Hugo D. Scolnick, Gabriela Chichilnisky, et al. 2004. *Catástrofe o nueva sociedad?: Modelo Mundial Latinoamericano: 30 años después*. Ottawa: Centro Internacional de Investigaciones para el Desarrollo.
Herrera Roberto G., Maria del Rosario Prieto, and Facundo Rojas. 2011. "Lluvias, sequías e inundaciones en el Chaco semiárido argentino entre 1580 y 1900." *Revista de la Junta de Estudios Históricos de Santa Fe* 65: 173–200.
Hobsbawm, Eric. 1987. *The Age of Empire: 1875–1914*. London: Weidenfeld & Nicolson.
Houspanossian, Javier, Raul Giménez, Juan I. Whitworth-Hulse, et al. 2023. "Agricultural expansion raises groundwater and increases flooding in the South American plains." *Science* 380, no. 6652: 1344–1348.
Huertas, Lorenzo. 2001. *Diluvios Andinos. A través de las fuentes documentales*. Lima: Pontificia Universidad Católica del Perú.
Instituto Brasileño de Geografía y Estadística (2020). Malha Municipal Digital do Brasil. Rio de Janeiro: IBGE. Disponible en: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/malhas-territoriais/15774-malhas.html.
Instituto Geográfico Nacional (2022). Capas SIG. Capas de información geoespacial para su descarga en: https://www.ign.gob.ar/NuestrasActividades/InformacionGeoespacial/CapasSIG.
Intergovernmental Panel on Climate Change (IPCC), ed. 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.
James, Preston. 1942. *Latin America*. New York: John Wiley.
Jefferson, Mark. 1926. *Peopling the Argentine Pampa*. New York: American Geographical Society.
Lanfranco, Bruno, Enrique Fernández, Bruno Ferraro, et al. 2022. "Historical changes in the Pampa biome, land use, and climate change." In *Handbook of Behavioral Economics and Climate Change*, ed. S. Niggol Seo, 162–192. Cheltenham: Edward Elgar Publishing.
Leal, Claudia, John Soluri, and José Augusto Pádua. 2019. *Un pasado vivo. Dos siglos de historia ambiental latinoamericana*. Bogotá: Fondo de Cultura Económica.
López de Albornoz, Cristina. 1997. "Crisis agrícolas y crisis biológicas en la jurisdicción de San Miguel de Tucumán en la segunda mitad del siglo XVIII." In *Historia y desastre en América Latina* Vol. 2, ed. Victoria García Acosta, 163–186. Lima: Red de Estudios Sociales en Prevención de Desastres en América Latina.
Mañay, Nelly, Adriana Z. Cousillas, Cristina Alvarez, et al. 2008. "Contaminación por plomo en Uruguay: el caso del barrio 'La Teja'." In *Reseñas de contaminación am-*

biental y toxicología. Reseñas de Contaminación Ambiental y Toxicología, ed. David M. Whitacre, 93–115. New York: Springer.

Mare, Federico. 2019. *El éxodo galés a la Patagonia: Orígenes, trasfondo histórico y singularidad cultural de Y Wladfa*. Mendoza: EDIUNC.

Marín, Yamandu. 2016. "La pesca industrial uruguaya desde la perspectiva de los sistemas social-ecológicos." Master's thesis, Universidad de la República.

Martínez-Díaz, Nelson. 1987. *Los ferrocarriles británicos en Uruguay: desde sus orígenes hasta la crisis del 90*. Montevideo: Ediciones del Nuevo Mundo.

Mateo, José Antonio. 2020. "La sustitución de importaciones pesqueras y el desarrollo de la pesca comercial marítima en Argentina (1930–1965)." *Estudios Atacameños* 65: 85–103.

McBride, George. 1938. *Chile: su tierra y su gente*. Santiago de Chile: Universidad de Chile.

McNeill, John Robert. 2014. *The Great Acceleration: An Environmental History of the Anthropocene since 1945*. Cambridge: Harvard University Press.

Mc Quilkin, Christopher. 2022. "'A National Calamity': Locust Eradication Efforts in Argentina, ca. 1890–1920." *Historia Ambiental Latinoamericana y Caribeña* 12, no. 2: 359–388.

Meseguer-Ruiz, Óliver, Manuel Prieto, and Kassandra V. González Carimán. 2022. "Conocimiento ecológico tradicional en el Altiplano chileno: entre la variabilidad climática y la percepción local." *Revista de Geografía Norte Grande* 83: 107–123.

Mitre, Antonio. 1981. *Los patriarcas de la plata: estructura socioeconómica de la minería boliviana en el siglo XIX*. Lima: Instituto de Estudios Peruanos.

Moore, Jason. 2017. "The Capitalocene, Part I: on the nature and origins of our ecological crisis." *The Journal of Peasant Studies* 44, no. 3: 594–630.

Moraes, María Ines. 2012. "Las transformaciones rurales en el Uruguay de la segunda mitad del siglo XIX: una síntesis revisada." In *Agricultura y modernizacion 1840–1930*, ed. Alcides Beretta Curi, 13–42. Montevideo: Universidad de la República.

Morales, Mariano, Edward R. Cook, and Jonathan Barichivich. 2020. "Six hundred years of South American tree rings reveal an increase in severe hydroclimatic events since mid-20th century." *Proceedings of the National Academy of Sciences (PNAS)* 117, no. 29: 16816–16823.

Moseley, Michael, Robert Feldman, and Charles Ortloff. 1981. "Living with crisis. Human perception of process and time." In *Biotic Crisis in Ecological and Evolutionary Time. Latin American Studies Program*, ed. Matthew Nitecki, 231–268. Ithaca: Cornell University.

Natenzon, Claudia, and Gabriela Olivera. 1994. "La tala del bosque en los Llanos de la Rioja (1900–1960)." *Desarrollo Económico* 34, no. 134: 263–284.

Nodari, Eunice Sueli. 2009. *Etnicidades renegociadas: prácticas socioculturais no oeste de Santa Catarina*. Florianopolis: UFSC.

———. 2013. "Um olhar sobre o oeste de Santa Catarina sob o viés da história ambiental." *Revista História: Debates e Tendências* 9, no. 1: 136–150.

Nodari, Eunice Sueli, and Marco Aurelio Espíndola. 2013. "Relações complexas: as estiagens no oeste de Santa Catarina." In *Migrações e Natureza*, ed. Eunice Sueli Nodari and Silvio Marcus de Souza Correa, 165–184. São Leopoldo: Oikos Editora.

O'Brien, Thomas. 1982. *The Nitrate Industry and Chile's critical transition 1870–1891*. New York: New York University Press.

Olivera, Gabriela. 2000. *Por Travesías y Oasis. Mercados de producción agraria y actores sociales de La Rioja (Los Llanos y Arauco, 1900–60)*. Córdoba: Editorial Universitaria U.N.C.

Osório, Helen. 2007. *O Império Português no sul da América. Estancieiros, lavradores e comerciantes.* Editora da UFRGS, Porto Alegre.

Paine, Alice, Fabian Ben Wadsworth, James Baldini, et al. 2022. "The case for volcanism as a major driver of Last Glacial millennial-scale climate change." Paper presented at Volcanic and Magmatic Studies Group Annual Meeting. University of Manchester and The Geological Society, January 10–12.

Patel, Raj, and Jason Moore. 2018. *A history of the world inseven cheap things: A guide to capitalism, nature, and the future of the planet*. London: Verso.

Pavetti, Daniel R. 2010. "Consideraciones para una Historia de la deforestación en el Paraguay." In *Geonaturalia, Geografía e Historia natural. Hacia una historia comparada. Estudio a través de Argentina, México, Costa Rica y Paraguay*, ed. Celina Ana Lertora Mendoza, 299–306. Buenos Aires: Ediciones FEPAI.

Pengue, Walter. 2023. *Economía ecológica, recursos naturales y sistemas alimentarios: ¿Quién se come a quién?*. Buenos Aires: Orientación Gráfica Editora.

Peri, Pablo Luis, Luis Mario Chauchard, Alejandro Brown, et al. 2021. "Historia y situación actual del uso del bosque nativo y principales técnicas silvícolas." In *Uso sostenible del bosque: Aportes desde la Silvicultura Argentina*, ed. Pablo Peri, Guillermo José Martínez Pastur, and Tomás Miguel Schlichter, 112–167. Buenos Aires: Ministerio de Ambiente y Desarrollo Sostenible de la Nación.

Piantoni, Giulietta. 2016. "La fundación de Parques Nacionales y sus agencias de control en Argentina y Brasil: una propuesta comparativa en la primera mitad del siglo XX." *Cuadernos del Sur – Historia* 45: 105–129.

Piel, Jean. 1995. *El capitalismo agrario en el Perú.* Lima: Instituto Francés de Estudios Andinos/Universidad Nacional de Salta.

Poulsen, Bo. 2010. "The variability of fisheries and fish populations prior to industrialized fishing: An appraisal of the historical evidence." *Journal of Marine Systems* 79: 327–332.

Pratt, Mary Louise. 2010. *Ojos imperiales. Literatura de viajes y transculturación*. Mexico City: Fondo de Cultura Económica.

Prieto, María del Rosario. 2007. “ENSO signals in South America: Rains and floods in the Parana River during colonial times.” *Climate Change* 83: 39–54.

Prieto, María del Rosario, and Elena M. Abraham. 1998. “Historia ambiental del sur de Mendoza (siglos XVI al XIX). Los factores críticos de un proceso de desertificación.” *Bamberger Geographische Schriften* 15: 277–297.

Prieto, María del Rosario, and Facundo Rojas. 2012. “Climatic variations in the Cordillera de Los Andes and their consequences over the environmental and social processes in the Mendoza Northern Oasis, between the 19th and 20th Century.” *Climate of the Past* 8: 951–961.

———. 2013. “Climate anomalies and epidemics in South America at the end of the Colonial Period.” *Climate Change* 118, no. 3: 641–658.

———. 2015. “Determination of droughts and high floods of the Bermejo River (Argentina) based on documentary evidence (17th to 20th century).” *Journal of Hydrology* 529: 676–683.

———. 2018. “Climate History in Latin America.” In *The Palgrave Handbook of Climate History*, ed. Sam White, Christian Pfister, and Franz Mauelshagen, 213–224. Basingstoke: Palgrave Macmillan.

Prieto, María del Rosario, María Eugenia Solari, Juana Crouchet, et al. 2012. “Fuentes documentales para el estudio del clima en la región sur-austral de Chile (40°–51° S) durante los últimos siglos.” *Bosque* 33, no. 2: 135–144.

Quadros Rûckert, Fabiano, Fabio Alexandre dos Santos, and Guillermo Banzato. 2021. *Aguas y políticas públicas en Argentina, Brasil y México*. Jaén: Editorial Universidad de Jaén.

Quiroz, Daniel, and Patricio Toledo, eds. 2014. *Balleneros del Sur. Antropología e Historia de la industria ballenera en las costas sudamericanas*. Santiago de Chile: Andros.

Reboratti, Carlos. 1989. *Población y ambiente en América Latina*. Buenos Aires: PROLAB/Grupo Editor Latinoamericano.

Reclus, Eliseé. 1893. “L'Amazonie de La Plata.” In N*ouvelle géographie universelle. La Terre et les hommes*, Vol. 19, *Amérique du Sud*, ed. Eliseé Reclus. Paris: Hachette.

Reyes Abadie, Washington, Oscar H. Bruschera, and Tabaré Melogno. 1974. *La Banda Oriental: pradera, frontera, puerto*. Montevideo: Ediciones de la Banda Oriental.

Ríos, W. 1958. “Lanas vs. Sintéticos.” *Argentina Austral* 29, no. 316: 33.

Rivera, Jorge Andrés. 2016. “Análisis geo-histórico del proceso de urbanización en América del Sur: de la ciudad indoamericana a la ciudad neoliberal.” *Perspectiva Geográfica* 21, no. 1: 151–178.

Rivera, Andrés, Juan Carlos Aravena, Alejandra Urra, et al. 2021. “Glaciares de la Patagonia Chilena y Consecuencias Medioambientales de sus Cambios.” In *Conservación en la Patagonia chilena: evaluación del conocimiento, oportunidades y desafíos*, ed. María José Martínez-Harms, Juan Carlos Castilla, and Juan J. Armesto, 473–491. Santiago de Chile: Ediciones Universidad Católica.

Rojas, Facundo. 2013. "Rol de la minería y el ferrocarril en el desmonte, del oeste riojano y catamarqueño (Argentina), en el período 1850–1940." *Revista Población y Sociedad* 20, no. 1: 5–39.

———. 2021. "Dimensiones sociales y territoriales de las sequías en San Juan (siglos XVIII–XXI): una propuesta de periodización." *Punto Sur* 5: 64–90.

Rojas, Facundo, Osvaldo Sironi, and Facundo Martín. 2023. "Sequías en Mendoza (Argentina): una mirada sociohistórica desde la segunda mitad del siglo XIX." *Agua y Territorio* 22: 147–166.

Rojas, Facundo, and Maria del Rosario Prieto. 2020. "La variabilidad hídrica en la cuenca del río Atuel, desde la climatología histórica. Siglo XVIII a mediados del XX." *Cuadernos de Geografía. Revista Colombiana de Geografía*, 29, no. 2: 326–353.

Romero, María Alejandra, Mariano A. Coscarella, Grant Adams, et al. 2022. "Historical reconstruction of the population dynamics of southern right whales in the southwestern Atlantic Ocean." *Scientific Reports* 12: 1–17.

Ruiz, Lucas Ernesto, Pedro Miguel Pitte, Andres Rivera, et al. 2022. "Current State and Recent Changes of Glaciers in the Patagonian Andes (~37° S to 55° S)." In *Freshwaters and Wetlands of Patagonia. Natural and Social Sciences of Patagonia*, ed. Gabriela Mataloni and Ruben Dario Quintana, 59–91. New York: Springer.

Sagrilo, Lauro Pereira Zago. 2015. "Origem e evolução da pecuária de corte no Rio Grande do Sul." Master's thesis, Universidade Federal do Rio Grande do Sul.

Schwerdtner Máñez, Kathleen, and Bo Poulsen. 2016. *Perspectives on Oceans Past A Handbook of Marine Environmental History*. New York: Springer.

Silva, Wallace Machado da, Carlos José Saldanha Machado, and Rodrigo Machado Vilani. 2023. "A História Ambiental e as Eras do Homem e do Capital." *Historia Ambiental Latinoamericana y Caribeña* 13, no. 2: 114–142.

Sironi, Osvaldo. 2022. "La actividad minera en Cuyo durante el Virreinato del Río de la Plata y las Provincias Unidas en Sud-América: aportes desde la antropología histórica ambiental." In *Ante la "ira de Dios": naturaleza, desastres y respuestas en la América hispana, siglos XVIII y XIX*, ed. Emilio José Luque Azcona and María Eugenia Petit-Breuilh Sepúlveda, 349–385. Madrid: Editorial Sílex.

Solari, María Eugenia, Clara Cueto, Fernando Hernández, et al. 2011. "Construcción histórica de los paisajes regionales: cartas temáticas georreferenciadas de la cuenca del río Valdivia (siglos XVI–XIX)." *Revista de Geografía Norte Grande* 49: 45–62.

Soluri, John. 2023. "The Wild Side: Hunting Guanacos in Patagonia." *Global Environment* 16, no. 1: 40–56.

Studnicki-Gizbert, Daviken, and David Schecter. 2010. "The Environmental Dynamics of a Colonial Fuel-Rush: Silver Mining and Deforestation in New Spain, 1522 to 1810." *Environmental History* 15: 94–119.

Suárez, Pablo Ernesto. 2021. *Documentos para la historia del agua en Santa Fe*. Rosario: Prohistoria ediciones.

Tonni, Eduardo Pedro. 2017. "Cambios climáticos en la región pampeana oriental durante los últimos 1000 años. Una síntesis con énfasis en la información zoogeográfica." *Revista del Museo de La Plata* 2, no. 1: 1–11.

Vázquez Presedo, Vicente. 1971. *Estadísticas Históricas Argentinas Comparadas. Primera parte 1875–1914*. Buenos Aires: Macchi.

Vicuña Mackenna, Benjamin. 1877. *Ensayo Histórico sobre el clima de Chile: desde los tiempos prehistóricos hasta el Gran Temporal de julio de 1877*. Valparaíso: Imprenta del Mercurio.

Vilches, Flora, Charles Rees, and Claudia Silva. 2008. "Arqueología de asentamientos salitreros en la región de Antofagasta (1880–1930): síntesis y perspectivas." *Chungará (Arica)* 40, no. 1: 19–30.

Villalba, Ricardo. 1994. "Tree-ring and Glacial Evidence for the Medieval Warm Epoch and the Little Ice Age in Southern South America." *Climatic Change* 26: 183–197.

Wallerstein, Immanuel. 2007. "The Ecology and the Economy: What Is Rational?." In *Rethinking Environmental History. WorldSystem History and Global Environmental Change*, ed. Alf Hornborg, John Robert McNeill, and Joan Martinez-Alier, 379–389. Lanhan: Altamira Press.

Zarrilli, Adrián. 2004. "Historia y economía del bosque chaqueño: la mercantilización de los recursos forestales (1890–1950)." *Anuario IEHS* 19: 255–283.

———. 2007. "Bosques y agricultura. Una mirada a los límites históricos de sustentabilidad de los bosques argentinos en un contexto de la explotación capitalista en el siglo XX." *Luna Azul* 26: 87–106.

———. 2016. "Transformaciones ambientales y producción agroforestal: El Gran Chaco Argentino en el siglo XX." *História: Debates e Tendências* 16, no. 1: 53–71.

Zolezzi, Mario. 1993. "La destrucción del Bosque de La Soledad durante el Ciclo Salitrero de Tarapacá." *Camanchaca* 14: 6–8.

Climate Change in the Andes from the Mid-Nineteenth Century to 1950

The End of the Little Ice Age and the Imminence of an Andean Environmental Change

Katherinne Mora Pacheco

At the end of the nineteenth century, the Colombian writer José María Cordovez Moure warned his contemporaries about the transformations that were taking place in the *Sabana de Bogotá*, an area of the Eastern Cordillera of his country. Although at that time ecological studies had not yet taken shape and there was no talk of ecosystemic imbalances, experience showed him that the civilizing ideal of his time was causing irreversible damage to nature. In that way, for example, he lamented the practice of hunting both for pleasure and at a rate that prevented the animals from reproducing. In particular, the extermination of carrion-eating birds that contributed to hygiene and of other species that fed on the worms, insects, and fungi that affected potato and wheat crops was especially noteworthy, as it favored the spread of diseases and pests. In the waters, widespread fishing, whether with poisons or in the species' breeding areas, had led to the decline of crabs and an endemic fish, a species of catfish known regionally as *el capitán* (*Eremophilus mutisii*). Also, forest clearings for cereals and pastures were one of the reasons why Bogotá's rivers were drying up and could no longer supply its inhabitants (Cordovez 1893: 238–240).

As will be shown in this chapter, this type of ecosystem intervention was widespread in the Andes during the nineteenth and twentieth centuries, the same period in which the Little Ice Age ended and the gradual increase in global temperature began. The new republics – not yet industrialized, but within the framework of the ideals of civilization and progress, mastery of nature, and insertion into world markets – turned to the production of raw materials for export. These efforts were mainly focused on tropical crops and mining extraction, which required expanding the agricultural frontier, deforesting watershed and lowland areas, draining swamps, and channeling rivers. When droughts, frosts, heavy rainfall, and floods occurred, in many cases linked to the occurrence of El Niño/Southern Oscillation

(ENSO), not only had natural regulators and buffers such as forests and swamps been diminished, but multiple social practices of subsistence had also been lost.

Even for the instrumental period (the period from which on we have climate data measured and recorded regularly by instruments), making a climatic history of the entire Andean region poses methodological challenges. Conditions in the Andes are heterogeneous when it comes to the occurrence of ENSO. Although this is not an unalterable law, in general, in the warm phase, El Niño causes an increase in precipitation on the Peruvian coast and in Chile, while the north of South America and the Peru-Bolivia Altiplano experience a water deficit; in the cold phase, La Niña, however, the opposite conditions are present (Camus and Jaksic 2021; Caviedes 2001; Ortlieb 1995; Pabón and Torres 2007; Poveda, Waylen, and Pulwarty 2006). The Andes' geological, topographical, climatic, and ecosystemic diversity also means that discussions about drought or abundant rainfall must have a reference point particular to each area. For example, in the Norte Grande of Chile, where desert conditions and annual precipitation averages ranging predominately between 0.5 and 2 mm, rainfall of 20 mm may be considered atypical (Ortlieb 1995: 520). On the other hand, for the *Sabana de Bogotá* in Colombia, where the wettest areas have rainfall averages ranging between 1,400 and 2,000 mm per year (IGAC 1996: 1950), a dry year does not mean a total absence of rainfall; even with 700 mm of precipitation, the area would be facing a water deficit of at least 50 percent. As will be seen, abundance or scarcity will depend not only on the climate of each subregion, but on the conditions of diverse human groups, which faced the water extremes, too.

Another methodological challenge for the present synthesis has to do with previous studies on climate history in South America. For the nineteenth and twentieth centuries, a series of quantitative records exist, at least for the main cities of the Andes and for periods covering a few lustrums (five-year periods) or decades. However, few published works compile these ranges or cover the 120-year period covered by this chapter (Barrero 2005; Betancourt 1982; Camus and Jaksic 2021). The spatial and temporal delimitations, often related to economic junctures, are varied and make it difficult to establish comparisons. Selections are therefore shaped by these biasing factors. The concentration of political and economic power of the press and travelers who left accounts means that the sources speak more about densely populated and urban areas, while little is known about rural areas considered marginal to their own countries. Gaps in climate information are frequent, especially in the first half of the republican life of the Andean countries, which were cyclically involved in civil and international wars, military coups, and dictatorships. These same conditions, together with international economic crises, overshadowed the climatic or hydrometeorological context that increased pressure on Andean societies. These challenges present an incentive for further research in the region.

This chapter is divided into two parts. The first part points to some evidence regarding the end of the Little Ice Age in the mid-nineteenth century and reconstructs the hydrometeorological "anomalies," mostly linked to the occurrence of ENSO. The second part exposes some conditions of social vulnerability related to war, the transformation of land tenure, the expansion of the agricultural frontier, the agro-export model, and hydraulic infrastructure. There are also examples of the State's inability to respond to hydrometeorological pressures, because the solutions proposed generated new vulnerabilities and the care of those most affected was left in the hands of citizens and charitable institutions.

Droughts and Floods Linked to the End of the Little Ice Age and ENSO

The 1820s, which align with the first years of republican life in the Andean countries, was also the last phase of one of the most critical moments in the Little Ice Age, known as the Dalton Minimum (c.1790–1830). Throughout the Andes, especially in Colombia (the designation 'Colombia' is employed throughout this work, notwithstanding the fact that the country underwent several name changes over the course of the 19th century) and southern Peru, there were droughts in confluence with dust plagues, frosts, or locusts that damaged crops, decimated livestock due to lack of pasture, or prolonged rains and floods in areas where precipitation is usually absent, such as northern Peru and Norte Grande de Chile (Caviedes and Waylen 1991; Huertas 2001; Mora 2019; Ortlieb 1995; Quispe 2013, 2017). Studies of Andean glaciers confirm that the last major advance in the last 200 years occurred in the first decades of the nineteenth century and that, in contrast, a slow but continuous retreat began in the mid-nineteenth century, accelerating from the 1940s onwards (Flórez 1990; Grove 1988; Jomelli et al. 2009; Velásquez 2005; Villalba 1994). These indicators are key to situate the current climatic change and to understand the role of the period dealt with in this chapter.

It should be clarified that the hydrometeorological pressures faced by Andean societies between the 1820s and 1940s were not necessarily related to climate change, but rather to interannual variability linked to the occurrence of ENSO. As already indicated, depending on the regional conditions with which they interact, El Niño and La Niña can explain the water deficit or surplus in the context of societies and ecosystems facing one of these extremes. However, as can be seen in Table 1, years that have been identified as Niño or Niña do not always cause "anomalies" in precipitation, indicating that ENSO is a necessary but insufficient condition (Ortlieb 1995). In methodological terms, unlike what usually happens with the sudden impact of floods, it is difficult to pinpoint the relationship between the occurrence of ENSO and drought because, depending on water reserves and their intensity and duration, the effects of the decrease in precipitation may only be felt more strongly several years later (Davis 2006). Explanations not related to ENSO, but to intra-annual climate variability must also be taken into account, which, for most of the Andes is related to the oscillation of the Intertropical Convergence Zone (ITCZ), atmospheric changes due to volcanic eruptions and, as will be seen in the next section, erratic management of available water sources. Even so, it is possible to identify numerous coincidences between ENSO and droughts or abundant precipitation and their effects in the Andes as summarized in Table 1.

Table 1: Occurrence of ENSO and Hydrometeorological "Anomalies" in the Andes

Year	Niño	Niña	"Anomalies" in the Andes
1819		S	Flooding of rivers and lagoons and flooding in the eastern Colombian Andes and the Orinoco foothills. Rains and floods in Arequipa, damage to bridges, the city takes on a green appearance due to the invasion of mold on the facades. Flooded vineyards in the Vitor valley. Flooding in the Pampa de Tamarugal, Norte Grande de Chile, Atacama region.
1820		S	
1823		M	Drought in the central-eastern Colombian Andes. In Bogotá, temperatures exceed 26°C (city with an annual average of 14°C). Prolonged rains and dysentery in Arequipa. Flooding in the Pampa de Tamarugal, Norte Grande de Chile, Atacama region.
1824	M		Severe drought in the Upper Magdalena Valley and the central-eastern Colombian Andes, accompanied by dust plague in the highlands and loss of maize, plantain, and cacao crops due to drought in the lowlands. Floods in northern Peru and droughts in the south.
1825		M	Severe drought continues in the Colombian Andes, high temperatures, low humidity, and crop losses. Heavy rainfall in Copiapó, Norte Chico, Chile.
1829	W		Neiva, a city in the Magdalena valley in Colombia, is hit by heavy flooding. In Peru, Arequipa faced drought since 1827, which would last until 1833, with a sharp drop in liquor production, loss of crops, livestock mortality, famine, and epidemics of rabies and dysentery. Year of abundant rainfall in Chile. Increased snowfall in the Mendoza Andes.
1832	W		Severe drought and crop losses in the central-eastern Colombian Andes.
1833	S		Abundant rainfall in the Huasco region and rivers overflow in Chile's Norte Chico.
1837	S		Drought, crop failure, famine, and measles epidemic in the northeastern Colombian Andes. Heavy rains on the northern coast of Peru and Chile.
1838	W		Drought in Chile.
1840		W	-
1841		W	Drought in Bogotá and its surroundings.

Year	Niño	Niña	"Anomalies" in the Andes
1843		W	-
1844	M		Heavy and abundant rainfall in Copiapó, Chile.
1845	VS		-
1846	W		-
1847	W	S	Frosts in Arequipa, accompanied by smallpox and tabardillo epidemics, inflation, war, and an earthquake. Increase in potato prices due to frost damage, food imports. In Puno, crop failure, famine, and migration to the coast.
1848	W	W	
1849		M	
1850		W	-
1851		M	Drought in the *Sabana de Bogotá*, interrupted by a flash flood in the capital. In Chile, heavy rainfall in Coquimbo and Copiapó.
1852	W		Floods in Atacama and Norte Grande de Chile.
1853	VS		Severe damage in Bogotá due to flooding.
1856	M		In the *Sabana de Bogotá*, floods damage infrastructure. In Chile, during March, a storm with eighty hours of rain in Coquimbo and a large increase in rainfall in La Serena.
1857	M	M	In the *Sabana de Bogotá*, heavy rainfall, and hailstorms. In southern Peru, rivers overflowed, especially in Moquegua.
1858	M		-
1860	W	VS	In Colombia, drought and locust infestation in the Cauca river valley, with crop damage. In Peru, heavy rainfall in southern Peru, Ica, Arequipa, and Moquegua. Rains also in Copiapó, Chile.
1861		VS	In Bolivia and the Puna de Jujuy, drought and epidemics (possibly smallpox or typhoid) generate peak mortality.
1862		M	
1863		VS	-
1864	W	W	Abundant precipitation on the northern coast of Peru and Chile. Drought in Arequipa converging with a typhoid epidemic.
1865	M		Drought in Arequipa.
1866	VS	M	Drought in Arequipa.
1867		S	Drought in Venezuela, spontaneous fires and "smoke" phenomena occur in the northern regions. Drought in Arequipa.
1868	VS	S	Drought in the central-eastern Colombian Andes. Flooding in the Tamarugal pampa and heavy rainfall in central Chile.
1870		VS	First quarter of the year with abundant rainfall in Santiago and Valdivia, with damage to wheat crops; the rest of the year, drought in Concepción. Foot and mouth disease epidemic spread from Argentina to Chile and with the sick oxen it was not possible to take the little wheat produced to the ports.

Year	Niño	Niña	"Anomalies" in the Andes
1871		VS	Heavy rains and floods in northern Peru collapse Trujillo's railway infrastructure.
1872		M	In Venezuela, locust plague that traveled from Colombia and affected the Orinoco forests. Loss of crops and crops with low yields in Chile, with major problems in Concepción due to soil degradation and loss of labor that migrated to the construction of Peruvian railroads.
1873		VS	-
1874	W	S	Drought in Chile, accompanied by a red dust plague that affects wheat production; soil degradation problems due to hillside cultivation and failure to let the land rest.
1875		S	
1876	W		-
1877	VS		In Colombia, drought in Bogotá, precipitation deficit close to 40 percent with respect to the 1866–1900 average and the current average. In the Cauca River valley, severe drought with a locust infestation that destroys corn and banana crops; hunger and migration to the cities. In the Caribbean plains, drought and locust plague that destroys crops, causes famine and migrations. In southern Ecuador, abundant rainfall, outbreak of yellow fever and increased sediment in the Guayas River prevented the supply of drinking water in Guayaquil. Abundant rainfall in northern Peru, flooding in Lambayeque, Trujillo, and Piura, total ruin of Saña, losses of cotton crops in rural areas. Roads, railways, and drinking water sources are destroyed. "Desert in bloom" in southern Peru. In the Peruvian-Bolivian Altiplano severe drought, water shortages around Lake Titicaca, increased temperatures recorded in Puno; crop failures, livestock deaths; price increases and attacks on markets in Sucre, Cochabamba, and Tarata; deaths from hunger and associated diseases in Cochabamba, Sucre, and Potosí. In Chile, at the beginning of 1877, drought and scalding of wheat with a dust plague in Talca and other southern provinces, low crop yields in Valdivia; in the middle of that year, catastrophic rainfall with flooding of neighborhoods in Santiago and destruction of roads by the rising Mapocho river; in Valdivia, overflowing of the San Carlos canal with great flooding that overturned buildings and caused drowning of people and animals; other towns affected by overflowing of the Aconcagua, Maipo, Claro, and Lontué rivers. Wheat production deficit due to excess humidity and sudden heat episodes that scald crops, reduction in revenues due to agricultural crises; wheat exports are reduced by 30 percent, and flour must be imported from the United States, Argentina, and Uruguay.
1878	M	W	
1879		E	Drought in Arequipa since 1878. The same biennium is critical for Bolivia due to a confluence of drought, famine, disease, and mortality. Up to 50 percent loss of corn and wheat crops that cannot be alleviated by price or import controls; emigration to larger cities or to Peru in search of "poor people's pots."

Year	Niño	Niña	"Anomalies" in the Andes
1880		VS	In Colombia, Caribbean plains affected by drought, locust infestation, and food shortages. In Chile, river flooding and heavy rainfall in La Serena and Coquimbo, Norte Chico.
1881	M		Locust infestation in the Andes and the coast of Venezuela with fruit shortages and crop damage; major losses in coffee, cacao, tobacco, plantain, and sugar cane crops. Severe drought in a large part of the Colombian territory with food shortages. Drought, frost, typhoid, and pneumonia epidemics in Arequipa.
1884	W		Locust plague in the Venezuelan coast and Andes with losses similar to those of 1881, but aggravated by lack of pasture for cattle, contamination of water and food with feces and dead bodies of the insects, world economic crisis, especially in the coffee market. Heavy rains in southern Peru, with flooding from Ica to Tacna and snowfall in the Huaracani mountain. In the Norte Grande of Chile, torrential floods in the Quebrada de Quisma ravine and flooding in the Tamarugal pampa; major flooding of the Loa River in Chacance; in the Andes, thirty consecutive days of rain. In Bolivia and the Puna of Jujuy, drought and diphtheria epidemics converge; the epidemic spreads more easily due to lack of water because of overcrowding and greater movements in search of watering places.
1885	S		Locust plague continues in Venezuela. In January and February, heavy rainfall in San Pedro de Atacama, Chile. Drought and diphtheria continue in Bolivia and the Puna of Jujuy.
1886		M	Locust plague continues in Venezuela. Heavy rains in Arequipa.
1887		VS	Locust plague continues in Venezuela. Heavy rains in Arequipa. Great flooding of the Huasco River in Chile's Norte Chico.
1888	VS		Locust plague continues in Venezuela. In northern Ecuador, a crisis following several years of epidemics, drought, and locust infestations. Heavy rains in northern Peru. In Chile, rivers overflowed, heavy rainfall in Copiapó, La Serena, and Coquimbo.
1889	W		Drought and locust crisis persists in Ecuador. Drought in Arequipa with low production of aguardiente and wine, cereal shortage, wheat imports from Chile required; smallpox, measles and scarlet fever epidemic.
1890		S	Locust infestation in Venezuela.

Year	Niño	Niña	"Anomalies" in the Andes
1891	VS	W	Flooding in Trujillo, Huanchaco, and Moche, northern Peru. Flooding of homes, paralysis of industry and commerce, destruction of crops and railroad infrastructure, and cut off from the port of Salaverry. Barricades and embankments are built to keep the land dry, but the water destroys them. In southern Peru, abundant rainfall in Arequipa and Pisco; the sandy areas surrounding the latter city flourish due to abundant rainfall. Abundant rainfall in Chile's Norte Chico, especially in La Serena, while Coquimbo and Copiapó had dry conditions.
1892		S	In Arequipa, heavy rains with flooding of homes and crops, significant losses in corn and potato crops, destruction of canals and irrigation ditches.
1893		VS	
1894		E	Rains in Arequipa accompanied by an outbreak of smallpox.
1896	M	W	Abundant rains in Arequipa, with hail and snowstorms, destruction of crops and agricultural and road infrastructure.
1897	S		Abundant precipitation in northern Peru.
1899	S		In Caracas, the rainfall deficit close to 28 percent. Drought in the Potosí region, coinciding with peak mortality. In Peru, since 1898, abundant rainfall and floods have been experienced from Ica to Ilo. In Arequipa, crops were destroyed, especially sugarcane, as well as water intakes and a hydroelectric plant; the rains coincided with an influenza epidemic. In Chile, abundant rainfall in the center and south of the country.
1900	VS		Heavy rainfall and flooding in southern Peru. In Chile, the period 1899–1900 was the rainiest of the entire series of precipitations from 1880 to 1920 and one of the rainiest in 200 years of republican life. As a result, homes and farms are flooded, animals are drowned, crops and rail and road infrastructure are destroyed, and wheat exports drop drastically. Prices rise and food becomes scarce, hardship and social unrest increase. Frosts burn the pastures and many animals starve to death. Smallpox epidemic and plague of rats with contagion of bubonic plague; a health crisis that would last for almost the entire decade.
1901	S		-
1902	VS		Heavy precipitation in Coquimbo and Copiapó.
1903	W		Flooding in the Tamarugal Pampa.
1904	W	W	Drought in Chile's Norte Grande, with rainfall ranging from 0 to 7 mm, while the center had abundant precipitation.
1905	E		In Chile's Norte Chico, abundant precipitation in the form of rain and snow, flooding.
1906	W		In Chile, at the beginning of the year, thick fog in Iquique, heavy rain and snowfall in the high mountain range and floods in the Pampa de Tamarugal. In Norte Chico, thaws and drought in Copiapó and Caldera.

Year	Niño	Niña	"Anomalies" in the Andes
1907		M	-
1908		S	In Colombia, Caribbean plains affected by drought and locust infestation.
1909		VS	-
1910		VS	-
1911	M		Drought in northern Venezuela, 20 percent rainfall deficit, food shortages, hunger, and migration. Drought in the Colombian Eastern Andes, decrease in river flows and El Alicachín reservoir. In Peru, the Tacna River exceeded its banks. In Chile, abundant rainfall in Antofagasta and Pampa de Tamarugal, with lagoon formation between Huara and Pozo, snowfall in San Pedro de Atacama and Calama; in contrast, drought in Coquimbo, Arica, and Iquique.
1912	VS		Drought continues in Venezuela with effects on the subsistence of the population; it is combined with a locust plague.
1913	VS		This year begins a period of abundant rainfall in Quito, which will end in 1919, and can only be compared to the rains of 1651–57, 1663–69, 1950–56, and 1981–85.
1914	VS		In Colombia, drought in the *Sabana de Bogotá*, with a decrease in the flow of the Bogotá River and depletion of the El Alicachín Reservoir. Abundant precipitation in Quito. In Chile, drought in the Norte Grande, while abundant rains were recorded in the Norte Chico region of La Serena, Ovalle, and Elqui, and in the center of the country.
1915	VS		Heavy rainfall in Quito.
1916		S	Heavy rainfall in Quito.
1917		VS	Abundant rainfall in Ecuador, accompanied by cocoa plague in lowlands.
1918	VS	S	Abundant precipitation in Quito. Atypical rainfall in Chañaral, Chile.
1919	S		Abundant precipitation in Quito. Drought in the Norte Grande of Chile, while rainfall was abundant in the Norte Chico and in the center.
1920	W		-
1921		W	-
1922		S	-
1923		W	-

Year	Niño	Niña	"Anomalies" in the Andes
1924	W		In November and December 1924 and until February 1925, in a normally dry period, rainfall increases in the Colombian Eastern Andes and the Magdalena valley. Areas of Bogotá were flooded, sewage systems were damaged, some roads in Boyacá were interrupted and navigation on the Magdalena River was blocked. In Chile, there was a severe drought, considered the most serious in republican times, accompanied by low temperatures, accompanied by the mortality of livestock and wild animals (including bees because they could not accumulate honey for the winter), ruined crops and pastures, low meat production, speculation and hoarding of food, unemployment in the fields, and migration to the cities.
1925	S		Drought in Venezuela, with smoke in lowlands due to forest fires. In Colombia, after the first months of rains, there was an intense drought that lasted until 1926. Loss of crops, death of livestock, and food shortage followed by an increase in price; impossibility of using the Magdalena for communication with the damming of goods in river ports, including construction materials for public works. In Ecuador, severe drought with crop losses; the precipitation deficit for Quito was 49 percent of the 1891 to 1896 average. In Peru, an increase in ocean temperature causes the disappearance of plankton, the mortality of fish and birds that feed on them, and the arrival of warm water species such as dolphins, sharks and spondyllus conch. Increased rainfall from Tumbes to Pisco. Tumbes and Lima suffer flooding, the Chira Canal is destroyed in Piura, in the Tablazo de Paita cotton cultivation is prevented for three years, in Pisco sandbanks flourish; throughout the country supply crisis due to crop damage and road blockage, spread of dysentery and tropical diseases such as malaria due to the proliferation of transmitting insects. In Chile, rainfall increases in the Norte Grande, but severe drought continues, with shortages of basic necessities and an economic, political, and social crisis.
1926	E		In Colombia, the drought and food shortages continue; the rainfall deficit exceeded 50 percent in the *Sabana de Bogotá* and the Cauca river valley. In Chile, abundant rainfall in the Norte Chico and deficiency in the Norte Grande.
1930	M		In Chile, gales and abundant rain and snow precipitation.
1931	S		-
1932		W	-
1933	W		In Colombia, during November and December, rains and floods in the Andean, Pacific, and Caribbean regions. In Chile, rainfall increased in San Pedro de Atacama, while in Norte Chico there was a deficiency.
1934		W	In Colombia, rains and floods continue, with damage to roads.
1935	W		-

Year	Niño	Niña	"Anomalies" in the Andes
1937	W		-
1938	M		In Colombia, heavy rainfall and flooding in the Cauca river valley, the western Andes and the Pacific coast, with loss of human lives, destruction of homes and crops.
1939	M		Drought in northern Venezuela; rainfall deficit in Caracas exceeds 40 percent. Drought in the *Sabana de Bogotá*, Colombia. In Chile, increased rainfall in San Pedro de Atacama, in contrast to the deficit in Visviri and Antofagasta.
1940	VS		Drought in northern Venezuela; rainfall deficit reaches 29 percent in Caracas. In Colombia, intense drought in the *Sabana de Bogotá*. In Chile, heavy rainfall in the Norte Chico; violent storm in Taltal, heavy rain and alluvium in Antofagasta, alluvium around Tocopilla and snowfall on the mountain peaks. In contrast, drought in Parinacota.
1941	E		In Colombia, intense drought continues in the *Sabana de Bogotá* and the Cauca River valley. Failures in Bogotá's aqueduct due to low flow of La Regadera reservoir. In Chile, increased precipitation throughout the north and center of the country.
1942	E		Abundant rainfall and floods in different parts of Colombia left forty people dead, the highest loss of human lives due to flooding in the first half of the twentieth century.
1943		W	-
1944	S		In Colombia, floods in the *Sabana de Bogotá* and the western slopes of the Eastern Cordillera, with flooding and landslides that inundated several neighborhoods in the capital and destroyed corn, wheat, and potato crops, as well as pastures for livestock. In Chile, abundant rainfall in the Norte Grande and Norte Chico, with rising rivers and streams and flooding.
1945		W	-
1946		S	-
1947	W		-
1949	W		-

Year	Niño	Niña	"Anomalies" in the Andes
1950		E	In Colombia, rains and floods throughout most of the country during the first months of the year, which is usually a dry season. Flooding of houses in the main cities, crops and pastures, drowning of livestock, landslides on main roads, destruction of several railway lines. The city of Cali is isolated due to damage to roads and flooding of its airport runway.

Chronology of El Niño and La Niña taken from (Gergis and Fowler 2009). E: extreme; VS: very strong; S: strong; M: moderate; W: weak. Sources for Andean anomalies (Aceituno et al. 2009; Barrero 2005; Camus and Jaksic 2021; Caviedes and Waylen 1991; Domínguez, García and Vicente 2017; Foghin-Pillin 2015; Galvis 2021; Gil 2004; Huertas 2001; Llache 2012; Maiguashca 2012; Mora 2019; Mora 2020; Mora and Cortés 2021; Ortlieb 1995; Pabón and Torres 2007; Prieto and Rojas 2012; Quispe 2013; Rocha 2011; Rodríguez 2012; Sánchez 2021; Vizuete 2017; Corporación OSSO n.d.).

The above table suggests several research routes and some inputs to further review the available ENSO chronologies (Caviedes 2001; Gergis and Fowler 2009; Hocquenghem and Ortlieb 1992; Ortlieb 1995; Prieto 2007; Quinn, Neal, and Antunez 1987; Quinn and Neal 1995). For example, there were several critical years of water deficit or excess in several subregions of the Andes, such as the periods 1827–1828 or 1854–1855, which have not been identified as ENSO. It would be worthwhile to consider whether local intra-annual climate variability is sufficient to explain the phenomena and at the same time explore whether this is some other phenomenon covering such an extensive region or, in effect, these are El Niño or La Niña years that we have not yet taken into account. In the same sense, years that have been identified as El Niño, such as 1924 and 1925, in Colombia and Chile had a La Niña behavior. It would be relevant to review whether these had a warm or cold ENSO phase in the light of other studies on the Andes or the South American Pacific coast. There are also several cases of strong or very strong occurrence of El Niño or La Niña, such as 1845, 1863, 1873, 1909, 1910, 1922, 1931, and 1946, for which information on hydrometeorological "anomalies" in the Andes does not exist. In contrast, the years with the most data, such as 1877, 1878, 1884, 1891, 1899, 1900, 1924, and 1925, cannot necessarily be taken as the most severe crisis lapses; rather, they have been the subject of more research. This highlights the need, already mentioned, for long and medium-term studies or those on unexplored conjunctures, to unify periodizations in order to be able to make comparisons and to dialogue with simultaneous phenomena in other parts of the world. But beyond the hydro-meteorological disturbances, what were the social conditions that generated the crisis or disaster? What was the response capacity of the Andean republics?

The Vulnerability of Andean Societies and their Responses to Crises

Several factors increased the vulnerability and reduced the response capacity of specific sectors of Andean societies throughout the nineteenth century and the first half of the twentieth century, as shown by the representative examples included in this section. The first factor, which played a leading role since the genesis of the Andean republics, was war. Independence movements, civil wars, and international conflicts, some of which occurred among the Andean countries themselves, resulted in the recruitment and high mortality rate of men, reducing the workforce available for agriculture. These conflicts also led to the theft of livestock and food for combat groups, causing shortages; the destruction of road infrastructure, affecting supplies from other regions or abroad; and forced displacement to cities or less affected areas, creating increased demand for food and water, overcrowding, and the spread of infections in the destination locations (Gil 2004; Mora 2019; Rodríguez 2012).

In this regard, based on the hydrometeorological pressures summarized in Table 1, the case of Peru and the civil wars of 1854 and 1856 to 1858 are exemplary because these conflicts converged not only with frosts, abundant rainfall, and floods but also with a peak of epidemics of typhus, typhoid, dysentery, and yellow fever, affecting the country's coasts and highlands. Therefore, it is understandable why staple products such as wheat suffered an increase of 100 percent in price and potatoes and corn an increase of 30 percent (Quispe 2013). In other instances, the war was a response to the social crisis that included the agricultural situation related to the climate and the unequal distribution of food, which led to increased supply challenges. A representative case is the War of the Pacific between the Bolivia-Peru alliance and Chile (1879–1884). In Bolivia, the peasant rebellion for land in the 1870s, highlighted by a significant conflict with the National Guard at the Battle of Quera in January 1875, resulted in increased mortality among men and livestock, the devastation of pastures, and incidents of cattle rustling (Gil 2004: 194–195). In the Peruvian-Bolivian Altiplano, the severe drought that commenced in 1876 and persisted until 1879, coupled with rising temperatures recorded in Puno, led to substantial crop loss and livestock mortality. Food became scarce, prices rose, deaths from diseases associated with malnutrition or hunger increased, and food riots and attacks on markets in towns such as Sucre, Cochabamba, and Tarata were common. The nitrate tax that Bolivia demanded from the Chilean company *Compañía de Salitres* (Saltpeter Company) and *Ferrocarril de Antofagasta* (Antofagasta Railroad) for the exploitation of what was then its Pacific coast – which was the trigger for the war – has been considered a response to the economic crisis linked to the severe drought (Aceituno et al. 2009: 403–405; Gil, Morales and Villalba 2010: 15–18, 27). On the Chilean side, the warlike response also had to do with its own crisis in the center and south of the country. At the beginning of 1877, the wheat scald and the powdery mildew plague combined to cause food shortages and famine; in the second half of the same year, rainfall was catastrophic for the road infrastructure, urban areas, pastures, and wheat fields. By 1878, wheat exports had declined by 30 percent compared to 1873, resulting in massive unemployment, defaults on foreign debt payments, trade deficits, and foreign currency drains due to the need to import wheat and flour from Uruguay, Argentina, and the United States (Insic 2021: 21–35).

In addition to the war, a second factor of vulnerability was the transformation in land tenure focused on the colonization of wastelands and the extinction of collective properties (Indigenous, ecclesiastical, and municipal, in the case of *ejidos*), not only as part of an exercise in the application of liberal and modernizing ideas but also as a solution to the fiscal deficit and indebtedness and as a way to promote participation in international markets. A third factor was precisely the configuration of agro-export economies, since, together with the change in land tenure, it meant the advance of the agricultural frontier, which required deforestation, canalization, irrigation, or drainage, and the shift from specialization to monoculture (Carrillo and Cuño 2017; Chonchol 1994; Maiguashca 2012). The disappearance of communal lands limited access to diverse altitude microclimates, forced a shift to intensive cattle ranching and eliminated subsistence mechanisms for those who could not work the land, such as the elderly, who fed on the produce of their communities. With the expansion of monocultures, which were not always focused on food crops – crops intended for textile fibers such as cotton, plants for stimulant beverages such as cocoa and coffee, or sugarcane for the production of sweeteners and alcoholic drinks prevailed – land for subsistence crops was sacrificed, pests were spread and producers became vulnerable to international market fluctuations due to a lack of diversification. The drive to export raw materials also led to labor being attracted to mines and the railroad construction, to the detriment of agriculture. The colonization of lowland wastelands, deforestation, and the domestication of water contributed to the alteration of microclimates due to the disappearance of elements such as vegetation and bodies of water that act as thermal regulators, while human settlements multiplied in floodplains, which meant a more frequent flooding of homes and crops. For this reason, a fourth and last factor to take into account, which can be considered as a social response to water scarcity and abundance, was the hydraulic infrastructure. Efforts to tame the water proved futile. Dams that promised to supply hydroelectric plants or urban aqueducts proved to be useless when drought set in. The canals and containment works collapsed in the face of the abundant rainfall and, having served as a reservoir, increased the effects of flooding.

The confluence of these three factors and their contribution to the generation of disasters in the face of hydrometeorological pressures is evident in several cases. In the last decades of the nineteenth century, coffee farms in the Venezuelan Andes were in the hands of foreign investors who had to face a crisis due to the international depreciation of coffee beans in 1885 and the locust plague that affected the region in the 1880s; however, the prioritization of export crops such as this one, caused shortages and limited supplies of food for domestic consumption (Rodríguez Alarcón 2012). In the case of Ecuador, the cocoa agro-export boom in the first decades of the twentieth century explains the expansion of the agricultural frontier on the Andean slopes where rainfall was higher and drainage capacity lower. In addition, the process coincided with the 1913–1919 humidity peak, a condition that explains the spread of a fungal infection that destroyed up to 95 percent of the cocoa crop in the Balao district in 1917 and continued to spread during the 1920s, causing abandonment of properties and migration to the coast (Domínguez, García, and Vicente 2017; Maiguashca 2012).

In the Colombian Andes, in the second half of the nineteenth century, there was a similar expansion of the agricultural frontier on the mountain slopes and the inter-Andean valleys for crops that had ephemeral upswings such as cinchona, tobacco, cotton, and indigo, or for coffee, the crop that would become the country's agro-export base for decades. The elimination of Andean forests altered ecosystems and their microclimates, reduced protection against erosion and at the same time increased sedimentation in the Magdalena and Cauca valleys, altered their water dynamics and, therefore, had an impact on flooding in agricultural and urban areas (Márquez 2016; Palacio 2006). In the case of the Cauca River Valley, the gradual expansion of sugarcane and sugar mills turned the overflowing of the rivers in the basin into an obstacle and the producers themselves joined forces to promote the draining of swamps and channeling of rivers, a process that has intensified since the 1950s with government support; these works, which made natural water regulation mechanisms disappear, explain to this day the disastrous floods periodically faced by the region (Perafán, Peña, and Buitrago 2018). In the *Sabana de Bogotá*, the inability to cultivate tropical crops due to high altitude, combined with frequent rainfall and flood-prone areas in the Bogotá River Basin, has presented challenges for urban development and connectivity within the capital. Canal-building and damming were not only a strategy against floods, but also a mechanism to supply the aqueduct and hydroelectric plants. However, as the droughts of 1912 and 1944 demonstrated, dams such as El Alicachín and La Regadera were not sufficient for either purpose; in the latter case, in contrast, the alteration of water dynamics and the accumulation of precipitation at its bottom made it a key element in the generation of floods in the self-built neighborhoods downstream (Sánchez 2021).

In the Peruvian case, faced with the progressive decline of guano exports in the mid-nineteenth century, interest shifted to cotton and sugarcane production, largely with foreign investment (Chonchol 1994). This not only meant that fewer hectares would be available for food crops but an increased vulnerability to atmospheric events. Thus, for example, in the face of abundant rainfall in the first halves of 1877 and 1878, the greatest damage, outside the urban area, was concentrated on cotton crops (Aceituno et al. 2009). In the typically arid conditions of northern Peru, agro-exports necessitated irrigation projects from the early twentieth century, such as the Chira River canal in Piura. However, the same rainfall that facilitated these works also led to their destruction in 1925. Consequently, the state had to acquire the canal for repairs. Additionally, in the same year, the irrigation systems in the Moche Valley collapsed, and the resultant water accumulation caused significant damage in Trujillo (Rocha 2011). The Peruvian government promoted hydraulic infrastructure as an alternative to drought and flooding, as occurred in the Chancay River valley in Lambayeque, with a succession of works between the 1920s and 1970s that did not stop the waters in times of El Niño, but instead altered the watershed and caused salinization and poor drainage of agricultural soils (Garcés and Guerra 1999).

In the Chilean Andes, agro-exports did not consist of tropical products but rather a crop common to other mid-latitude countries: wheat. The peak period for Chilean wheat exports occurred during the 1850s and 1860s, with a decline beginning in the 1870s. As in the previous cases, wheat also demanded the expansion of the agricultural frontier and irrigation works (Chonchol 1994). Although it was a staple foodstuff for domestic consumption, in times of crisis it was hoarded to raise its price or was diverted abroad to improve profits, a condition that exacerbated domestic shortages and famines. The specialization in this crop contributed to the proliferation of a dust plague during the drought periods of 1874 and 1875. This crisis was exacerbated by several factors: fluctuations between drought and heavy rainfall that lowered yields and, in critical years such as 1877 and 1878, destroyed crops; the loss of pasturelands and an outbreak of foot-and-mouth disease originating from Argentina, which decimated the oxen used for plowing and transporting goods to the ports; soil degradation resulting from land clearing and continuous cultivation without fallow periods; and the migration of agricultural laborers to Peru for railroad construction (Camus and Jaksic 2021). Although wheat production was not completely abandoned, starting in the 1880s, with the annexation of the Bolivian coast after the War of the Pacific, Chile, like its competitor, concentrated on mining exports.

Regarding Chile's hydraulic infrastructure to combat droughts and floods, the Maipo-Mapocho river connection or San Carlos Canal is a prime example. In planning since the 1710s, it only came into partial operation in the 1820s, as a promise of a source of irrigation in times of drought and protection for Santiago against floods in times of rain (Noria 2018). As in other Andean cases, this infrastructure yielded to hydrometeorological pressures and exacerbated the effects of heavy rainfall. Such was the case in 1899 and 1900, considered the rainiest years in two centuries of republican life, due to the collapse of the San Carlos Canal and the *Zanjón* de la Aguada, which stopped retaining water and ended up flooding homes, crops, and pastures. Another example can be found in the aforementioned crisis of the 1870s. Between 1872 and 1873, the drought prompted the appointment of a water judge to supervise the distribution of the diminished flows of the Aconcagua and Tinguiririca rivers.

An expedition was organized to the Negra and Encañado lagoons, located over 100 km from the center of Santiago, to evaluate possibilities for urban supply. A proposal was made to build a dam in Colina and to refine studies on the climate since the arrival of the Spaniards to show that the conditions were naturally dry and suitable for rainfed crops (Camus and Jaksic 2021).

In the face of the crises linked or confluent with hydrometeorological pressures, summarized in Table 1 – in addition to the already outstanding technical response that failed to control water abundance and scarcity with infrastructure – the states were poorly prepared to avoid, or even overcome, the crises. Public charity, donations, and soup kitchens – also known in Latin America as *ollas comunitarias* or community pots – were frequently used to care for the victims. For example, in the critical 1878–1879 biennium in Bolivia, due to the confluence of drought, epidemics, and war, although the government took measures to import wheat and curb price speculation and tried to reduce public spending by reducing salaries of civil servants and closing schools, there were frequent uprisings for bread, attacks on bakeries and houses where there were flour reserves, banditry, migrations, towards the main cities of the country and Peru in search of *ollas de pobres* (paupers' pots) and the care of the sick and hungry in relief houses owned by individuals or religious communities (Pentimalli and Rodríguez 1989). A similar situation was experienced in Chile during the crisis of 1899–1900, with effects during almost the entire following decade, due to the smallpox epidemic and the high rainfall and floods that drowned livestock, destroyed crops, road, and water infrastructure, and flooded homes. Although the national government imported wheat and local governments proposed constructing more hydraulic infrastructure or roads on less flood-prone routes, many found immediate solutions through shelters and soup kitchens organized by religious institutions, collections from artistic events, and neighborhood committees that monitored disease outbreaks and transported the deceased for incineration. Despite this, economic hardship became widespread and is considered a contributing factor to several uprisings, including the Valparaiso longshoremen's strike in 1903, the Red October or meat strike in 1905 in Santiago, and the Santa Maria de Iquique massacre (Camus and Jaksic 2021).

In other cases, the response was led by the state and was of a fiscal or customs nature, although with no better results. Such was the case of the aforementioned nitrate tax imposed by Bolivia as a trigger for the War of the Pacific. It was not the only one, however. In Argentina, the position of *capitación indigenal* was established as a successor to the colonial tribute for the Indigenous people of the Puna de Jujuy, which was in force between 1840 and 1851; salt was taxed in 1840 (essential for feeding livestock or preserving food) and cattle in 1863, with charges that were transferred from the absentee owners to their tenants, most of whom were Indigenous, which increased their poverty (Gil 2004). During the 1924 drought in Chile, the discussion about a tax on matches made the danger of famine visible; in the context of the economic and political crisis, power was seized by a military junta that, despite reducing railroad freight costs for fertilizers and staple foods, failed to control the crisis and was overthrown the following year. The provisional civilian government also failed to contain the crisis and, on the contrary, unleashed a wave of repression against the discontented population; it only managed to increase food supplies, especially meat, with the elimination of import duties on Argentine cattle, cattle freight cost reduction, and the creation of the *Sociedad de Ollas Infantiles* (Children's School Feeding Society) (Camus and Jaksic 2021).

The solution of establishing sanctions against speculators, prohibiting food exports or discouraging them through tariffs were common strategies and had roots in colonial times. To these were added the food imports purchased by governments and the tariff reductions on imported food and agricultural inputs. In 1848, this happened, for example, in Peru, with the delivery of various foodstuffs to the city of Arequipa (Quispe 2013); in 1878 and 1900, when Chile had to import wheat in view of the shortage of the cereal in its territory (Camus and Jaksic 2021); in 1925, in the face of flood damage in Peru, which led the government to suspend the collection of storage fees in customs, prohibit the export of rice, exempt the jerky, coffee, potatoes, and vegetables imports from tariffs, and reduce the charge for the livestock imports by 50 percent (Rocha 2012); or in 1927, when in Colombia an emergency law was issued to reduce food tariffs in response to the crisis of food shortages and prices related to the drought of 1925 and 1926 (Barrero 2005). These solutions shared a circumstantial nature and failed to alleviate shortages for specific sectors of the population or to provide a preventive response to the recurrent hydrometeorological pressures in these territories.

Conclusions

Although more regional and long-term studies are needed in Latin America on the climate-society relationship during the nineteenth century and the first half of the twentieth century, some generalities can be established. In the Andes, the beginnings of current climate change, which began to manifest with a retreat of high mountain glaciers, were not linked to a large volume of greenhouse gas emissions. However, there was an Andean contribution to the Anthropocene associated with the Industrial Revolution due to the focus on the raw material exports and the demand for more land to produce them. Expansion over wetland areas, the domestication of water through canalization and drainage works, changes in agricultural production and the regulation of water sources, the disappearance of communal lands, and the reduction of areas cultivated with food for domestic consumption have increased the region's vulnerability to climate variability and change. Neither the water deficit nor the water surplus were sufficient ingredients to generate crises or even disasters. It was necessary for them to mix with societies facing political instability, internal conflicts, international wars, the dispossession and uprooting of Indigenous and peasant communities, accelerated migration to the cities, unemployment, and a lack of state mechanisms to meet basic food needs. In these conditions, droughts and floods found Andean societies in a process of maladaptation that would later accelerate in the second half of the twentieth century.

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References

Aceituno, Patricio, María del Rosario Prieto, María Eugenia Solari, et al. 2009. "The 1877–1878 El Niño episode: Associated impacts in South America." *Climatic Change* 92: 389–416.

Barrero, Álvaro. 2005. "Análisis de la sequía histórica de 1925–1926." *Meteorología Colombiana* 9: 87–92.

Betancourt, Darío. 1982. *Reseña histórica de la meteorología en Colombia*. Bogotá: HIMAT.

Camus, Pablo, and Fabián Jaksic. 2021. *Clima y Sociedad: El Fenómeno de El Niño y La Niña en la historia de Chile*. Santiago de Chile: Instituto de Geografía Pontificia Universidad Católica de Chile.

Carrillo, Germán, and Justo Cuño, eds. 2017. *Historia agraria y políticas agrarias en España y América Latina desde el siglo XIX hasta nuestros días*. Madrid: Gobierno de España, Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente.

Caviedes, César. 2001. *El Niño in history. Storming through the ages*. Gainesville: University Press of Florida.

Caviedes, César, and Peter Waylen. 1991. "Chapters for a Climatic History of South America." In *Beiträge zur Regionalen und Angewandten Klimatologie, Freiburger Geographische Hefte* 32, ed. Wilfried Endlicher and Hermann Gossmann, 149–180. Freiburg: Universität Freiburg.

Chonchol, Jacques. 1994. *Sistemas agrarios en América Latina. De la etapa prehispánica a la modernización conservadora*. Mexico City: Fondo de Cultura Económica.

Cordovez, José María. 1893. *Reminiscencias de Santafé y Bogotá*. Bogotá: Librería Americana.

Corporación OSSO. n.d. "Base de datos." *Desinventar.org*. https://www.desinventar.org/.

Davis, Mike. 2006. *Los holocaustos de la era victoriana tardía: El Niño, las hambrunas y la formación del tercer mundo.* Valencia: Universitat de Valéncia.

Domínguez, Fernando, Ricardo García, and Sergio Vicente. 2017. "Wet and dry extremes in Quito (Ecuador) since the 17th century." *International Journal of Climatology* 38: 2006–2014.

Flórez, Antonio. 1990. "La recesión de los glaciares colombianos desde la pequeña edad glaciar." *Colombia Geográfica: Revista del Instituto Geográfico Agustín Codazzi* 16, no. 1: 7–16.

Foghin-Pillin, Sergio. 2015. "El año de las humaredas. Registro histórico de algunas sequías extremas en Venezuela." *Bitácora-e. Revista Electrónica Latinoamericana de Estudios Sociales, Históricos y Culturales de la Ciencia y la Tecnología* 2: 3–25.

Galvis, Margarita. 2021. "Análisis del fenómeno de la sequía en Colombia." Master's tesis, Universidad Nacional de Colombia.

Garcés, Carlos, and Julio Guerra. 1999. *Consideraciones sobre impacto ambiental por efecto de las obras de regadío en el distrito de riego Chancay-Lambayeque, Perú. IWMI*. Mexico City: Instituto Internacional del Manejo del Agua.

Gergis, Jöelle, and Anthony Fowler. 2009. "A history of ENSO events since A.D. 1525: Implications for future climate change." *Climatic Change* 92: 343–387.

Gil, Raquel. 2004. "Población, medio ambiente y economía en la Puna de Jujuy, Argentina, siglo XIX." *Revista de Demografía Histórica* 22, no. 1: 185–208.

Gil, Raquel, Mariano Morales, and Ricardo Villalba. 2010. "Población y economía en los Andes: Las crisis de subsistencia en Talina entre los siglos XVII y XX." *Surandino Monográfico, segunda sección del prohal monográfico* 1, no. 2: 1–33.

Grove, Jean. 1988. *The Little Ice Age*. London: Methuen.

Hocquenghem, Anne-Marie, and Luc Ortlieb. 1992. "Eventos El Niño y lluvias anormales en la costa del Perú: Siglos XVI–XIX." *Bulletin de l'Institut français d'études andines* 21, no. 1: 197–278.

Huertas, Lorenzo. 2001. *Diluvios andinos a través de las fuentes documentales*. Lima: Pontificia Universidad Católica del Perú.

IGAC. 1996. *Diccionario Geográfico de Colombia*. Vol. 4. Bogotá: Instituto Geográfico Agustín Codazzi.

Jomelli, Vincent, Vincent Favier, Antoine Rabatel, et al. 2009. "Fluctuations of glaciers in the tropical Andes over the last millennium and palaeoclimatic implications: A review." *Palaeogeography, Palaeoclimatology, Palaeoecology* 281, no. 3–4: 269–282.

Llache, Guillermo. 2012. "La dinámica poblacional del Socorro, San Gil y Barichara entre 1778 y 1837." *Historia 2.0 Conocimiento histórico en clave digital* 2, no. 1: 72–88.

Maiguashca, Juan. 2012. "La incorporación del cacao ecuatoriano al mercado mundial entre 1840 y 1925, según los informes consulares." *Procesos. Revista Ecuatoriana de Historia* 35, no. 1: 67–98.

Márquez, Germán. 2016. "Un río difícil. El Magdalena: historia ambiental, navegabilidad y desarrollo." *Memorias: Revista Digital de Historia y Arqueología desde el Caribe* 28: 29–60.

Mora, Katherinne. 2019. *Entre sequías, heladas e inundaciones. Clima y sociedad en la Sabana de Bogotá, 1690–1870*. Bogotá: Universidad Nacional de Colombia.

———. 2020. "'General invierno: ¿Salvó usted la patria?'. Apuntes para la reconstrucción de la relación entre el clima y la independencia neogranadina." In *Gentes, pueblos y batallas. Microhistorias de la Ruta de la Libertad*, ed. Javier Guerrero and Ángela Parra, 121–150. Tunja: Universidad Pedagógica y Tecnológica de Colombia.

Mora, Katherinne, and José David Cortés. 2021. "Bajo el sol ardiente y la lluvia torrencial. Viajeros extranjeros y clima colombiano en el siglo XIX." *Anuario Colombiano de Historia Regional y de las Fronteras* 26, no. 2: 137–164.

Noria, Andrea. 2018. "Estrategias frente a eventos climáticos extremos en la época colonial hispanoamericana. El caso de las sequías en Santiago de Chile en la etapa borbónica." PhD diss., Universidad Autónoma de Chile/Universidad de Sevilla.

Ortlieb, Luc. 1995. "Eventos El Niño y episodios lluviosos en el desierto de Atacama: El registro de los últimos dos siglos." *Bulletin de l'Institut Français d'Études Andines* 24, no. 3: 519–537.

Pabón, José, and Germán Torres. 2007. "Impacto socioeconómico de los fenómenos El Niño y La Niña en la Sabana de Bogotá durante el siglo XX." *Cuadernos de Geografía* 16: 81–94.

Palacio, Germán. 2006. *Fiebre de tierra caliente: Una historia ambiental de Colombia 1850–1930*. Bogotá: Universidad Nacional de Colombia.

Pentimalli, Michela, and Gustavo Rodríguez. 1989. "Las razones de la multitud. Hambruna, motines y subsistencia: 1878–79." *Estado & Sociedad. Revista Boliviana de Ciencias Sociales* 5: 15–33.

Perafán, Aceneth, Enrique Peña, and Óscar Buitrago. 2018. *Humedales vallecaucanos. Escenario natural de cambios históricos de ocupación y transformación*. Cali: Universidad del Valle.

Poveda, Germán, Peter Waylen, and Roger Pulwarty. 2006. "Annual and inter-annual variability of the present climate in northern South America and southern Mesoamerica." *Palaeogeography, Palaeoclimatology, Palaeoecology* 234, no. 1: 3–27.

Prieto, María del Rodario. 2007. "ENSO signals in South America: Rains and floods in the Paraná River region during colonial times." *Climatic Change* 83: 39–54.

Prieto, María del Rosario, and Facundo Rojas. 2012. "Documentary evidence for changing climatic and anthropogenic influences on the Bermejo Wetland in Mendoza, Argentina, during the 16th–20th century." *Climate of the Past* 8: 951–961.

Quinn, William, and Víctor Neal. 1995. "The historical record of El Niño events." In *Climate since A.D.1500*, ed. Raymond Bradley and Philip Jones, 623–648. London: Routledge.

Quinn, William, Víctor Neal, and Santiago Antunez. 1987. "El Niño occurrences over the past four and a half centuries." *Journal of Geophysical Research* 92, no. C13: 14449–14461.

Quispe, Edison. 2013. "Entre la magnitud y la vulnerabilidad. Variaciones climáticas, economía y sociedad: Estudios de caso y de larga data; Arequipa, siglos XVIII y XIX." Paper presented at I Congreso Peruano de Historia Económica, Huamanga, August 12–14.

Quispe, Edison. 2017. "Historia, clima y sociedad: Una aproximación a la historia climática a partir de los desastres en el sur andino; siglos XVI–XIX." Paper presented at International Congress on Climate Change and its Impacts, Huaraz, November 29–December 1.

Rocha, Arturo. 2011. "Las famosas lluvias de 1925 y 1926: ¿El primer meganiño del siglo XX?." Paper presented at IV Congreso Internacional HIDRO y GEO, Lima, May 20–21.

Rodríguez, María. 2012. "Desastres agrícolas y vulnerabilidades: Las plagas de langostas y la sociedad venezolana del siglo XIX." *Revista Geográfica Venezolana* 53, no. 2: 307–327.

Sánchez, Vladimir. 2021. *La urbanización del río Tunjuelo: Desigualdad y cambio ambiental en Bogotá a mediados del siglo XX*. Buecaramanga: Universidad Industrial de Santander.

Velásquez, César. 2005. *Paleoecología de Alta Resolución del Holoceno Tardío en el Páramo de Frontino, Antioquia*. Medellín: Universidad Nacional de Colombia.

Villalba, Ricardo. 1994. "Tree-ring and glacial evidence for the Medieval Warm Epoch and the Little Ice Age in Southern South America." *Climatic Change* 26: 183–197.

Vizuete, Luis. 2017. "'El mismo amor, la misma fe, las mismas lágrimas': Iniciativas eclesiales en Ecuador sobre el culto a la Virgen del Quinche en defensa de una República del Sagrado Corazón (1883–1889)." *Historia y Sociedad* 33: 279–312.

Climate Change in the Amazon from the Mid-Nineteenth Century to 1950

The Tropical Amazon: The Scientific Discourse about Climate (1800–1950)

Eduardo Relly and Claudio de Majo

Introduction

José Carlos Junqueira Schmidt, a Brazilian climatologist of German descent, commenced his article *O clima da Amazônia* (1942: 465) with the observation: "Among the great natural regions of the earth, Amazonia stands out […] because of the vastness and grandeur of its natural setting. The study of its climate is of particular interest today […] given the growing economic importance of the region it covers." Seven years later in France, noted tropical geographer Pierre Gourou (1949: 12–13) reiterated established perspectives on Amazonian climate, characterizing its natural environment as a contemporary "geographical problem." Despite this, he stayed dedicated to the belief that the Amazon was clearly moving beyond its "history of poverty, Indigenous roots, and colonial past." He cited recent organized and large-scale economic ventures in the region, such as the Ford experiment and the rice and jute farming initiatives led by the *Instituto Agronômico do Norte de Belém*, as evidence. These examples gave him confidence that land use would gradually change – potentially reducing the region's Indigenous character and leading to what he assumed would be a milder climate.

Both accounts indicate that, from a climatic perspective, the mid-twentieth century marked a significant turning point in the history of the Amazon. Despite the impact of the rubber boom between the 1870s and 1920, as well as associated demographic growth – particularly in regions *such a*s Belém do Pará, Manaus, and Iquitos (Peru) – the ecological integrity of the Amazon remained largely intact until 1950. This is evidenced chiefly by the sustained forest cover relative to the standards of 1500 (Pádua 2015: 247). The region's evapotranspiration rates, hydrologic cycles, and the influence of phenomena like El Niño, together with extensive convective systems driven by its equatorial position, provided valuable insights into climate patterns that, as observed by Pierre Gourou, persisted since colonial times. Furthermore, around 1950, government policies rooted in national developmentalism began to conceptualize the Amazon as a new frontier for capitalist expansion (Acker 2017: 8), thereby necessitating comprehensive understanding of macroregional climate dynamics, as emphasized by Schmidt.

Since the nineteenth century, foreign and Latin American scientists and public officials have worked to classify the climate of the Amazon. Guided primarily by Western-oriented climate science, these efforts often neglected regional distinctions, resulting in uniform explanations for vast geographical areas. Early analysts such as Robert Southey, in the third volume of his *History of Brazil* (1819), noted unique climate conditions along the region's main waterways. Nevertheless, climate experts frequently accepted the mistaken notion of uniform vegetation patterns, with climate regarded merely as a reflection of such patterns. Insalubrity, humidity, and extreme temperatures became proxies for tropical weather, although the Amazon did not conform to conventional representations of the tropics as exemplified by the Caribbean, the Atlantic coast of Brazil, or Southeast Asia. Consequently, the Amazon entered the field of modern climatology as an ultraperipheral region, shaped by longstanding pre-climatological and colonial assumptions. Its climate presents ongoing challenges – stemming from its vast geographical scale, the integration with Indigenous, maroon, and traditional knowledge systems, and its critical role in global climate dynamics – for Western science and society at large.

The examination of climate and climatology in the Amazon region from 1800 to 1950 – the focus of this chapter – remains a relatively understudied area. Despite the pivotal influence of climate on the ecological and socio-economic development of the Amazon, scholarly research addressing historical climate patterns and their effects across countries within the region is limited. The vast size of the Amazon and its status as both a global and national periphery in post-independence contexts present considerable obstacles for researchers seeking to reconstruct historical climate conditions, particularly from a historiographical perspective. Of the nation's comprising the Amazon basin – Brazil, Peru, Colombia, Venezuela, Ecuador, Bolivia, Guyana, Suriname, and French Guiana – Brazil has made the most substantial contributions to the literature on historical climatology. This predominance is attributable to Brazil's significant investments in agricultural expansion and settler colonial policies in the Southeast and South, reflecting the close connection between climate science and agriculture in modern times (Relly 2022: 121). Conversely, other Amazonian countries have produced comparatively fewer studies. As a result, much of the available understanding of climate patterns in the Amazon during the nineteenth and early twentieth centuries is derived from Brazilian sources and frequently extended to other areas of the region with minimal corroboration.

This chapter examines the historical trajectory of the Amazon's climate from 1800 to 1945, highlighting the period's significant political, economic, social, and ecological transformations across the region. With the consolidation of national independence, increased foreign exchange, and notable demographic shifts, these changes profoundly influenced the Amazon. Efforts by Western scientific communities and emerging political cultures sought to conceptualize the macroregional landscape, frequently characterizing it as an infrastructural challenge in line with Harvey's "spatial fix" (2001: 24), and alternatively as a natural or national mythos (Murari 2009) or even a utopian vision (Vieira 2018). Accordingly, this chapter will address the climate of the Amazon through three principal dimensions: 1) prevailing discourses on climate, 2) patterns of economic expansion during the specified timeframe, and 3) the development of climate sciences within the Amazon. In conclusion, we aim to elucidate the Amazon's role in shaping the Anthropocene, not only by referencing material-economic processes that have influenced climatic trends, but also by contrasting these with cosmological perspectives held by Amazonian inhabitants, wherein nature, society, and climate are inherently interconnected.

Our approach is shaped more by the history of climate than by historical climatology itself; our objective is to examine the qualitative aspects associated with the concept of climate, moving beyond a strictly scientific narrative (Carey 2012). Drawing on insights from Latin American writer Victor Leonardi (1999), we argue that any analysis of the Amazon's historical development must take into account the significance of discontinuity and diversity, which reflect the complex interpretations of climate found within Amazonian societies.

Discourses and Sciences on the Climate of the Amazon

Since the late eighteenth century, the Amazon has played a significant role in various academic discourses and scientific fields. Notably, early botanical studies shaped the modern understanding of the Amazon primarily as a distinct and expansive vegetation kingdom, often relegating climate considerations due to the influence of botanists who were captivated by the remarkable biodiversity and local botanical communities. The conception of the Amazon as a unique botanical region, initially articulated by Carl von Martius in his *Flora Brasiliensis* (composed between 1840 and 1906, with contributions from Austrian and German scholars following Martius's original work), dominated discussions on Brazilian phytogeography for decades. Martius employed the term *Nayades* to describe the Amazon, emphasizing its vegetational diversity and essential connection to abundant waterways. While kinship with other South American phyto-regions was generally recognized in his classification, the Humboldtian notion of *Hylea* (Figueiredo, Chambouleyron, and Ruiz-Peinado Alonso 2017: 504) became predominant in later frameworks, such as that put forth by influential botanist Alberto de Sampaio in 1940. De Sampaio, for example, classified Brazilian flora primarily from the perspective of the Amazon, identifying only two phytogeographical provinces: (a) the Amazon province or *Heleae* (the term refers to a Portuguese adaptation of the Humboldtian concept of Hylea), and (b) the extra-Amazonian provinces or General *flora* (Costa et al. 2013: 4–10). August Grisebach (1872), renowned for his work *Die vegetation der Erde nach ihrer klimatischen Anordnung* and recognized as the author of one of the nineteenth century's most precise vegetational maps based on climate types, was also a significant early contributor to climatology, frequently cited by Julius Hann and Vladimir Köppen. Grisebach emphasized the unique meteorological characteristics of the Amazon, ar*ticul*ating the relationship between vegetation and climate, and thus advanced the Hylea concept as originally outlined in Humboldt's plant geography.

Approximately a century after Buffon's *Histoire Naturelle* (first published in 1749) and De Pauw's *Recherches philosophiques sur les Américains* (1771), scholarly discussions continued to advance theories regarding the perceived inferiority of American nature and promoted concepts of social and natural degeneration, frequently employing Enlightenment rhetoric (Rinke 2015). Climate descriptions of the Amazon persisted in referencing unhealthy conditions, humoral vapors, and other harmful elements, reflecting the ongoing influence of Jean Bodin and his humoral pathology framework (Mauelshagen 2018). However, in subsequent decades, contributions from Humboldtian science, travel literature, nation-building activities in former Spanish and Portuguese colonies, and emerging naturalist (and later evolutionist) perspectives gradually reduced the prevalence of Buffon's and De Pauw's scientific paradigms.

On the periphery of the Amazon forest – particularly around Lake Valencia in Venezuela and also in Peru – climate science and climate change research experienced significant advancement through the early nineteenth-century work of Prussian naturalist Alexander von Humboldt and French scientist Aimé Bonpland (Cushman 2011: 21). In their publication *Ideen zu einer Geographie der Pflanzen nebst einem Naturgemälde der Tropenländer* [Essay on the Geography of Plants: Accompanied by a Physical Summary of the Equinoctial Regions] (Humboldt and Bonpland 1807: 38–39), they outlined a research agenda encompassing networks related to vegetation, animal life, agricultural development, air temperature, and air density. Although many climate observations were conducted outside the core Amazon region, Humboldt and Bonpland maintained a focus on tropical environments as key subjects of scientific investigation, with particular emphasis on vegetation and biological diversity. In their studies of Lake Valencia, they examined the interaction between air currents from the Atlantic Ocean and the Amazon forest, developed isotherms, and conceptualized lake basins as closed systems serving as laboratories for the analysis of local climate variability and patterns. The north-central coastal range of present-day Venezuela enabled selective atmospheric observation while largely disregarding broader influences associated with the Amazon. Humboldt's work established a foundational research agenda on neotropical climate that persisted for generations, often at the expense of alternative knowledge systems. For example, in former Spanish-administered cities throughout South America – particularly in Peru and coastal Venezuela – scientists of mixed or European descent, referred to as “creolean,” developed advanced theories about climate that were subsequently overshadowed by Humboldtian perspectives (Cushman 2011: 23). Through his work *Kosmos*, the invention of isothermal lines, and his detailed descriptions of neotropical phenomena, Humboldt and his followers created a transnational body of climatic knowledge across Latin America (Strobl 2021: 391). Under Humboldt’s classification, the Amazon region continued to be characterized as belonging to the torrid climate zone.

In nations such as Brazil, the intelligentsia aligned the drive to explore the Amazon with broader goals of national development. Technical advancement, efficient utilization of natural resources, population growth, and evolving land use patterns were identified as critical national priorities. Advocates for these initiatives included figures like Euclides da Cunha, who envisioned the “nationalization of the Amazon” through engineering projects, and military leader Candido Rondon, who promoted integrated plans involving Indigenism, infrastructure, and state formation (Murari 2009: 323). In the early twentieth century (1912–1913), Carlos Chagas and Oswaldo Cruz – prominent members of Brazil’s social hygiene movement – conducted official surveys of sanitary conditions in the Amazon at the federal government’s request. Their work significantly contributed to framing the connection between medical expertise and the region’s development within public discourse. The association of malaria with the climate of the Amazon reinforced long-standing assumptions and prompted Brazilian politicians and intellectuals to consider national modernization through the lens of climate (Botelho and Lima 2019). In his work “*Clima e doenças do Brasil*” (1907), physician Afranio Peixoto, a contemporary and rival of Chagas, countered Chagas’ fatalistic perspective. Peixoto attributed the high prevalence of malaria in the Amazon primarily to insufficient public health investments for its population. By referencing the occurrence and persistence of tropical diseases in other parts of the world, Peixoto aimed to refute the concept of tropical disease as exclusive to certain regions and rejected claims that areas such as the Amazon were inherently resistant to modernization. His vigorous advocacy for the tropical character of Brazil and its capacity for human progress established Peixoto as a prominent global proponent of tropical societies.

Imaginaries of the Amazon as a place for modernization carried mixed meanings. Interestingly, during the American Civil War (1861–1865), renowned oceanographer and meteorologist Matthew Fontaine Maury proposed a plan to relocate enslaved Africans from the southern United States to Brazil, referring to it as the “Deepest South” (Horne 2007: 108). Believing the Amazon’s tropical climate was suitable, Maury supported the interests of southern slave-owners by suggesting that enslaved labor could flourish there, claiming Africans were naturally adapted to harsh weather conditions. He also envisioned an Amazon controlled by white people, whom he viewed as uniquely positioned to benefit from the region's resources. This collaboration between North American and Brazilian efforts to sustain slavery is often considered an early example of U.S. involvement in the Amazon. In scientific circles, climate studies were frequently used to justify much of this American intervention. The interplay between slavery, climate, and scientific racism facilitated the development of tropical discourse, academically defined as "tropicality" (Monzote 2018: 45). However, the distinct characteristics of Amazonian peoples and environments did not align completely with the traditional classification of a tropical landscape. Despite La Condamine's observation in 1751 that the tropics were marked by intense flooding, the Brazilian Caribbean and Atlantic coastlines generally conformed more closely to prevailing expectations of the "natural" tropics (Arnold and Sivaramakrishnan 2015: 130).

During the 1960s, increased archaeological activity in Brazil yielded more complex climatic interpretations for the Amazon region, a development further influenced by the geographical theories of Aziz Ab'Saber. The *Programa Nacional de Pesquisa Arqueológica* (PRONAPA), conducted from 1965 to 1970 in the Alto Xingu and lower Rio Negro regions, commenced shortly after the 1964 military coup that removed President João Goulart. PRONAPA represented a collaboration between the Brazilian government and the Smithsonian Institution, with additional involvement from the Instituto Nacional de Pesquisas da Amazônia-Museu Goeldi. Research was coordinated by Clifford Evans and Betty Meggers across an extensive area, followed by a subsequent initiative, PRONAPABA, in 1976, which focused on the lower Tocantins River under their leadership (Simões 1977). After Evans's death in 1981, Meggers continued to publish extensively on the interplay between historical climate fluctuations, adaptation, and demographic trends (Meggers 1979). Nevertheless, her perspectives – particularly the notion that climate patterns significantly constrained the development of Indigenous cultures – have been subject to substantial criticism as reflective of late colonialist assumptions, thereby highlighting persistent north-south disparities within contemporary scientific discourse (Noelli 2007).

Aziz Ab'Saber's refuge theory, alongside his strong belief in paleo-Indigenous environmental intervention, was largely founded on climate shifts during the Pleistocene-Holocene. With contributions from Meggers, this work helped clarify historical factors affecting the Amazon's climate, and led Ab'Saber to classify Brazilian landscapes using morphoclimatic domains, with the Amazon designated as a unique system (Ab'Saber 2010: 405–407). Since the 1980s, *geomorphological a*nd palynological evidence has accumulated, highlighting the significant variability of ancient Amazonian climates. These findings pointed to dynamic climatic events shaped by global insolation c*hanges, vegetation t*ransitions between forests and savannahs, and glacial fluctuations – linking global geohistorical studies with local climatological advances in the Amazon (Fisch, Marengo, and Nobre 1998). Soil studies on *terra preta de índio* date back to German ethnologist Curt Nimuendajú, who, in the late 1930s, proposed that these black soils along Amazon rivers were human-made rather than natural or flood-induced. Investigating terra preta de índio has influenced our understanding of the Amazon's climate, supporting the idea of populous settlements before European arrival. Human-driven climate change may thus be part of the region's history, as Indigenous societies practiced agriculture, supported larger populations, and fostered greater agrobiodiversity.

These perspectives questioned long-held beliefs rooted in nineteenth-century scientific thinking, which often portrayed the Amazon as a purely natural realm (Hilbert and Soentgen 2021). Wim Sombroek, a Dutch soil scientist who led the International Society of Soil Science and formerly directed the Land and Water Development Division at the FAO, strongly advocated for spreading the principles and techniques of terra preta de índio globally – by developing what he termed *terra preta nova* – to address soil fertility challenges worldwide, combat deforestation, and help sequester carbon in an effort to mitigate anthropogenic climate change (Kern, Ruivo, and Frazão 2009). Reevaluating Paleoamazonian climates, land use, and societies has opened new interpretations regarding human migrations within South America, particularly concerning late-Holocene climate changes. This has notably benefited Tupi-Guarani archaeology (Iriarte et al. 2017), while archaeological research has expanded our understanding of Indigenous groups' abilities to shape their environments and local climates, providing insights that challenge biases originating from naturalistic Western science theories (Robinson et al. 2018).

Climate and Science in the Amazon

The evolution of climatology in Latin America is closely linked to imperial science, colonial ambitions, and a push toward modernization, especially in agriculture. Countries such as Peru (Palacios Díaz et al. 2016: 69), Mexico (Prieto, Rojas, and Castillo 2019: 146), and Colombia (Caicedo 2016: 82) were at the forefront of early climate research on the continent since colonial times, although their involvement in the Amazon was limited. During the 19th and 20th centuries, much of the continent's scientific work focused on understanding and managing the natural environment, frequently to further European settlement and colonization. In the Amazon, Brazil played a leading role in climate studies. Early colonial attempts to record and analyze regional climates – mainly for domination and exploitation – occurred across what are now several nations within the Amazon bioregion. Martine Tabeaud's (2021) examination of French Guiana illustrates how climate research in this area developed alongside European colonial projects and depended on environmental data to tackle challenges such as disease, harsh weather, and resource extraction in the tropics. These efforts were not purely scientific; they were closely tied to colonial goals of controlling and transforming local environments for European economic interests and settlement.

While Brazil assumed a leading role in Amazonian investigations due to its extensive territorial jurisdiction and strategic significance, other countries such as Argentina, Chile, Peru, and Colombia contributed substantially to the broader understanding of South America's intricate climatic systems. These efforts reflected each nation's unique priorities and historical contexts influenced by colonial legacies. Notably, research in historical climatology beyond Brazil highlights a persistent colonial impetus to acquire environmental knowledge for effective navigation and resource exploitation in challenging landscapes. For instance, Pabón Caicedo's (2006) examination of Colombia's historical climate records from the 16th to 19th centuries illustrates how colonial administrators systematically documented climatic patterns to mitigate the risks presented by tropical climates and mountainous terrains. Utilizing sources such as correspondence, travel narratives, and official reports, these records emphasize the significant influence of climate on settlement distribution and resource management strategies. Furthermore, comparative studies discussed by Lorenzo Río (2023) identify a recurring colonial approach among nations including Argentina, Chile, and Venezuela, demonstrating that the analysis of local climates was integral to the expansion of European agricultural practices, urban planning initiatives, and industrial development. By the mid-20th century, historical foundations had developed into systematic scientific methods, creating a continent-wide approach for tackling environmental issues while still reflecting the impacts of colonization and resource extraction. Importantly, Eneas Salati – often called the "father" of the flying rivers – and José Marques (1984: 85–86) pinpointed 1970 as the start of quantitative, systematic climatological research in the Amazon, as described in their widely referenced book chapter. This pivotal research emerged from collaboration between two Brazilian organizations: the Center for Nuclear Energy in Agriculture (CENA) and the National Institute for Amazon Research (INPA). Their partnership sparked a new area of knowledge that formed the basis for an integrated geosciences research program. Consequently, Brazil has maintained its prominence in Amazon climate studies, a leadership position it still holds today.

Brazilian initiatives to scientifically understand the Amazon's climate date back prior to the widespread adoption of modern quantitative and spatial methodologies, as noted by Salati and Marques. In 1883, Julis Hann, regarded as the founding father of modern climatology, observed that "The enormous Brazilian Empire has […] only two or three coastal meteorological stations, from which one seldom gets climatological data: only in the German colonies in southern Brazil are climatological data observed and collected" (1883: 342). From the early development of climatology in Brazil and globally, imperial scientific endeavors and power projection were closely associated with the establishment of modern climatological infrastructure. Internal colonialism in Brazil – furthered by policies encouraging European and Japanese settlement – significantly influenced this dynamic, as meteorological investments were predominantly directed toward southern Brazil. Until the 1930s, these regions, where agricultural frontiers were being redefined, disproportionately benefited newcomers (Relly 2022: 123).

This trend of climate research being associated with colonial expansion was not limited to Brazil. Other Latin American countries such as Argentina, Chile, and Peru also established climatological stations in areas crucial for agriculture and infrastructure development. For instance, Argentina's Pampas received notable investments in meteorological studies essential for wheat cultivation and livestock management, while southern Brazil drew European settlers focused on farming (Adelman 2011). Similarly, the Andean regions of Chile and Peru saw meteorological investigations targeting mining and agriculture, as well as efforts to prevent volcanic activity and earthquakes dating back to colonial times (Prieto, Rojas, and Castillo 2019: 157). However, large tropical or inland areas like the Amazon and Central America remained outside the main sphere of scientific attention.

The development of climate predictability played a key role in attracting migrants for agricultural purposes. Henrique Morize, originally from France and director of the Brazilian National Observatory for nearly fifty years, was an early advocate of Brazil's meteorological network established in 1908. In 1915, Morize noted that there were only thirteen meteorological stations across the Amazonian territory, although Julius Hann (1883: 352) observed that Manaus and Iquitos provided reliable meteorological data. In contrast, Rio Grande do Sul – the southernmost state and focus of European agrarian colonization policies – had thirty-five stations by that time (Morize 1987), leaving the entire Amazon region far behind. Earlier, during the period when Santa Catarina was still a province (before becoming a state in 1889), German national-liberal politician Ottokar Dörffel sought refuge in Joinville following the failed 1848–1849 revolutions and established meteorological stations there, maintaining communication with prominent European climatologists (Matzke 2019).

These examples demonstrate the peripheral status of the Amazon in Brazilian modernization efforts and national priorities during the late nineteenth and early twentieth centuries. The region received limited climatological attention until the 1970s, when the establishment of the *Instituto Nacional de Pesquisas Especiais* (INPE) marked a turning point. The introduction of satellite imagery and aerial photography significantly advanced research on the Amazonian climate. However, it is important to note that prior to the 1970s, the climatological instruments used for studying Brazilian climates were primarily sourced from the Global North and tailored to temperate climate conditions (Mendonça 2012).

Nevertheless, the scientific discourse surrounding Amazonian climate knowledge should be balanced by recognition of native *and* local perspectives that persist within society. The dynamic interplay between traditional knowledge systems and

Western scientific frameworks is evident not only in Brazil but throughout much of Latin America. For instance, in the Andes, Indigenous communities continue to employ longstanding agricultural calendars and observations of natural phenomena to forecast weather, thus providing valuable climatological insights (Legoas 2022). As noted by Curt Nimuendajú (2000: 111), "in three centuries, hundreds of priests and friars did not succeed to ban the pajé from the perimeter of the capital Belém," highlighting that climate understanding for many was shaped primarily by traditional knowledge, customs, and cosmological beliefs. During the catastrophic drought of 1877–1879 – attributed to El Niño imbalances – laborers from Ceará and Paraíba in the northeast migrated to the Amazon, introducing new perspectives and experiences of aridity. Comparable migration patterns in response to climatic disruptions are observable elsewhere in Latin America; for example, droughts in northern Mexico have frequently resulted in population movements toward the more fertile south (Liverman 1999). Similar trends can be seen among maroon communities established in the Amazon since the colonial era (Leonardi 1999), paralleling the experiences of Afro-descendant groups in Colombia who have historically resided in remote rainforest regions.

The earliest modern climate observations in the Amazon came from two outsiders. Between 1754 and 1756, the priest Ignácio Sermantoni noted changes in the weather in Barcelos based on sensory experience. Nearly a century later, U.S. consul Henry Dewey used systematic and quantitative methods to measure the climate in Belém (Rego 2021). In addition, José da Costa Azevedo, known as the Barão de Ladário, was a pioneer of Amazonian climatology, carefully recording weather conditions and temperatures in Manaus from 1861 to 1866 (Sant'Anna Neto 2003). Despite these efforts, none led to long-term studies or sustained analysis of local weather patterns.

The first comprehensive climatological survey of Brazil, *Esboço para uma climatologia do Brasil* (1889) by Henrique Morize (a French-born scientist), identified the Amazon region as part of the "tropical, torrid and equatorial zone" (Morize 1889: 7). This type of climate classification was common throughout Latin America; researchers frequently categorized areas according to rainfall and temperature patterns. For instance, in Argentina, Wladimir Köppen's early work contributed to defining the country's wide range of climates (Iriondo and Garcia 1993).

Morize's early climatological studies of Brazil were significantly informed by the work of German engineer Frederick Draenert, who conducted research at the Agricultural School of Bahia and subsequently expanded upon Morize's foundational efforts. Draenert prioritized precipitation as the primary variable for climate classification. Consequently, Morize adopted Draenert's perspectives when conceptualizing the climate of the Amazon, establishing three distinct climatological regions: (1) the Upper Amazonas, (2) the interior lands – including the states of Pará and Mato Grosso, and (3) the coastal regions, also including Pará.

Additionally, Morize characterized only two meteorological seasons within the Alto Amazonas: a period of high precipitation (from February to June) and a period of lower precipitation (starting in October and concluding in January). Notably, Morize's classification did not delineate a specific climatological zone exclusively for the Amazon, as substantial portions of Pará and Mato Grosso were grouped into categories that overlapped with non-Amazonian areas, such as the northeast. While his approach incorporated contemporary climatological frameworks established by Vladimir Köppen and Julius Hann, Morize diverged from the prevailing central European methodology that closely linked vegetation with climate. For example, Köppen's influential work, *Versuch einer Klassifikation der Klimate* (1900: 610), categorized the Amazon as part of the "Megathermen" region, characterized by the absence of pronounced seasons, consistent temperature stability, and a dominance of hygrophilous tree species with limited phenological variation. Köppen referred to it as "Lianenklima," linking the climate to the dense, almost impenetrable nature of the forest. A few years later, Carlos Delgado de Carvalho (1917) published *Météorologie du Brésil* in London, where he argued against labeling the Amazon climate as tropical, emphasizing instead the distinctions between equatorial and tropical climates. He characterized the Amazon primarily by its high humidity. Afranio Peixoto, on the other hand, emphasized the tropical nature of Brazil's climate overall, extending its boundaries beyond previous classifications by Morize and Delgado de Carvalho. For the Amazon region, Peixoto stressed its equatorial climate and separated conditions into hot, humid zones (Upper Amazonas) and hot, subhumid zones (the interior of Pará, Maranhão, and Mato Grosso). Peixoto's perspective on climate was strongly influenced by the traditional link between climate and health, but he also used geographic reasoning to shape his model (Sant'Anna Neto 2003).

The Amazon's climate reports consistently highlight the importance of precipitation in shaping meteorological patterns. Interestingly, rainfall in the region reverses typical seasonal expectations; familiar terms like summer and winter do not align with Earth's actual position. The so-called *inverno amazônico* starts in December – just before the austral summer solstice – and lasts until about the austral spring equinox. Generally, this Amazonian winter spans nine months, peaking during periods of heavy rainfall, especially toward late March and early April. People in the Amazon perceive colder temperatures throughout this season because rain is frequent and cold fronts – known locally as *friagens* – move in from southern climatic zones. These *friagens* particularly impact the south and southwest edges of the Amazon, sometimes dropping temperatures to as low as 13–15°C. By September, the Amazonian winter gives way to drier conditions, with rainfall decreasing below 60 mm and temperatures climbing higher. Intense heat and elevated levels of tree evapotranspiration trigger torrential downpours, contributing to the region's monsoon-like climate, which defines its summers (Lima e Silva, Vilhena, and Freitas 2018). The Amazon's summers and winters challenge traditional ideas of the seasons. Despite this reality, national weather forecasts – broadcast through numerous telecommunication channels – still fail to capture the local concepts developed by residents of the Amazon.

Generally, solar and seasonal concepts such as spring and autumn remain peripheral in the Amazon, where communities continue to rely on their own climatic frameworks, a practice observed for centuries. Factors such as precipitation, temperature sensations, and specific plant phenologies have traditionally informed local climate understanding (Caldas 2018). Research focused on popular climate concepts or climate ethnoknowledge is relatively limited; instead, scholarship has predominantly emphasized ethnobotanical knowledge, often leaving questions related to climate insufficiently addressed (Braga 2015). Contemporary discourse on climate change and the Anthropocene increasingly reflects changes in Indigenous livelihoods (Kronik and Verner 2012), with active contributions from local leaders (Krenak 2019).

Although historical documentation remains scarce, the past twenty-five years have witnessed the emergence of "ethno-meteorology" or "*antropologia del clima*," as introduced by various European and Latin American scholars. These fields investigate the relationship between meteorological phenomena and Indigenous knowledge systems (Rudnev 1997; Goloubinoff, Katz, and Lammel 1997). Wilbert (1996) developed the concept of "religious climatism" among the Warao Indians of Venezuela, highlighting the integration of climate patterns with religious beliefs. This framework seeks to explore how the Warao adapt to interactions with national society, particularly through the adoption of new strategies to mitigate reduced control over local resources. Comparable practices are observed among Indigenous groups throughout Latin America. For instance, the Maya in Central America employ the Ha'ab solar calendar to align agricultural cycles with celestial events and conduct rituals such as Ch'a Cháak to invoke rain (Camacho-Villa et al. 2021). Similarly, the Mapuche in southern Chile associate natural occurrences with spiritual forces, perceiving the land (Mapu) as a sentient entity that must be maintained in harmony. This perspective is evident in their agricultural methodologies and seasonal ceremonies (Arias-Bustamante and Innes 2021).

Research on climate perception in Brazil primarily focuses on modern society, often emphasizing the contrast between urban and rural environments (Sartori 2014; Mendonça 2012). For the Amazon region, Faulhaber's (2004) work stands out as a major contribution to climate anthropology. His study explores the connection between climate and cosmology among the Ticunas, not to demonstrate alignment between their perspectives and scientific weather forecasts, but rather to reveal distinct influences shaping Ticuna meteorological beliefs that go beyond typical Western physical forces. The Ticunas interpret celestial bodies – star constellations, the sun, and the moon – as living entities, and these views, together with the myth of primordial incest, interact with their observations of plant cycles and water seasonality.

From the perspective of nineteenth-century Brazilian administration in Amazonian territories, Braga (2015) highlighted how regional intellectuals defended Amazonian climates against international critics and scientific theories that excluded the region from narratives of progress and modernization. Following the establishment of the province of Amazonas in 1852, these intellectuals encompassed not only individuals born in the Amazon, but also Brazilian officials from other regions and foreigners involved in commerce, industry, and the arts. While presenting an array of notable figures from nineteenth-century Amazonian society, the discourse on climate often disregarded local resource management and the impact of inhabitants on the environment. The Amazonian elite played a role in naturalizing climatic standards, echoing scientific rationalism in their analysis. As in southern Brazil, discussions around European colonization arose in relation to optimal Amazonian microclimates – some areas were perceived as more suitable for foreign settlers. Overall, there was a lack of consideration for the perspectives of diverse Amazonian societies in shaping varied explanations of climate, and Western scientific models tended to predominate.

The impetus for organized research, publication, and dissemination of Amazonian natural and ethnological knowledge is largely attributed to the establishment of the Museu Paraense in 1871. Several decades later, the institution was renamed Museu Goeldi in recognition of the significant contributions made by Swiss naturalist Emilio Goeldi, particularly his assistance to Brazilian diplomats in resolving a border dispute with France in Guyana. Scientific exploration in the Amazon advanced considerably following Louis Agassiz's expedition from 1865 to 1866. Capitalizing on the increased attention, local leaders such as Lauro Sodré, Justo Chermont, and José Veríssimo promoted the concept of the Amazon as a center for international scholarly activity (Sanjad 2005). Upon assuming directorship of the Museu Paraense in 1894, Emilio Goeldi brought with him European meteorological instruments from the unsuccessful Colonia Alpina project in Rio de Janeiro, which he had managed with his father-in-law. Goeldi's interest in climatology dated back to the formative years of scientific meteorology, and he maintained professional connections with Austrian meteorologist Julius Hann.

Climatological research was a principal focus at the Museu Paraense. Supported by funding from the state of Pará, Goeldi procured numerous European instruments, primarily sourced from Germany and Austria-Hungary. Prior to shipment to the Amazon, Dr. Peter Vogel – an astronomer associated with the German Military Academia and the Munich Observatory – conducted thorough testing of these devices. The initial measurements commenced in 1895, with data regularly sent to Julius Hann in Graz or Vienna. Hann utilized this information in his publication *Der tägliche Gang der Temperatur in der inneren Tropenzone* (1905) and referenced Goeldi's findings in Belém in several shorter works. Goeldi meticulously recorded observations and endeavored to interpret climatic trends based on vegetation patterns. This climatological program was subsequently continued by other researchers, including the entomologist Adolpho Ducke, who published *Notas sobre o Clima da Amazônia* (1911), and Paul Le Cointe, whose *Le climat Amazonique* (1906) incorporated hygienist perspectives and investigations regarding the Amazon's historical context. Goeldi employed "meteorologists" such as the German Ernst Clément, the Swiss Joseph Schönmann, and the Austrian Matthias Zisl; all were trained entomologists responsible for operating meteorological stations. Goeldi's meteorological service in the Amazon operated within a limited scope. It faced competition from the *Servico de Estatística* de Manaus as well as meteorological measurements conducted by military personnel stationed in the region. Additionally, Goeldi's ambition to establish an extensive network of meteorological stations across Pará was not realized. The outbreak of the First World War, coupled with financial constraints, further impacted the service, which was active between 1895 and 1922. The predominance of scientists from German-speaking Europe and the decline in rubber extraction activities also contributed to the discontinuation of the service (Da Cunha and Bastos 1973).

In 1942, José Carlos Junqueira Schmidt published a pioneering paper entitled *O clima da Amazonia*, focusing exclusively on the climatology of the Amazon basin while excluding non-Amazonian Brazilian regions. This work represented a significant milestone in establishing the Amazon as a distinct subject for climatological study, assessed according to its unique terms and dynamics. Drawing upon geological, marine, solar, and atmospheric knowledge, and building on Köppen's classifications, Schmidt utilized comprehensive data from numerous climatological stations across various Amazonian cities to provide an extended temporal analysis of the region's climate for the first time. Although he was unable to meet the International Meteorological Organization's requirement of 30 years of observations, his findings on Amazonian climatology have been highly regarded. The majority of regional climates were classified as tropical forest climates (Af) and tropical forest climates with a brief dry season (Am). Weather stations were established in locations such as São Gabriel do Rio Negro (now São Gabriel da Cachoeira), Belém, Manaus, Taperinha (near Santarém), Clevelandia do Norte, Sena Madureira, Rio Branco, Mato Grosso (in an isolated area), Boa Vista dos Tocantins, Porto Nacional, Santa Luzia, and Santa Rita do Araguaia. Writing in the post-rubber boom era, Schmidt diverged from the humoral and hygienist perspectives on climate, aligning instead with the nationalist spectrum articulated decades earlier by Afranio Peixoto. These positions were reinforced by the policies of the Estado Novo under Getúlio Vargas, which aimed to achieve national integration, promote industrial development, and encourage colonization of peripheral regions. Amidst a period of economic transition and the decline of traditional activities in the region, and during the context of World War II, Schmidt revised climatological terminology to support scholarly justification in the

Amazon. Rather than focusing on modernization or civilization – rhetorical devices prevalent in the nineteenth and early twentieth centuries – Schmidt emphasized unequivocally that "the Amazon offers no climatic obstacle for development" and underscored its "economic importance" (Schmidt 1942: 465, 493).

Conclusions

In broad terms, the process of individualizing the climate of the Amazon has progressed at a considerably slower rate compared to advancements within the natural sciences, particularly botany. As a result, relatively few scholars possessed the necessary expertise to identify a direct correlation between land use patterns and climatic processes. Additionally, indigenous and mixed societies – such as *ribeirinhos, caboclos*, and maroon communities – were often regarded as lacking the capacity to influence and shape the climate. This perspective was reinforced by foreign researchers, explorers, and members of both landed and intellectual elites, who promoted frameworks that facilitated epistemic and factual colonization in the diverse field of climate understanding and awareness.

German (phyto)geography and Austrian climatology, alongside earlier climate theories such as humoral and disease climates and civilizationism rhetoric, significantly influenced discussions regarding Amazonian climate from 1800 to 1950. The initial advancement of scientific climatology in the region was largely attributed to German-speaking scientists, who played a central role both in expertise and in the production of meteorological instruments. The establishment of the Museu Paraense, later renamed Goeldi's Museum in the 1890s, was instrumental in these developments. Following this period, local and national scholarship on Brazilian and Amazonian climates flourished. Although the Amazon remained peripheral to the broader national strategy for climatology – primarily aimed at agricultural development and colonization in southeast and southern Brazil – various social groups succeeded in integrating the region into global climate networks. This shift encouraged a more quantitative, evidence-based approach to studying the local climate, moving away from previous mythical, humoral, and civilizationistic perspectives. Nonetheless, the resulting model was predominantly Eurocentric, often disregarding local accounts, perspectives, and cosmologies, relegating them to folklore, literature, and ethnology. Ultimately, these initiatives were undermined by the collapse of rubber extraction in the area.

Climatology in Brazil, largely advanced by scientists based in the southeastern region, was oriented toward developing a comprehensive national framework. Debates arose regarding the appropriate classification of Amazonian climates – specifically, whether they should be defined as tropical or equatorial. Analyses frequently differed on the roles assigned to the arid *caatinga* and the humid, narrow coastal zones of the Northeast within these classification systems. Notably, climatological research supported agricultural initiatives rooted in European colonization and facilitated the growth of coffee plantations. Despite significant research conducted at the Goeldi Museum in Belém, most infrastructure and weather stations were concentrated in southern and southeastern Brazil. By 1909, meteorological services across various states had been centralized under the *Diretoria de Meteorologia e Astronomia* (Ministry of Agriculture, Industry, and Commerce), overseen by the National Observatory in Rio de Janeiro. Consequently, priorities shifted toward establishing a unified national agenda, often at the expense of addressing the specific regional characteristics of the Amazon.

Climatological studies of different regions gained prominence following Getúlio Vargas's assumption of office in Rio de Janeiro, which marked the end of local *oligarquías* and radical federalism. Policies focused on cultural nationalization, the "march to the west," national integration, and developmental ideologies – particularly in response to the decline of rubber production – served as driving forces for economic expansion. Consequently, from the 1940s onward, scholarly and governmental interest in the Amazon intensified, shifting from civilizational, hygienist, or determinist rhetoric to a perspective that emphasized national development and the utilization of natural resources, beyond extractivist activities such as rubber exploitation and low-scale agriculture by Indigenous, *ribeirinho*, and *caboclo* groups. Notably, colonial-era notions regarding the Amazon have persisted into contemporary discourse and now coexist with advanced technological capabilities for economic exploration.

After 1950, significant transformations occurred in the Amazon, particularly in the study of climate and climate dynamics, as capitalist development expanded into the region, resulting in environmental degradation, deforestation, and human rights concerns. Against the political backdrop of the Cold War, technological advancements such as satellites and aerial photography gradually supplanted direct field observations conducted by earlier naturalists and scientists. This technological shift enabled the integration of new climatic variables with traditional elements, facilitating enhanced understanding of evapotranspiration, forest micrometeorology, albedo effects on the extensive forest cover, and the influence of phenomena such as El Niño – a process notably accelerated by the severe drought of 1983. Additionally, studies incorporated atmospheric convection between cold and warm fronts, aerial humidity flows, and the impacts of southern *friagens*, thereby generating new insights and questions regarding Amazonian climate dynamics (Fisch, Marengo, and Nobre 1998).

Despite these advances, the knowledge base reflecting local perspectives and Indigenous cosmologies remains markedly limited, highlighting the predominantly top-down approach to climate policy in the region. A critical aspect of contemporary research focuses on the profound shifts in land use – namely the expansion of cattle ranching, industrial agriculture, infrastructural development, and urbanization – which are fundamentally altering the trajectory of the Amazon in unprecedented ways. Amidst increasing global concern over unchecked planetary warming, the Amazon is experiencing significant contributions to worldwide declines in air quality, biodiversity, and social diversity.

References

Ab'Sáber, Aziz Nacib. 2010. "A organização natural das paisagens inter e subtropicais Brasileiras." In *A obra de Aziz Nacib Ab'Sáber*, ed. May Celso Dal Re Modenesi-Gauttiere, Matias B. De Andrade Lisboa, Virginio Mantesso-Neto, et al., 404–414. São Paulo: Beca.

Acker, Antoine. 2017. *Volkswagen in the Amazon: The Tragedy of Global Development in Modern Brazil*. Cambridge: Cambridge University Press.

Adelman, Jeremy. 2011. *Frontier Development: Land, Labour, and Capital on the Wheatlands of Argentina and Canada 1890–1914*. Oxford: Oxford University Press.

Arias-Bustamante, José R., and John L. Innes. 2021. "Mapuche Spirituality and Its Contribution to Climate Change Mitigation." In *Handbook of Climate Change Management*, ed. Walter Leal Filho, Johannes Luetz, and Desalegn Ayal, 1–32. Cham: Springer.

Arnold, David J., and Kalyanakrishnan Sivaramakrishnan. 2015. *The Tropics and the Traveling Gaze: India, Landscape, and Science, 1800–1856*. Washington, D.C: University of Washington Press.

Botelho, André, and Nísia Trindade Lima. 2019. "Malarial philosophy. The modernista Amazônia of Mário de Andrade." In *Intimate frontiers. A literary geography of the Amazon*, ed. Felipe Martínez-Pinzón and Javier Uriarte, 150–176. Liverpool: Liverpool University Press.

Braga, Pedro Henrique Maia. 2015. "O clima do Amazonas: uma interpretação dos discursos de administradores provinciais (1850–1890)." Master's thesis, Universidade Federal da Paraíba.

Caldas, Raquel Coehlo. 2018. "Verão e Inverno amazônicos. uma análise da relação entre o conceito científico e a concepção popular de clima a partir das localidades ribeirinhas do distrito de Juaba no município de Cametá-Pará." Master's thesis, Universidade Federal do Pará.

Camacho-Villa, Tania Carolina, Tania Eulalia Martinez-Cruz, Alejandro Ramírez-López Alejandro Ramírez-López, et al. 2021. "Mayan Traditional Knowledge on Weather Forecasting: Who Contributes to Whom in Coping With Climate Change?." F*rontiers; Sustainable Food Systems* 5: 1–17.

Carey, Mark. 2012. "Climate and history: a critical review of historical climatology and climate change historiography." *WIREs Climate Change* 3, no. 3: 233–249.

Carvalho, Carlos Delgado de. 1917. *Météréologie du Brésil*. London: John Bale and Sons.

Costa, Jorge Luis P. Oliveira, Francisco de Assis Veloso Filho, Antonio Alberto Jorge Farias Castro, et al. 2013. "A Divisão Natural das Paisagens Vegetais do Brasil no Escopo dos Sistemas Nacionais de Classificação Fitogeográfica (1824–2006)." *Publicações Avulsas em Conservação de Ecossistemas* 30, no. 30: 1–43.

Cushman, Gregory T. 2011. "Humboldtian science, Creole meteorology, and the discovery of human-caused climate change in South America." *Osiris* 26: 19–44.

Da Cunha, Osvaldo Rodrigues, and Therezinha Xavier Bastos. 1973. *A contribuicao do Museu Paraense Emilio Goeldi à metereologia na Amazonia*. Belem-Pará: Museu Paraense Emilio Goeldi.

Faulhaber, Priscila. 2004. "'As estrelas eram terrenas': antropologia do clima, da iconografia e das constelações Ticuna." *Revista de Antropologia* 47, no. 2: 380–426.

Figueiredo, Aldrin Moura de, Rafael Chambouleyron, and José Luis Ruiz-Peinado Alonso 2017. "Amazônia e história global – Apresentação." *Tempo* 23, no. 3: 504–505.

Fisch, Gilberto, José A. Marengo, and Carlos A. Nobre. 1998. "Uma revisão geral sobre o clima da Amazônia." *Acta Amazonica* 28, no. 2: 101–126.

Goloubinoff, Marina, Esther Katz, and Annamaria Lammel, ed. 1997. *Antropología del clima en el mundo hispanoamericano*. Quito: Abya-Yala.

Gourou, Pierre. 1949. "L'Amazonie: Problèmes Géographiques." *Les Cahiers d'Outre-Mer* 2, no. 2: 1–13.

Grisebach, August H. R. 1872. *Die Vegetation der Erde nach ihrer klimatischen Anordnung: Ein Abriss der vergleichenden Geographien der Pflanzen*. Leipzig: Wilhelm Engelmann.

Hann, Julius von. 1883. *Handbuch der Klimatologie*. Stuttgart: J. Engelhorn.

Hilbert, Klaus, and Jens Soentgen. 2021. "From the 'terra preta de índio' to the 'terra preta do gringo'. A history of knowledge of the Amazonian Dark Earths." In *Ecosystem and Biodiversity of Amazonia*, ed. Heimo Mikkola, 129–146. London: IntechOpen.

Horne, Gerald. 2007. *The Deepest South: The United States, Brazil, and the African Slave Trade*. New York: New York University Press.

Humboldt, Alexander von, and Aimé Bonpland. 1807. *Ideen zu einer Geographie der Pflanzen nebst einem Naturgemälde der Tropenländer: Auf Beobachtung und Messung gegründet, welche von 10ten Grade nördlicher bis zum 10ten Grade südlicher Breite, in dem Jahren 1799, 1800, 1801, 1802 und 1803 angestellt worden sind*. Tübingen/Paris: F. G. Cotta/F. Schoell.

Iriarte, José, Richard J. Smith, Jonas Gregorio de Souza, et al. 2017. "Out of Amazonia: Late-Holocene climate change and the Tupi–Guarani trans-continental expansion." *The Holocene* 27, no. 7: 967–975.

Iriondo, Martin H., and Norberto O. Garcia. 1993. "Climatic variations in the Argentine plains during the last 18,000 years." *Palaeogeography, Palaeoclimatology, Palaeoecology* 101, no. 3–4: 209–220.

Kern, Dirse Clara, Maria De Lourdes Pinheiro Ruivo, and Francisco Juvenal Lima Frazão. 2009. "Terra Preta Nova: The Dream of Wim Sombroek." In *Amazonian Dark Earths: Wim Sombroek's Vision*, ed. William I. Woods, Wenceslau G. Teixeira, and Johannes Lehmann, et al., 339–349. Dordrecht: Springer Netherlands.

Köppen, Wladimir. 1900. "Versuch einer Klassifikation der Klimate, vorzugsweise nach ihren Beziehungen zur Pflanzenwelt." *Geographische Zeitschrift* 6: 593–611, 657–679.

Krenak, Ailton. 2019. *Ideias para adiar o fim do mundo*. São Paulo: Cia das Letras.

Kronik, Jakob, and Dorte Verner. 2010. *Indigenous peoples and climate change in Latin America and the Caribbean*. Washington, D.C.: World Bank.

La Condomine, Charles Marie de. 1751. *Journal du voyage fait par ordre du roi, à l'Equateur, servant d'introduction historique à la mesure des trois premiers degrés du méridien*. Paris: De l'imprimerie royale.

Le Cointe, Paul. 1906. "Le climat amazonien et plus spécialement le climat du Bas Amazone." *Annales de Géographie* 84: 449–462.

Legoas, Jorge P. 2022. "Performing Symmetry in Andean Weather Forecasting: The Practice of Cabañuelas, Beyond Divination and Suffering." *Journal of the American Academy of Religion* 90, no. 4: 987–1009.

Leonardi, Victor. 1999. *Os historiadores e os rios: Natureza e ruína na Amazônia brasileira*. Brasília: Editora UnB.

Lima e Silva, Raullyan Borja, Jefferson Erasmo de Souza Vilhena, and João da Luz Freitas. 2018. *Climatologia do Amapá: Quase um século de história*. Rio de Janeiro: Gramma.

Liverman, Diana M. 1999. "Vulnerability and Adaptation to Drought in Mexico." *Natural Resources Journal* 99: 99–115.

Mauelshagen, Franz. 2018. "Climate as scientific paradigm – Early history of climatology to 1800." In *The Palgrave Handbook of Climate History*, ed. Sam White, Christian Pfister, and Franz Mauelshagen, 565–588. London: Palgrave Macmillan.

Meggers, Betty J. 1979. "Climatic Oscillation as a Factor in the Prehistory of Amazonia." *American Antiquity* 44, no. 2: 252–266.

Mendonça, Francisco. 2012. "La connaissance du climat au Brésil : entre le vernaculaire et le scientifique." *confins* 15.

Miranda, Ires Paula de Andrade. 1999. "Memória. Adolpho Ducke: Uma visão de conservação da Amazônia." *Acta Amazonica* 29, no. 3: 501.

Nimuendajú, Curt. 2000. *Cartas do sertão*. Lisbon: Assírio & Alvim.

Morize, Henrique. 1889. Esboço para uma climatologia do Brasil. Rio de Janeiro: Impressores do Observatorio.

———. 1987. *Observatório Astronômico: Um século de história (1827–1927)*. Rio de Janeiro: Museu de Astronomia e Ciências afins.

Monzote, Reinaldo Funes. 2018. “The greater Caribbean and the transformation of tropicality.” In *A living past. Environmental histories of modern Latin America*, ed. John Soluri, Claudia Leal, and Jose Augusto Pádua, 45–66. New York: Berghahn.

Murari, Luciana. 2009. *Natureza e cultura no Brasil*. São Paulo: Alameda.

Noelli, Francisco Silva, and Lúcio Menezes Ferreira. 2007. “A persistência da teoria da degeneração indígena e do colonialismo nos fundamentos da arqueologia brasileira.” *História, Ciências, Saúde-Manguinhos* 14, no. 4: 1239–1264.

Pádua, Jose Augusto. 2015. “Mata Atlântica e a Floresta Amazônica na construção do território brasileiro. Estabelecendo um marco de análise.” *Revista de História Regional* 20, no. 2: 232–251.

Paibón Caicedo, José Daniel. 2006. “El clima de Colombia durante los siglos XVI–XIX a partir de material histórico. Parte I: inventario de fuentes de información.” *Cuadernos de Geografía: Revista Colombiana de Geografía* 15: 75–92.

Palacios Díaz, Julio, Martín Arana Cardó, Juan Torres Guevara, et al. 2016. *Historia ambiental del Perú, siglos XVIII y XIX*. Lima: Ministerio del Ambiente del Perú.

Peixoto, Afranio. 1907. *Clima e doenças do Brasil; notas escriptas para o Brazilian year book de 1908*. Rio de Janeiro: Imprensa Nacional.

Prieto, María del Rosario, Facundo Rojas, and Leonardo Castillo. 2019. “La climatología histórica en Latinoamérica. Desafíos y perspectivas.” *Bulletin de L'Institut Francais d'Etudes Andines* 42: 141–167.

Rego, Willy Hagi Teles. 2021. “As contribuições do esquecido Serviço Meteorológico do Museu Paraense Emílio Goeldi.” *Amazonia Latitude*, July 26. https://www.amazonialatitude.com/2021/07/26/as-contribuicoes-do-servico-meteorologico-do-museu-emilio-goeldi/.

Relly, Eduardo. 2022. “Imigração alemã, ciência imperial e a tradução/colonização de ecologias locais do clima subtropical na América do Sul.” *Fronteiras: Revista Catarinense de História* 39: 119–136.

Rinke, Stefan. 2015. *América Latina e Estados Unidos. Uma história entre espaços: do período colonial aos dias atuais*. Rio de Janeiro: Editora Autografia/EDUPE.

Rudnev, Vyacheslav. 1997. “Ethno-meteorology: a modern view about folk signs.” In *Antropologia del clima en el mundo hispanoamericano*, ed. Marina Goloubinoff, Esther Katz, and Annamaria Lammel, 27–34. Quito: Abya-Yala.

Salati, Eneas, and José Marques. 1984. “Climatology of the Amazon region.” In *The Amazon: Limnology and landscape ecology of a mighty tropical river and its basin*, ed. Harald Sioli, 85–126. Dordrecht: Springer Netherlands.

Sanjad, Nelson R. 2005. “A coruja de Minerva. o Museu Paraense entre o Império e a República, 1866–1907.” PhD diss., Casa de Oswaldo Cruz.

Sant'Anna Neto, João Lima. 2003. “A gênese da climatologia no Brasil: o despertar de uma ciência.” *Geografia, Rio claro* 28, no. 1: 5–27.

Sartori, Maria da Graça Barros. 2014. *Clima e percepção geográfica: fundamentos teóricos da percepção climática e à bioclimatologia humana*. Santa María: Gráfica Editora Pallotti.

Schmidt, José Carlos Junqueira. 1942. "O clima da Amazônia." *Revista Brasileira de Geografia* 4, no. 3: 465–500.

Simões, Mario F. 1977. "Programa Nacional de Pesquisas Arqueológicas na Bacia Amazonica." *Acta Amazonica* 7, no. 3: 297–300.

Strobl, Michael. 2021. "Alexander von Humboldt's climatological writings." *German Life and Letters* 74, no. 3: 371–393.

Robinson, Mark, Jonas Gregorio De Souza, S. Yoshi Maezumi, et al. 2018. "Uncoupling human and climate drivers of late Holocene vegetation change in southern Brazil." *Scientific Reports* 8, no. 1: 1–10.

Vieira, Patricia I. 2018. *States of Grace: Utopia in Brazilian Culture*. New York: State University of New York Press.

Wilbert, Johannes. 1996. *Mindful of famine: Religious climatology of the Warao Indians*. Cambridge: Harvard University Center for the Study of World Religions.

Climate Change in Mesoamerica from the Mid-Nineteenth Century to 1950

"May It Rain Coffee": Climate and Human Actions in the Nineteenth and Twentieth Century

John Soluri and Antonio Escobar Ohmstede

Today, there is rising concern over the implications of climate change not only on a global scale, but also at local levels where rainfall patterns, species reproduction cycles, and – above all – the ways in which inhabitants confront environmental events have shifted markedly. Phenomena once perceived as isolated or specific to a given place are now understood as connected to global or planetary processes. The effects of climate change continue to vary depending on the regions and social contexts in which they unfold. This broader reality, together with the themes developed in this chapter, gives meaning to its title, which draws on a line from a song by Dominican singer-songwriter Juan Luis Guerra. The phrase "*Ojalá que llueva café*/May it rain coffee" conveys the hope of providing relief to the most vulnerable in times of crisis – wishing that at least "it would rain coffee on them [...] blessed by the hand of God" so that their basic needs might be met. This sentiment echoes what many people in the past expressed when facing crop failures, livestock mortality, drought or excessive rainfall, and the spread of pests: they raised their pleas to the heavens, whether through ecclesiastical authorities or in their own voices. In this sense, the title borrowed from a popular song also reminds us of the deep entanglement between biophysical conditions and cultural meanings, between events and the interpretations they generate.

Approaching climate change through the lens of the Anthropocene – a concept discussed extensively in this volume's introduction – provides an entry point into the themes explored in this chapter. Olaf Kaltmeier (2024: 32) argues, "the Anthropocene is not only a geological concept but a discursive event that marks a fundamental rupture in the history of human life on the planet." This perspective invites consideration of the diverse levels and modes of perception that vary based on who is analyzing the phenomenon – whether individual or collective actors – and on the moment when the concept emerged, as well as how it relates to the environmental impacts generated by extractive processes (Leal, Soluri, and Pádua 2022: 11–32).

"Greater Mesoamerica" – defined here as the territories that comprise contemporary Mexico and the countries of Central America – encompasses remarkable biocultural diversity. It is a mosaic of varied ecosystems, ethnically and socioeconomically diverse human populations, multiple economic structures, and extensive infrastructures, including transportation networks, as well as distinct configurations of social and political power. From the perspectives of anthropology and cultural geography, the concept of Greater Mesoamerica risks homogenizing heterogeneous cultural areas. On the other hand, a "Greater Mesoamerica" allows for a broad, synthetic view of the socio-ecological spaces where climatic shifts occurred and where different effects and responses emerged. The notion of a "Greater Mesoamerica" thus enables an analytical approach that highlights complexity and contextual variation, avoiding linear historical narratives. If we conceive of "borders" solely as limits, we risk overlooking the ways in which populations on either side identify with and interact across them, and the diverse processes through which identities, territories, and family networks are constructed. Border communities often develop their own relationships with national "centers" (Castillo, Toussaint, and Vázquez 2006). This perspective, in turn, points to the existence of multiple territories within contemporary nation-states, rather than imagining homogeneous spaces in terms of ecological systems, identities, cultures, populations, or modes of production and access to natural resources. In other words, the limitations of nation-state based historical frameworks make regional, comparative perspectives crucial for revealing shared histories and experiences.

Our approach is informed by both historical climatology and climate history. The former focuses on "climate behavior at different temporal scales, its possible future scenarios, alterations in atmospheric circulation, and extreme meteorological phenomena – hurricanes, torrential rains, droughts, cold and heat waves – which also makes it possible to observe social responses to crisis situations and management capacities to mitigate or adapt to new conditions" (Barriendos 2021: 35). The field has, to a considerable extent, taken up Emmanuel Le Roy Ladurie's proposal for writing a "long history of climate" (Arrioja 2021: 25; Arrioja and Alberola 2021: 9–30; Barriendos 2021: 33–72). Moving beyond historical climatology's focus on documenting climatic variability, climate history examines the interaction between human activities and changing climates; in other words, people do not merely respond to climatic variations, they help to create them at different rhythms and scales. (Boyer and Radding 2016: 17–50; White, Pfister, and Mauelshagen 2018; Carey 2014; García and Prieto 2000; García and González 1999).

Historical research on meteorological phenomena in Mexico has grown significantly in recent years in response to academic debates, public policies, and the effects of climate change. Among the pioneering works is that of Guillermo Padilla (1980), who examined the major droughts of nineteenth-century Mexico and produced a chronology later taken up by Enrique Florescano and Susan Swan (1995). In the same vein, the studies of Carlos Contreras Servín (1999; 2005; 2016) have analyzed droughts in the north-central region and, more broadly, across the Mexican republic, linking them to the so-called Little Ice Age (LIA). The LIA has attracted the interest of scholars in both the natural and social sciences, who generally regard it as a cooling period between 1550 and 1850 (Garza 2014: 83–85), although other authors extend its duration to five centuries, from 1300 to 1870 (Arrioja and Alberola 2021: 11). In Mexico and in the former Kingdoms of Guatemala, this period brought reduced rainfall at various points during the sixteenth, seventeenth, and eighteenth centuries, with a particularly marked phase in Mexico toward the end of the late colonial period and just before independence, as well as in certain years of the nineteenth century. These phenomena, combined with epidemics and floods, spurred efforts to prevent or lessen the effects of natural events.

In a state-of-the-field assessment on how LIA has shaped the climate history of New Spain (Mexico) and broader trends in the historiography on Mesoamerica, Arrioja (2021) highlights the new avenues opened for analyzing droughts, floods, pandemics, plagues, and epizootics. Among these studies are comparisons between Mexico and Spain (García Acosta 2021: 91–128), research on the relationship between diseases and climatic oscillations in Central America (Arrioja 2019), and analyses of adverse conditions in the rural world of southern Mesoamerica. These studies show how political-administrative divisions are porous, such that similar climatic phenomena affected Nicaragua, Guatemala, Mexico, Honduras, and El Salvador (Arrioja and Alberola 2021: 16–17; Arrioja 2019), though not always during the same periods or with the same effects or responses.

The desire to move beyond the political-administrative borders that structure national histories and official state documents has encouraged the search for new sources capable of revealing climatic variability and the outcomes of "catastrophes" (Garza 2014: 82–94; Garza 2021: 169–204; García Acosta 2016: 61–80; García Acosta 2024: 42–62; Lorenzo, Rodríguez, and Marcilhacy 2019), as well as the production in Mexico of major catalogues of "agricultural disasters" based on colonial primary sources (García Acosta, Molina, and Pérez 2003). Disentangling the causes of problems linked to climatic variability is seldom easy. As the Guatemala-based research of Guevara-Murua demonstrates, determining whether a nineteenth-century municipal council debated the reconstruction of a bridge damaged by floods because of unusually intense rains, sedimentation caused by agricultural practices, or a combination of both requires meticulous archival work (Guevara-Murua et al. 2018), along with consideration of variables that allow for more integrated analyses.

Building on scholarship in these growing fields while mindful of the gaps that persist, we have chosen to present evidence on the socioecological effects of intense climatic events ("disasters") and to draw attention to the actions that contributed to rising atmospheric CO_2, whether through increased emissions or through land-use changes, including deforestation that reduced carbon-capture capacity. Between

1800 and 1950, the world undoubtedly underwent transformations that steadily increased atmospheric CO_2 concentrations. It is equally clear that the vast majority of social actors – individual and collective – in "Greater Mesoamerica" were not thinking about CO_2 when they burned a patch of forest to plant their milpa or when they sought employment in a petroleum field. Only recently have scholars begun to examine how these actors perceived and constructed ideas about climate and its variability (Goebel 2009); only now are we beginning to glimpse and unravel forms of "popular knowledge," as in the case of locust plagues (*chapulines* in Mexico and Central America, referring to grasshoppers and locusts) that, during prolonged droughts, even served as protein substitutes.

In this sense, our work represents a first step toward an integrated history of climates and societies in Mesoamerica. The central question is the extent to which we can move from present to past – or from past to present – without falling into linear historical narratives, while attending to the multiple scales at which climatic variations manifest and to the responses of social actors, both individual and collective.

A Brief Consideration of Climate and Geography in a "Greater Mesoamerica"

As noted above, it is not easy to compare spaces that exhibit far more differences than similarities, nor to overlook the fact that the territories contained within national borders are themselves environmentally and culturally diverse. In the Mexican case, from the present-day northern border – arid, yet crossed by major rivers that enabled colonization before and after the arrival of the Spanish – to the states of Chiapas and Yucatán and their political borders with Belize and Guatemala; and from the Gulf of Mexico to the Pacific Ocean, where ecological and cultural diversity makes it impossible to generalize about how climate affected communities or how they responded to hydrometeorological events. Mexico is considered a "megadiverse" country due to the total number of species and ecosystems it contains, as well as the abundance of endemic life forms (SEMARNAT, n.d.).

The region known as the Central Highlands, long favored by its natural conditions, has a cool, dry high-altitude climate in winter and fertile soils derived from volcanic ash – features that made it a major center of human settlement long before the arrival of the Spanish. It is therefore a key region for studying the effects of climatic change and agricultural development (Contreras 1999: 156; Tutino 2016). In northern Veracruz, the area referred to as La Huasteca, which was already multiethnic prior to the Spanish arrival led by Nuño de Guzmán, transitioned into an agropastoral region during the sixteenth century. During the late nineteenth and early twentieth centuries, La Huasteca developed into a significant hub for petroleum production, making it an important region for studying the effects of fossil fuel extraction on regional environments.

In nineteenth-century republican Mexico as state control over territory expanded, agriculture started to adapt more closely to Mexico's landscape – where mountains cover two-thirds of the country. Meanwhile, private enterprises began exploiting the vast southern forests, particularly in Chiapas, Tabasco, and Yucatán, for valuable timber and rubber from the mid-nineteenth century onwards. The central and northern regions were largely too dry for consistent farming, so successful harvests and supplying food for people and livestock depended on significant investments in hydraulic infrastructure during both the nineteenth and twentieth centuries.

In the case of Central America, we find an equally notable degree of biocultural and bioregional diversity. Drawing on information from Fonseca and Barillas, Ronald Díaz observes:

> Central American geography is shaped by two slopes, one facing the Pacific and the other the Caribbean, divided by a mountain range that runs across the isthmus. The former includes a set of zones characterized by the presence of a defined dry season, which on average takes place between November and May. Rainfall tends to be lower than on the Caribbean coast, and the physical conditions of these areas make them prone to droughts. (Díaz 2019)

More specifically, the Pacific side of Central America experiences a prolonged dry season (December–May) followed by a rainy season (May–September). The latter is interrupted by short drought periods in late July and early August, whose distinctiveness gave rise to the vernacular terms *canícula* or *veranillo* (Maurer et al. 2022). The beginning and end of the annual rainy season in Pacific Central America are tied to the movement of the Intertropical Convergence Zone (ITCZ), a band in the lower atmosphere where the northern and southern trade winds converge, forcing the ascent of moisture-laden air and generating a convective cycle that produces intense tropical rainfall (NASA 2023; Guevara-Murua et al. 2018). In contrast, Central America's Caribbean lowlands have historically experienced abundant rainfall that feeds the region's major rivers.

Establishing causal connections between large-scale phenomena such as ENSO and local variations in precipitation or temperature is difficult, due in part to the mountainous geography of "Greater Mesoamerica." The Central American cordillera blocks east-to-west winds, thereby modulating ENSO's impacts in the region (Carvalho 2020; Baldwin 2021). Likewise, the rugged topography generates a mosaic of microclimates (Gallini 2009; Hall and Pérez Brignoli 2003: 18–19). In other words, hemispheric-scale climatic phenomena such as the ITCZ and ENSO tend to manifest locally or regionally because of the isthmus's topographic characteristics.

Broad climatic characterizations tend to obscure important interannual variations in precipitation, driven in part by large-scale phenomena such as ENSO. Significant interannual variability has been documented in many parts of Mesoamerica: in Mexico, episodes spanning several centuries (González Álvarez 2008); and in Central America, during the first half of the twentieth century (Bengtson 1925; Parsons 1955). In Costa Rica, evidence suggests a link between the "mega-ENSO" events of 1877–1878 and 1925–1926 – which caused a marked decline in precipitation – and severe locust outbreaks in regions that contemporary meteorologists describe as the "Central American dry corridor" (Alfaro-Martínez et al. 2022; Díaz Bolaños et al. 2019; Ortiz and Zuleta 2020: 313–370). In some cases, these episodes prompted recollections of similar events from the late colonial period in New Spain and from republican-era Mexico (Córdova 2002: 1181–1196). Scholars have documented numerous periods of reduced rainfall – characterized as "droughts" – throughout the nineteenth and early twentieth centuries (Goebel and Viales 2011; McCreery 1994).

Climate, of course, is not defined solely by precipitation patterns; nonetheless, in "Greater Mesoamerica," interannual variability in rainfall has been a key element of its history, something also visible in processes of deforestation and, more broadly, in the transformations that nature(s) have undergone over time. The cultural importance of rainfall and drought patterns in Mesoamerica (subtropical and tropical zones) can be seen in the use of the summer/winter binary, which refers to differences in precipitation rather than to variations in sunlight or temperature. That is, "winter" is associated with rainfall; "summer," with its relative absence.

Historically, inhabitants of the territories that today make up the Central American countries and Mexico have used a variety of terms to describe rainy events, such as *aguaceros* (brief, intense storms) and *temporales* (sustained rainfall) (Hall and Pérez Brignoli 2003). These popular concepts – and the variations in the patterns they describe – were of great importance in the nineteenth century, when roughly eighty percent of the population depended on agriculture, livestock raising, and/or hunting and fishing.

Nation-States, Reduced State Power, and Observations of Climatic Variability

While a comprehensive analysis of the formation and evolution of nation-states in "Greater Mesoamerica" falls beyond the scope of this chapter, a concise overview is essential for providing context for the gradual development of what are now known as public policies, which were designed to advance understanding of climate and enhance preventative measures against potential negative impacts of climate on the daily lives of inhabitants. This includes the modernizing impulses promoted by governments, which shaped perceptions of climate and the ways it could affect new activities and new means of transportation (railroads, canals, river navigation), new agro-industrial categories (textiles, coffee, sugarcane), and, in the Mexican case, new forms of energy production (dams and petroleum) (Rodríguez 2024: 201–240; Méndez 2024: 241–272; Falcón 2016: 209–242; Acuña 2014).

Environmental historiography on "Greater Mesoamerica" has generally approached nineteenth-century social conflicts as the consequence of transformations induced by nineteenth-century "liberal modernity" (Boyer and Radding 2016: 17–50; Soluri, Leal, and Pádua 2019: 11–34; Boyer and Cariño 2019: 35–56). In this context, the nation-state functions as a key player in hierarchical power dynamics and thus contributes to the creation of inequalities – evident in shifts in land ownership; in the appropriation, access, management, and control of natural resources; and in the growth of agriculture and increasingly capitalist agrarian policies. Examples include coffee production along the western slopes of Central America and in the Sierra Sur of Oaxaca, or the cultivation of vanilla in places like Papantla, which transformed landscapes and altered social relations (Kouri 2004; Lurtz 2019). These actions resulted in changes that were either promoted or enforced upon Indigenous or campesino communities, whose ways of life did not always align with those established during colonial times. While this perspective is valid up to a point, the reality is that social, cultural, economic, and political relationships were more intricate than state discourses that contrasted "traditional" and "modern" would suggest, especially since timelines varied across countries, regions, and localities (Jong and Escobar Ohmstede 2016: 17–18).

As nation-state power expanded, institutes dedicated to meteorological measurement and data collection were established. In this regard, Contreras notes:

> the oldest precipitation data refer to Mexico City and date back to 1841; the next site is Tepic, Nayarit. Between 1841 and 1876 – the year before the inauguration of the Central Meteorological Observatory – rainfall records exist for the following places: Mexico City, Colima, Córdoba, Guadalajara, Mérida, Hacienda del Mirador (Veracruz), Orizaba, Pabellón (Aguascalientes), Querétaro, Tepic, and Zacatecas. Most of the information corresponds to the period 1860–1876. Because the records lack continuity, a complete study of rainfall is impossible; nonetheless, the years 1844, 1859, 1860, 1863, 1873, and 1875 show a decrease in average precipitation, while 1861, 1870, and 1874 show an increase in rainfall. (Contreras 1999: 153)

In Mexico, the inauguration of the Central Meteorological Observatory in 1877 marked the expansion of the country's meteorological network, as well as the standardization of observation schedules (Contreras 2005: 124). As Carlos Contreras observes, the observatory's creation marked a significant turning point in the study of meteorology in Mexico (Contreras 1999: 17, 31–51). Even so, how widely this information circulated among those who depended on knowing weather conditions is unknown. In many rural areas, popular knowledge filled the gap; people could read the clouds according to the season.

In Central America, a history of relatively impoverished state institutions hindered the widespread and consistent collection of "basic" data such as daily precipitation or air temperature. This was especially true during the nineteenth century, when government surveys were scarce and it was difficult to record the activities of rural populations (McCreery 1994: 58; Lauria-Santiago 1999). In Guatemala, the first issue of the *Revista del Observatorio* appeared in 1883 (Claxton and Hecht 1984: 189). In Costa Rica, government officials published rainfall data no later than 1863, but sustained, instrumental measurement did not begin until the establishment of the *Instituto Físico-Geográfico* in 1889 (Goebel and Viales 2011; Hall and Pérez Brignoli 2003: 11; Solano et al. 2013; Morales 1989). Foreign interest in building canals and railroads across Central America and the Isthmus of Tehuantepec in Mexico led to mapping projects undertaken by outside actors (Dym 2004), as well as increased water and timber consumption by railroad companies (Boyer and Cariño 2022: 42–43). By the late nineteenth century, maps often included information on regional climates (Urroz 2012). Paradoxically, nineteenth-century actors produced both detailed studies and enduring myths about the landscapes and climates of Central America and Mexico (Gallini 2004; Offen 2004; Raby 2017).

Climate, Water, and Agriculture in the Nineteenth Century

Ecological, climatic, demographic, and economic conditions reshaped daily life in republican Greater Mesoamerica over the course of the nineteenth century, especially around the intensive production of grains and the development of high-value commercial crops such as sugar, cotton, henequen, indigo, and coffee. In the first half of the century, mining and the export of cochineal (a red dye obtained from the cochineal insect), along with cotton and vanilla, were essential elements in the regionalization of southern Mexico and the Guatemalan Highlands (particularly Quetzaltenango, Totonicapán, Sololá, Quiché, Retalhuleu, Huehuetenango, San Marcos, and Suchitepéquez). In Mexico, a growing shift toward livestock in the north was accompanied by an intensification of mining in the center and south. As Daniela Marino and Cecilia Zuleta note, the process of "productive diversification and specialization unfolded gradually between 1850 and 1930," with the sugar and pulque industries standing out in the country's central region (Marino and Zuleta 2010: 454–468).

As Mexico was unsettled by continuous civil wars and persistent institutional disorder, agriculture and access to water underwent significant transformations. In the center-north, many large haciendas – the basis of the power and prestige of families of colonial origin – experienced a slow and uneven process of fragmentation, while in other regions, a gradual encroachment on communal natural resources became apparent in Michoacán, Yucatán, Veracruz, Oaxaca, and the surroundings of Mexico City. The fragmentation of private estates and communal lands brought notable changes in patterns of land access and the emergence of a sector of medium and small farmers, as well as modifications in irrigation systems and, more broadly, in agricultural practices, which had to adapt to the climatic shifts of the nineteenth century.

Agrarian structures were particularly vulnerable to pests (Arrioja 2019; Córdova 2025, 1161–1200; Ortiz and Zuleta 2020: 313–373), to climatic variations that delayed the onset of rains and the recharge of aquifers, and to periods in which natural phenomena disrupted the life cycles of rural inhabitants (Escobar Ohmstede 2004). Drawing on information provided by Escobar Ohmstede (2004: 31–32) and comparing it with that of Contreras (2005; 2016), it is possible to estimate the number of droughts and floods recorded throughout the nineteenth century. Cases of water scarcity in Mexico between 1822 and 1900 – often associated with floods, pests, and epizootics – appear more frequently in records from the second half of the century, largely because greater availability of information and advances in meteorology made it possible to document them in greater detail.

Research drawn from various local and national repositories helps partially compensate for the lack of rainfall data for the first half of the nineteenth century. The available evidence suggests that water scarcity during this period was most common in northern states and in the Yucatán Peninsula. San Luis Potosí alone shows at least three droughts between 1822 and 1841, while Mexico City, Nuevo León, and Puebla recorded episodes of abundant rainfall. Most of the surviving information, however – as noted above – clusters in the 1840s and 1850s, a pattern similar to that of records on heavy rains, snowfall, and frost. In this regard, Carlos Contreras Servín (2016: 157–158) identifies ninety-three droughts in north-central Mexico during the second half of the nineteenth century. Yet the synthesis compiled by Escobar Ohmstede (2004) shows that recurrent shortages of rainfall were not limited to the northern states: Veracruz, San Luis Potosí, and Guanajuato also experienced multiple moments in which authorities reported insufficient water for crops, livestock, and local populations.

By the 1860s, Coahuila, Nuevo León, San Luis Potosí, and Oaxaca were regarded as the states most affected by the lack of rain. Authorities in Coahuila and San Luis Potosí repeatedly noted the irregularity of precipitation during those years, but drought was not confined to the north. Early in the decade, officials in Oaxaca reported large waves of migrants descending from the northern highlands into the central valleys because of water shortages in a region otherwise known for its forests. Conditions did not improve for rural inhabitants in the following decade. Reports from northern states, the Atlantic coast, the Gulf of Mexico, the Central Plateau, and the Yucatán Peninsula described not only the scarcity of rainfall but also speculation in seeds by local merchants seeking personal gain (Escobar Ohmstede 1997: 232–245; 2004). In the late 1870s, maize was imported from the United States, but states whose finances prevented access to international markets had to request assistance from neighboring entities to avoid migration to the cities, the abandonment of fields, and, above all, what officials described as deaths from hunger. Between 1880 and 1900, Mexico experienced nine intra-summer droughts and 158 hydrometeorological events that can be considered droughts. During those same two decades, 120 pest outbreaks were recorded, some of which followed commercial routes used by pack animals transporting goods – at times arriving from Guatemala, at others moving along wartime routes or across agrarian landscapes where crops disappeared under swarms of insects. Guatemala figured prominently in the imagination of public officials in southern Mexico, for by the mid-nineteenth century the idea circulated that the pests afflicting the region originated in "Central America," reinforced by reports claiming that "countless bands of destructive insects, moving from Central America into our territory and devouring everything in their path, threatened the unfortunate inhabitants of the invaded localities with the horrors of famine, prompting an alarm in Tehuantepec [Oaxaca] that spread terror across various parts of the Republic" (Escobar Ohmstede 2004: 81; Córdova 2025: 1161–1200).

From 1880 through the late 1890s, Mexico faced not only intermittent rainfall shortages but also maize scarcity, abuses by transporters and merchants who speculated with grain from regions more favored by precipitation, and the inability of local and state authorities to prevent unrest caused by the lack of food. Reports from across the country indicated that, beginning in the early 1880s, the seasonal rains that were expected to supply fields and cities foreshadowed the drought of 1891–1892 (Contreras 2016: 159–160). During those years, a warming of Atlantic currents was reported, and nineteen Mexican states were said to have suffered partially or entirely from the absence of rainfall needed to sustain rural life (Escobar Ohmstede 1997: 228–232).

In the transition from the late colonial period to republican Mexico, urban and rural societies developed various strategies to improve their situation in the face of hydrometeorological events that disrupted daily life (García Acosta 2024: 42–62). In a country with deep Catholic roots, but also with preserved or hybrid elements of pre-Hispanic religions, processions, supplications, and devotions to saints and virgins were central resources for confronting – or at least mitigating – the effects of these events. These practices were accompanied by donations, collections, and the importation of maize from abroad (Escobar Ohmstede 1997: 232–245; Contreras 1999: 156–182; Contreras 2005: 130–132; Florescano and Swam 1995; Córdova 2025: 1172–1174).

Droughts could do far more than dry out fields; they prompted religious and civic ceremonies to seek divine assistance, encouraged speculation in grain markets, and led municipal authorities to restrict the movement of food from areas favored by rainfall to those that had received little. As in the colonial period, civil and ecclesiastical authorities forged a kind of alliance in which saints and virgins were asked to intercede so that rain might fall on the fields. They also sought protection where precipitation was excessive and cities were affected by overflowing rivers and the destruction of homes, as occurred in San Luis Potosí in 1887 and in Guanajuato in 1905 (Lagos and Escobar Ohmstede 1996: 329–372; Lorenzo 2019: 249–280). Authorities appealed to the wealthier sectors of society for donations, and these groups organized gatherings in which the sale of food and drink helped raise funds so that those in need could feed their families. Press coverage was crucial, both for mobilizing support in other regions and for scrutinizing the actions of officials. Food shortages – caused by both insufficient and excessive rainfall – generated uncertainty, fear, migration, and, above all, desperation among those affected not only by rising prices but also by speculation and the profits secured by certain sociopolitical groups in republican Mexico. Although the violence of the insurgent wars of 1810 did not recur later in the century, violent uprisings were recorded in Saltillo, Culiacán, and Durango, as well as in Nuevo León and Michoacán. While further research is needed on the social violence associated with rainfall shortages, it is clear that none of the rural rebellions of the nineteenth century stemmed solely from a lack of seed, in contrast to urban areas, where most disturbances were triggered by the absence of food.

Climatic variability was one of the reasons why, once the Mexican state was able to assume control over public investment, it promoted an irrigation policy that included the construction of dams and improvements to irrigation systems. This policy took shape after 1926 with the creation of the National Irrigation Commission (1926–1946). It sought to modernize the countryside and mitigate the effects of climatic variability, while also responding to the political ecology of post-revolutionary governments, which aimed to restore and grant land but also emphasized the need to protect the forests and waters of future ejidos. A locust plague that devastated regions in Mesoamerica between 1940 and 1950, prompted the creation of an international cooperative body to confront agricultural destruction and improve control techniques (Ortiz and Zuleta 2020: 341–359). Climatic variability and its effects contributed to the technification of agriculture as part of the so-called Green Revolution in the mid-1940s (Wolfe 2017).

In Central America, as in Mexico, most nineteenth-century agricultural and livestock activities were oriented toward subsistence and local or regional markets. The gradual formation of coffee economies unfolded largely in what is now known as the Central American Dry Corridor (Díaz 2019). Coffee production began in the fertile volcanic soils of Costa Rica's Central Plateau in the 1820s (Montero 2023). The crop later spread to the Sierra Sur of Oaxaca and to parts of Veracruz and Chiapas (Romero 1886: 61–148), as well as to El Salvador, Guatemala, and Nicaragua, particularly in areas where volcanic eruptions had created light, fertile soils on the Pacific-facing mountain slopes. Most export-oriented coffee zones in Central America and Mexico lay between roughly 450 and 1,500 meters above sea level, an altitudinal range with moderate temperatures. Arabica varieties thrived in regions with well-defined dry seasons, which facilitated labor-intensive harvesting on often steep terrain.

Despite the emergence of large coffee estates in some regions – especially in southern Mexico, Guatemala, and El Salvador – much of the coffee produced in Greater Mesoamerica was grown by smallholders. During the harvest season, coffee producers relied heavily on hired labor, often secured through debt (Méndez 2024: 241–272; Falcón 2016: 209–242; Dore 2003; McCreery 1983). Coffee was intercropped with bananas, medicinal plants, and trees that provided shade, fruit, or firewood (Charlip and Gallini 2004; McCreery 1994; Montero 2023). Detailed studies, including those on large estates in Guatemala, show that land resources were divided among food crops, sugarcane, coffee, pasture, and forest plots (McCreery 1994: 195–207). Prior to the 1950s, increases in coffee exports were typically driven by the geographic expansion of coffee cultivation. This expansion often entailed clearing forests, which were regarded as indicators of fertile soils; however, coffee also frequently replaced existing crops or pastureland (McCook 2017). Consequently, it is not possible to broadly generalize the relationship between the growth of coffee estates and deforestation. Even so, research on coffee-growing regions in Mexico, Costa Rica, El Salvador, and Guatemala has documented forest clearing, particularly on steep slopes, which reduced water absorption and increased flood risks during the rainy season. Studies have also shown that water sources were contaminated by coffee processing, as observed in El Salvador (Acosta 2023; Ward 1945).

Arabica coffee production tended to take place in highland areas, often near the headwaters of streams and tributaries that fed larger rivers. This meant that coffee cultivation could have consequences downstream. The coffee industry within Greater Mesoamerica relied significantly on water resources for post-harvest processing operations. The prevalent adoption of the wet method for removing the skin and pulp from coffee beans (i.e., the seeds) was integral to the production of the "mild" coffees that are characteristic of Central America (McCreery 1994: 215–216; Viales and Montero 2010). In Costa Rica, by the late nineteenth century, processors had consolidated capital and established quality controls by purchasing harvested cherries from small and medium-sized growers. In Guatemala, many large estates operated their own mills and exported beans directly. Estates in the Nicaraguan region of Matagalpa relied on abundant water resources to adopt wet processing on a larger scale than producers in Carazo, where water supply was a "constant problem" and droughts encouraged growers to promote the installation of pumps and reforestation (Charlip 2003: 88–89; Revels 2000). Water was therefore essential not only for securing abundant harvests but also for producing coffee considered to be of "high quality" (Samper 2003).

> The wet method, still widely used today, generates a serious pollution problem due to the large volumes of water required and the solid waste produced. With local variations, each quintal (46 kg) of parchment coffee can generate between 800 and 900 liters of wastewater, which contains sugars, pectic substances, and degradation products. The scale of the issue becomes clear when considering that processing one kilogram of ripe coffee cherries requires roughly forty liters of water. From another perspective, since only about five percent of the weight of the fresh fruit is ultimately used, producing one kilogram of parchment coffee involves the use of approximately eighteen liters of water. (Acosta 2023: 169)

The so-called modernization of agriculture did not eliminate agroecological vulnerability to climatic variability; it merely transformed it. The export of coffee, livestock, or sugarcane depended on reliable water supplies. The installation of wells or dams did not fully resolve the risks associated with droughts or floods, especially in regions where agricultural commercialization encouraged specialization and, consequently, a reduction in the diversity of cultivated crops.

Climate and Socioecological Transformations in the Age of Fossil Fuels

The 1850s marked the entry of Greater Mesoamerica into the age of fossil fuels – not because coal or petroleum were widely extracted or used in the region, but because steamships and railroads, built of iron and powered by coal (and wood), made possible volumes and speeds of transport previously unattainable across diverse social and geographic spaces. This new form of transportation, in turn, enabled greater consumption of natural resources (Yáñez et al. 2013: 66–69).

The region was home to two major infrastructure projects that reshaped global commerce: a railroad across the Isthmus of Tehuantepec and the Panama Canal. In Mexico, the Isthmus of Tehuantepec was identified as a strategic corridor between the Gulf of Mexico and the Pacific Ocean, considered for its potential as an interoceanic route. The railroad, spanning 310 kilometers from Coatzacoalcos to Salina Cruz (Reina 2013), required twenty-seven years for completion and effective operation between 1880 and 1907. Initial construction commenced in 1859 under contract with the Louisiana Tehuantepec Company; however, inadequate construction quality and the lack of port terminals and facilities for cargo and passengers resulted in the granting of a concession to Pearson and Sons in 1899 for the line's renovation and port enhancements. The company inaugurated the improved railway in 1907. Petroleum extraction began a year earlier in the northern Isthmus, known as the

"Golden Lane," which intensified resource extraction activities in southeastern Veracruz and the mountains of Oaxaca, as well as increased labor demands for track maintenance, oil operations, building upkeep, food supply logistics, and ship-repair facilities. Coastal plains were utilized to supply and transport materials, equipment, and products necessary for railroad and industrial infrastructure, indicating significant intensification of resource extraction (Martínez, Sánchez, and Casado 2002: 118–135), which subsequently affected coastal, mountainous, and lowland microclimates. Timber for railroad ties and housing came from the mountains of Oaxaca and Veracruz, while efforts were made to secure water supplies for locomotives and human consumption.

Investors also envisioned railroads and canals across the Central American isthmus, a region that acquired considerable strategic value for nineteenth- and twentieth-century empires. The first major railroads and steamship lines in Central America were not built to export goods but rather to move people and goods across the isthmus. The volume of travelers increased dramatically after the United States acquired California following the war with Mexico (1845–1848) and after the discovery of gold in 1849. In 1852, Cornelius Vanderbilt inaugurated a steamship line that transported passengers across Nicaragua via the San Juan River and Lake Nicaragua. Three years later, a railroad across Panama began operating, increasing the flow of U.S. migrants. Railroad construction had localized ecological impacts; for example, building a terminal required clearing mangroves and filling wetlands on Manzanillo Island in the Caribbean (Castro 2007: 125).

The growing construction and adoption of coal-powered, steel-hulled ships was a vital technological component that expanded the scale and pace of resource use in "Greater Mesoamerica." In 1838, when the American entrepreneur William Wheelright sought British investment to establish a steamship line between Peru and Panama, he estimated that coal would account for more than a quarter of total operating costs. He anticipated sourcing coal from Chile, Britain, or Australia – an indication of the transoceanic scales envisioned in an emerging fossil-fuel era. In the early years, coal extracted in Talcahuano, Chile, helped fuel the steamships of the Pacific Steam Navigation Company (PSNC), which operated between Chile, Peru, and Panama. As expected, Panama became the hub of many of the earliest steamship routes.

High coal consumption contributed to the growing interest in constructing a canal that would allow steamships to avoid the long voyage around Cape Horn. French investors and engineers, fresh from building the Suez Canal, began work on a canal in Panama – a project with global repercussions and local impacts through the alteration of landscapes and coastal microclimates. However, the French *Compagnie Universelle du Canal Interocéanique* went bankrupt in 1889, temporarily halting canal construction in Central America. In 1902, under intense pressure from President Theodore Roosevelt, the U.S. Congress approved the construction of a canal through the newly independent Republic of Panama (Clayton 1987; Lasso 2019).

The construction and operation of the Panama Canal transformed regional hydrological cycles. As Guillermo Castro aptly observed, the U.S. canal project was

> a technological solution that took advantage of what had previously been one of the greatest obstacles to large-scale infrastructure: rainfall, the enormous volume of water carried by the Chagres River, and the challenging topography of its watershed. The environmental reordering carried out by the U.S. government made navigation across the Isthmus possible by using the very geographic conditions that had once made transit impossible. (Castro 2007: 68)

U.S. engineers designed a lock system that depended on freshwater to function. In order to maintain the enormous quantities of water needed to operate the canal, they oversaw the construction of Gatun Lake, a 423-square-kilometer reservoir that was, at the time, the largest in the world. Water levels in Gatun Lake were carefully monitored. In the early twentieth century, the watershed received more than 126 inches of rain annually. However, from January to March, rainfall dropped to less than three inches a month – far too little to keep the canal running or meet other needs like generating electricity or supplying Panama City with drinking water. The stored water in Gatun Lake helped cover this shortfall during the dry season. In the early 1930s, U.S. authorities constructed a second reservoir on the Alajuela River (Bonilla 2025; Carse 2014; Castro 2007). Scientists employed by the U.S. government studied and closely monitored regional hydrological cycles (Alfaro-Martínez et al. 2022), advocating for "watershed management." This policy led to the relocation of rural residents whose farming activities were considered harmful to forest and soil health over an area of about 3,300 square kilometers (Castro 2007). Interestingly, the Barro Colorado biological research station was established on an island formed when land became isolated after Gatun Lake's creation, and it eventually grew into a key U.S. hub for tropical biodiversity research in the Americas (Raby 2017).

Interactions between the country's water resources and the canal extended to urban areas such as Colón and Panama City, where U.S. and Panamanian officials collaborated to build piped-water systems, drainage, and sewer infrastructure. The U.S. government – and ultimately Panamanian taxpayers – invested millions of dollars in drainage and sewer systems (Bonilla 2025). The demand for labor to build the canal and install hydraulic infrastructure contributed to the growth of Colón and Panama City, whose combined population rose from roughly 20,000 in 1900 to 55,000 in 1915 (Bonilla 2025).

The construction and maintenance of the Panama Canal illustrate how U.S. geopolitical, economic, and technological power enabled a vast and complex project that transformed Panama's economy but did not eliminate vulnerabilities to short- or long-term climatic change. In the end, despite its reservoirs and rain gauges, canal operations depended on rainfall almost as directly as Mesoamerica's milpas.

The growing consumption of fossil fuels facilitated the movement of travelers and goods across the Mesoamerican Isthmus and made it possible to link regions that had previously been difficult to connect. These new connections showcased the advances associated with modernization, the circulation of high-value commercial products, and rising agricultural productivity, all of which enabled producers to reach more distant and competitive markets. Railroads functioned to integrate regions and, in some cases, to link national capitals with major ports. In Mexico, rail lines connected the central plateau with the northern border adjoining the United States, while additional efforts sought to establish links with the Gulf of Mexico's principal ports and with the south through Oaxaca via the *Ferrocarril del Sur*. Between 1850 and 1910, roughly twenty thousand kilometers of track began operating in Mexico, a network that required companies and their administrators to negotiate or acquire forests and lands, secure water concessions, and mobilize labor.

Railroad construction in Central America, as in Mexico, was driven largely by the expansion of agro-export sectors. Export commodities, railroads, and ports formed mutually reinforcing systems. Deep-water ports were essential for steamship traffic and facilitated the efficient loading of bulky products. The extension of rail lines, in turn, fueled land speculation and investment in commercial crops. In Costa Rica, Guatemala, and Nicaragua, railroads often ran through alluvial valleys, following river courses upstream to connect national capitals with ports.

In Costa Rica, the government hired Henry Meiggs in 1871 to construct a railroad meant to support coffee exports, yet regular service between San José and the Caribbean port of Limón only began in 1890. Train service was frequently disrupted during the rainy season, when sections of the line were affected by floods or landslides. The Northern Railroad Company and the Costa Rican government responded by attempting to alter river courses, reroute tracks, and repair infrastructure (Goebel and Viales 2011; Viales 1998). In Guatemala, the state contracted several companies and international financiers in the 1890s to build a railroad from Guatemala City to the Caribbean port of Puerto Barrios. Officials soon learned that torrential rains could inflict costly damage on poorly built infrastructure, and they began holding contractors responsible for repairs after the first rainy season (Ross 1977). In Honduras, concessions granted by early twentieth-century governments to U.S. fruit companies led to the construction of nearly 1,500 kilometers of track through the Ulúa, Aguán, and Cuyamel river valleys (Soluri 2021).

By the 1930s, the United Fruit Company alone operated more than 2,400 kilometers of railroads in Central America (Kepner and Soothill 1935). Not all Central American railroads, however, ran through the humid Caribbean lowlands. In 1878, construction began on a railroad from the Pacific port of Corinto, Nicaragua, which reached Momotombo on Lake Nicaragua in 1886, where several steamship lines provided connections to Managua. Over the next two decades, railroads linked other coffee-growing centers in the region, such as Masaya and Diriamba. In 1884, a line was built between Guatemala City and the Pacific port of San José, several years before the completion of the line to Puerto Barrios. In El Salvador, railroads connected the principal coffee-producing regions with the Pacific port of Acajutla. By 1920, every Central American capital except Tegucigalpa was linked by rail to an ocean port equipped to dock and load steamships. Twelve shipping lines connected Central American ports with Europe and the United States (Hall and Pérez-Brignoli 2003).

Building railroads through the alluvial valleys of the Caribbean coast took advantage of relatively flat terrain, fertile alluvial soils, and abundant rainfall. In Honduras, fruit companies reshaped lowland hydrology by constructing extensive drainage canals and spillways that diverted silt-laden floodwaters into wetlands, filling them to make the land suitable for cultivation (Soluri 2021). Even in the comparatively wet Caribbean lowlands, banana companies in Honduras also relied on rivers to irrigate crops in the Sula and Aguán valleys.

Export-oriented landscapes created new vulnerabilities to windstorms, floods, and hurricane-driven storm surges. Between 1800 and 1950, hurricanes struck Central America less frequently than the Caribbean islands, but their impacts could be long-lasting (Johnson 2015; Rappaport and Fernández-Partagás 1995; Millás 1968). Major storms were recorded in 1906 (Honduras/Nicaragua), 1928 (Guatemala), 1934 (El Salvador/Honduras), 1935 (Honduras), 1941 (Honduras/Nicaragua), 1954 (Honduras), and 1956 (Guatemala) (Tannehill 1938; Offen 2004). A storm that hit El Salvador in June 1934 – possibly a Pacific cyclone – brought torrential rains that destroyed "entire towns" (Tannehill 1938), and relief teams estimated two thousand deaths. In Honduras, the Ulúa River rose forty-five feet above its usual level, forcing residents to seek refuge on surrounding hillsides (Tannehill 1938, 74). In October 1935, three days of heavy rain and strong winds caused the Ulúa and Chamelecón rivers to overflow in the Sula Valley, destroying homes, farms, and livestock belonging to banana workers, and interrupting water and electricity service in expanding urban areas (Soluri 2021). The same storm struck Nicaragua's Atlantic coast, delivering what one researcher described as a "death blow" to the region's export banana industry (Offen 2004; see also Parsons 1955).

The 1935 floods triggered long-term changes in Central America's banana-export industry. After the storm, a pathogen – an airborne fungus (Sigatoka) – spread rapidly across banana plantations in Central America and Mexico. Its swift advance led major banana companies to invest in an intensive chemical-control system that required large inputs of copper, water, and labor. Although fumigation succeeded in controlling the pathogen, it drove many small banana producers in Costa Rica, Honduras, and Mexico out of business (Kepner and Soothill 1935; Marquardt 2002; Soluri

2021). The Sigatoka epidemic was not caused by the 1935 hurricane, but the floods played a significant role in its initial outbreak. The fungus's tendency to thrive in relatively cool, humid climates forced United Fruit Co. to shift production from the Caribbean lowlands to the drier Pacific lowlands in Tiquisate (Guatemala), Golfito (Costa Rica), and Puerto Armuelles (Panama) (Viales 1998). Companies compensated for lower rainfall through irrigation systems, showing that firms like United Fruit Co. did not "conquer" the tropics but instead improvised – and invested – to take advantage of Central America's climatic diversity.

As might be expected, coffee and banana production contributed to deforestation in both lowland and highland forests, although export agriculture did not occupy as much land as cattle ranching or milpa agriculture in Central America and in northern and central Mexico. In Guatemala, crops such as maize and beans accounted for at least half of cultivated land in the 1920s; coffee occupied perhaps one-fifth (McCreery 1994: 199–201). In Costa Rica's Central Valley, urban expansion, pastureland, cropland, and fuelwood extraction may have caused more deforestation than coffee cultivation itself (Goebel 2013). These activities directly contributed to climate change by reducing the capacity of landscapes to absorb carbon dioxide.

Throughout the first half of the twentieth century, urbanization in Central America and Mexico progressed steadily; however, approximately 80 percent of Central America's six million residents continued to reside in rural areas (Dunkerley 1990; Goebel 2013; Hall and Pérez-Brignoli 2003; Viales 1998). In the 1950s, precipitation patterns remained a critical factor influencing the livelihoods of the majority, given the reliance on water for agricultural and livestock production. Consequently, rural activities persisted as the primary modes of both water management and consumption, rendering them particularly susceptible to climatic variations.

From Chapopote to Black Gold: The Mexican Oil Industry

Oil extraction in Mexican territory began in northern Veracruz, in the region known as the Huasteca. In the nineteenth century, the area was home to Teenek and Nahua communities, as well as Afro-descendant and mestizo populations engaged in farming and livestock raising, and in some areas, fishing along the Gulf of Mexico. Oil, referred to as *chapopote* (from the Nahuatl word *chapopotli*, related to *tzauctli*, meaning glue or adhesive), was not only used in artistic creations and rituals, but also viewed as a problem for grazing livestock and roaming animals, since its presence could decrease the value of land where it appeared. According to Myrna Santiago, the first foreign geologists who arrived in the Huasteca in search of oil relied on local guides to locate sites with *chapopote* (Santiago 2006). The oil boom in the region was facilitated by changes in Mexican legislation regarding "the juices of the earth" – subsurface mineral resources. During the Porfiriato, the state abandoned its monopoly over these resources and allowed landowners to claim what lay beneath their properties. After Porfirio Díaz went into exile, dozens of foreign oil companies entered the country, following the path opened by Weetman Pearson, an English engineer and ally of Díaz's regime.

Oil exploitation transformed the Huasteca landscape in ways similar to developments in oil-producing regions of the United States. The arrival of British and U.S. companies complicated existing land-tenure structures. In some cases, companies purchased haciendas, but more often they negotiated extraction rights on lands governed by complex systems of private and communal ownership, such as *condueñazgos* (Escobar Ohmstede and Gordillo 1998: 17–74; Serna 2008). Companies did not generally seek to acquire large tracts; they preferred to lease land, following the model of some mining-benefit haciendas. It is possible that Teenek and Nahua communities – accustomed to incursions by hacendados and to losing livestock in areas with *chapopote* – did not anticipate the scale of ecological change that oil extraction would bring.

The construction of wells, pipelines, and refineries in the port of Tampico did not occupy as much land as the haciendas, but extraction processes introduced new risks, including explosions and water and air pollution. In 1908, a massive explosion at a well in San Diego de la Mar, on the shores of the Tamiahua lagoon, revealed both the region's wealth and the dangers associated with its exploitation, as well as the limited technical knowledge available, despite concessions having been granted since 1864 under the Empire of Maximilian. The spill contaminated rivers and lagoons, killing birds and fish as it advanced toward the Gulf of Mexico. That same year, the explosion of the Dos Bocas well caused worker deaths and a fire that burned for nearly two months. The release of hydrogen sulfide also killed people, plants, and animals in surrounding areas (Santiago 2006).

During the Revolution, most of the oil was exported to the United States or Europe, generating serious conflicts between oil companies, the U.S. government, and post-revolutionary Mexican governments. The latter supported peasants and workers who occupied lands that companies left under the watch of reduced staff, since oil firms depended on the backing of revolutionary generals to maintain production (Serna 2008). In 1921, Mexican production reached nearly 200 million barrels, a figure close to that of the United States, but the end of World War I reduced the international market for Mexican oil. In some cases, peasants reclaimed abandoned and degraded lands in the Huasteca through invasions or through agrarian-reform laws enacted after 1915; in others, they migrated to cities and oil fields. New deposits were opened in Veracruz, and the refineries in Tampico employed thousands of workers.

In the 1930s, the government of Lázaro Cárdenas nationalized the oil industry to use the resource for national industrialization – a policy that other oil-producing countries would emulate throughout the twentieth century. In Mexico, railroads were the main consumers of petroleum derivatives in the first half of the century. The expansion of Mexico's automobile fleet led to increased oil consumption, particularly among industries located in the capital by 1937. In that year, Mexico was ranked ninth globally for oil consumption, with Argentina being the only Latin American nation ahead (Uhthoff 2010: 7–30). Since the early twentieth century, oil production and utilization have played a pivotal role in national development. Post-1930, the sector emerged as a significant contributor to economic growth and a major source of carbon dioxide emissions. By 1950, Mexican society relied on water, oil, and mining as essential resources for its continued progress.

In contrast, Central American countries did not develop significant fossil-fuel extraction, and their aggregate oil consumption did not exceed twenty million barrels annually until the 1970s (CEPAL 2011). By the mid-twentieth century, a marked inequality in fossil-fuel extraction and consumption had taken shape across Greater Mesoamerica.

Conclusions

Between the 1800s and 1950s, geographic and temporal variations in rainfall played a central role in shaping what "climate" meant for rural and urban populations in Central America and Mexico. Although rainfall did not determine historical trajectories outright, the ways Mesoamerican nations managed water made possible the socioecological changes that took place. Many of these changes were "rain-fed": maize for tortillas and coffee for export markets depended on rainfall as did the Panama Canal and the infrastructure that enabled the dramatic growth of cities in the twentieth-century.

By examining the horizontal and vertical dimensions in which diverse social actors functioned – including their negotiations with counterparts both beyond local and regional contexts and the resources required to address daily challenges – we gain greater insight into how people accessed and managed resources as well as the strategies that historical actors implemented to mitigate the impacts of climatic variability in both rural and urban environments. The surviving documentation also shows how nineteenth-century societies confronted climatic fluctuations and their consequences for water. In broad terms, an integrated climate-history perspective allows us to glimpse aspects of everyday life and the interests of diverse social actors, both individual and collective via the dynamic relationship between water and climate.

This history matter today when we must acknowledge how little progress has been made in reducing the global forces that reshaped Greater Mesoamerican climates and environments – forces intensified by the search for markets, the extraction of raw materials, and the pollution generated by factories, textile mills, and mining. In the twenty-first century, we are witnessing these effects firsthand: from the reduced water levels of the Panama Canal – which have disrupted shipping and international trade – to extreme temperatures, forest fires in multiple regions, and shortages of potable water in major metropolitan areas. In Mexico City, the notion of "day zero" has been invoked to describe a breaking point at which the population would lack the water it needs, a scenario driven both by unequal distribution and by climatic changes that have altered rainfall patterns and aquifer recharge, forcing consideration of water transfers from neighboring basins. If nothing else, historical perspectives on climate signal the importance of water for sustaining life in Greater Mesoamerica past, present, and presumably, in the future.

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References

Acosta, Antonio. 2023. "Agua, café y contaminación. El Salvador ca. 1900." *Boletín Americanista* 73, no. 87: 167–189. https://doi.org/10.1344/BA2023.87.1041.

Acuña, Víctor, Molina, Iván y Pérez Brignoli, Héctor. 2014. *Formación de los Estados Centroamericanos*. Costa Rica: Programa Estado de la Nación.

Alfaro-Martínez, Eric J., Gabriel Madriz-Sojo, and Ronald Díaz Bolaños. 2022. "El Mega-Niño de 1925–1926 y sus repercusiones en la sociedad costarricense." *Diálogos* 23, no. 1: 1–39.

Arrioja Díaz Viruell, Luis A. 2019. *Bajo el crepúsculo de los insectos: Clima, plagas y trastornos sociales en el Reino de Guatemala (1768–1805)*. Mexico City: El Colegio de Michoacán – Universidad de San Carlos – FLACSO – Universidad Autónoma de Honduras.

———. 2021. "Historia y clima en México: perspectivas y horizontes desde la historiografía." *Estudis d'Història Agrària* 33: 13–31.

———, and Armando Alberola, eds. 2016. *Clima, desastres y convulsiones sociales en España e Hispanoamérica, siglos XVII–XX*. Mexico City: El Colegio de Michoacán–Universidad de Alicante.

———, and Armando Alberola. 2021. "Introducción. Algunas consideraciones sobre historia y clima." In *Estudios sobre Historia y Clima. Argentina, Colombia, Chile, España, Guatemala, México y Venezuela*, vol. I, ed. Luis A. Arrioja Díaz Viruell, and Armando Alberola, 9–32. Mexico City: El Colegio de Michoacán – Universidad de Alicante – Instituto Mora – El Colegio de San Luis.

Baldwin, Jane W., Alyssa R. Atwood, Gabriel A. Vecchi, and David S. Battisti. 2021. "Outside Influence of Central American Orography on Global Climate." *AGU Advances* 2, no. 2. https://doi.org/10.1029/2020AV000343.

Barriendos, Mariano. 2021. "La climatología histórica y sus retos en el contexto historiográfico hispanoamericano. Reflexiones sobre una investigación compleja y multidisciplinar." In *Estudios sobre Historia y Clima. Argentina, Colombia, Chile, España, Guatemala, México y Venezuela*, vol. I, ed. Luis A. Arrioja Díaz Viruell, and Armando Alberola, 33–72. Mexico City: El Colegio de Michoacán–Universidad de Alicante–Instituto Mora–El Colegio de San Luis.

Bengtson, Nels A. 1925. "The Resources of Honduras." *Journal of Geography* 24, no. 4: 125–139.

Bonilla, Francisco Javier. 2025. "Downstream from the Locks: The Politics of Water and Wastewater Infrastructures in Panama City's Borderlands, 1890–1953." PhD diss., Carnegie Mellon University.

Boyer, Christopher, and Cynthia Radding. 2016. "Las fronteras historiográficas del medio ambiente." In *Historia, Medio Ambiente y Áreas Naturales Protegidas en el centro-norte de México*, ed. Sergio Cañedo, and Cynthia Radding, 17–50. Mexico City: El Colegio de San Luis.

Boyer, Christopher, and Martha Michelin Cariño. 2022. "Las revoluciones ecológicas en México." In *Un pasado vivo. Dos siglos de historia ambiental latinoamericana*, ed. Claudia Leal, John Soluri, and José Augusto Pádua, 35–57. Mexico City: Fondo de Cultura Económica.

Carey, Mark. 2014. "Beyond Weather: The Culture and Politics of Climate History." In *The Oxford Handbook of Environmental History*, ed. Andrew C. Isenberg, 23–51. Oxford: Oxford University Press.

Carse, Ashley. 2014. *Beyond the big ditch: Politics, ecology, and infrastructure at the Panama Canal*. Boston: MIT Press.

Carvalho, Leila. 2020. "Assessing precipitation trends in the Americas with historical data: A review." *Wiley Interdisciplinary Reviews: Climate Change* 11, no. 2.

Castillo, Manuel Ángel, Mónica Toussaint, and Mario Vázquez. 2006. *Espacios diversos, historia en común*. Mexico City: Secretaría de Relaciones Exteriores.

Castro, Guillermo H. 2007. *El agua entre los mares: La historia ambiental en la gestión del desarrollo sostenible*. Panamá: Editorial Ciudad del Saber.

CEPAL. 2011. *Estudio sectorial regional sobre energía y cambio climático en Centroamérica*. Mexico City: Naciones Unidas.

Charlip, Julie. 2003. *Cultivating Coffee: The Farmers of Carazo, Nicaragua, 1880–1930*. Athens, OH: Ohio University Press.

Claxton, Robert H., and Alan D. Hecht. 1978. "Climatic and Human History in Europe and Latin America: An Opportunity for Comparative Study." *Climatic Change* 1: 195–203.

Clayton, Lawrence. 1987. "The Nicaragua Canal in the Nineteenth Century: Prelude to American Empire in the Caribbean." *Journal of Latin American Studies* 19, no. 2: 323–352.

Contreras Servín, Carlos. 1999. "El clima en la República Mexicana, siglo XIX." PhD diss., Facultad de Filosofía y Letras, UNAM.

———. 2005. "Las sequías en México durante el siglo XIX." *Investigaciones Geográficas* 56: 118–133.

———. 2016. "Las sequías en la región centro-norte de México, 1868–1950." In *Historia, Medio Ambiente y Áreas Naturales Protegidas en el centro-norte de México*, edited by Sergio Cañedo and Cynthia Radding, 153–176. Mexico City: El Colegio de San Luis.

Cordón-Pedregosa, Ana, and Víctor M. Toledo. (2014). *La construcción de la historia ambiental en América Latina*. Mexico City: UNAM.

Córdova, Maira Cristina. 2025. "Pesan sobre nosotros las pestes y nos abruman nuevas enfermedades: plaga de langostas, clima adverso y padecimientos en el estado de Oaxaca de 1880 a 1888." *Historia Mexicana* 74, no. 3: 1161–1200.

Díaz Bolaños, Ronald E. 2019. "El Corredor Seco Centroamericano en perspectiva histórica." *Anuario de Estudios Centroamericanos* 45: 297–322.

Díaz Bolaños, Ronald Eduardo, Eric J. Alfaro Martínez, and Leninger Leitón Gutiérrez. 2019. "La plaga de langostas Schistocerca sp. (Orthoptera: Acridae) y su relación con el Mega Niño de 1877–1878 en Costa Rica." *Cuadernos de Investigación UNED* 11, no. 2: 54–64.

Dore, Elizabeth. 2003. "Debt Peonage in Granada, Nicaragua, 1870–1930: Labor in a Noncapitalist Transition." *Hispanic American Historical Review* 83, no. 3: 521–559.

Dunkerley, James. 1990. "Guatemala Since 1930." In *The Cambridge History of Latin America*, vol. 7, edited by Leslie Bethell, 211–250. Cambridge: Cambridge University Press.

Dym, Jordana. 2004. "'More calculated to mislead than inform': Travel writers and the mapping of Central America, 1821–1945." *Journal of Historical Geography* 30, no. 2: 340–363.

Dym, Jordana. 2004. "Cartografía y Estado en Centroamérica, 1821–1920." *Mesoamérica*, 46: 101–134.

Escobar Ohmstede, Antonio. 1997. "Las sequías y sus impaactos en las sociedades del México decimonónico, 1856–1900." In *Historia y desastres en América Latina*, edited by Virginia García Acosta, vol. II, 219–258. Lima: LA RED – CIESAS – ITDG.

———. 2004. *Desastres agrícolas en México. Catálogo histórico, siglo XIX (1822–1900)*. México: Fondo de Cultura Económica – Centro de Investigaciones y Estudios Superiores en Antropología Social.

———, and Jacqueline Gordillo. 1998. "¿Defensa o despojo? Territorialidad indígena en las Huastecas, 1856–1930." In *Estudios campesinos en el Archivo General Agrario*, 17–74. México: RAN – CIESAS.

Falcón, Romana. 2016. "'No tenemos voluntad de ir al trabajo forzado…' Una Comparación de los Nexos entre Indígenas y Jefaturas Políticas en México y Guatemala. Segunda Mitad del Siglo XIX." In *Las poblaciones indígenas en la conformación de las naciones y los Estados en la América Latina decimonónica*, ed. Ingrid de Jong, and Antonio Escobar Ohmstede, 209–248. Mexico City: El Colegio de México – CIESAS – El Colegio de Michoacán.

Florescano, Enrique, and Susan Swan. 1995. *Breve historia de la sequía en México*. Xalapa: Universidad Veracruzana.

Florescano, Enrique. 1969. *Precios del maíz y crisis agrícolas en México (1708–1810): Ensayo sobre el movimiento de los precios y sus consecuencias económicas y sociales*. México: El Colegio de México.

Gallini, Stefania. 2004. "A Maya Mam Agro-ecosystem in Guatemala's Coffee Revolution: Costa Cuca, 1830s–1880s." In *Territories, Commodities and Knowledges: Latin American Environmental History in the Nineteenth and Twentieth Centuries*, ed. Christian Brannstrom, and Stefania Gallini, 23–49. London: Institute for Latin American Studies.

———. 2009. *Una historia ambiental del café en Guatemala. La Costa Cuca entre 1830 y 1902*. Guatemala City: AVANCSCO.

García Acosta, Virginia. 2024. "Inundaciones y medidas preventivas en la Nueva España en la década de 1790." *Revista de Historia Moderna* 42: 42–62.

———. 2016. "La prensa novohispana y sus aportes para el estudio histórico social de los desastres en México." In *Clima, desastres y convulsiones sociales en España e Hispanoamérica, siglos XVII–XX*, ed. Luis A. Arrioja Díaz Viruell and Armando Alberola, 61–80. Mexico City: El Colegio de Michoacán–Universidad de Alicante.

García Acosta, Virginia, América Molina, and Juan Manuel Pérez. 2003. *Desastres agrícolas en México. Catálogo histórico. Época prehispánica y colonial (958–1822)*. Mexico City: Fondo de Cultura Económica–CIESAS.

———, ed. 1996. *Historia y desastres en América Latina*. Vol. I. Lima: LA RED – CIESAS – ITDG.

———, ed. 1997. *Historia y desastres en América Latina*. Vol. II. Lima: LA RED – CIESAS – ITDG.

García Martínez, Bernardo, and Alba González Jácome, eds. 1999. *Estudios sobre historia y ambiente en América*. Vol. I. Mexico City: El Colegio de México – Instituto Panamericano de Geografía e Historia.

García Martínez, Bernardo, and María del Rosario Prieto, eds. 2000. *Estudios sobre historia y ambiente en América*. Vol. II. Mexico City: El Colegio de México – Instituto Panamericano de Geografía e Historia.

Garza Merodio, Gustavo. 2014. "Caracterización de la Pequeña Edad de Hielo en el México central a través de fuentes documentales." *Investigaciones Geográficas* 85: 82–94.

———. 2021. "Variabilidad climática en el centro y sur de México a través de las fuentes documentales, 1760–1830." In *Estudios sobre Historia y Clima*, edited by Luis A. Arrioja and Armando Alberola, vol. I, 169–204. Mexico City: El Colegio de Michoacán–Universidad de Alicante–Instituto Mora – El Colegio de San Luis.

Goebel McDermott, William Anthony. 2009. "Una lluvia de males: El régimen de precipitaciones en la Costa Rica del 'progreso' (1860–1940)." *Revista Historia* 59–60: 57–97.

———. 2013. *Los bosques del "progreso": Explotación forestal y régimen ambiental en Costa Rica (1883–1955)*. San José: Editorial Nuevas Perspectivas.

Goebel McDermott, Anthony, and Ronny J. Viales Hurtado. 2011. "Blaming It on the Weather: The Role of 'Inclement' Rainfall in Society–Nature Relations in Liberal Costa Rica (1860–1940)." *Global Environment* 3, no. 6: 8–67.

González Navarro, Moisés. 1983. *Cinco crisis mexicanas*. Mexico City: El Colegio de México.

Guevara-Murua, Álvaro, Caroline A. Williams, Erica J. Hendy, and Pablo Imbach. 2018. "300 Years of Hydrological Records and Societal Responses to Droughts and Floods on the Pacific Coast of Central America." *Climate of the Past* 14, no. 2: 175–191.

Hall, Carolyn, and Héctor Pérez Brignoli. 2003. *Historical Atlas of Central America*. Norman, OK: University of Oklahoma Press.

Hernández Rodríguez, Carlos. 2017. "La historia interminable: El huracán Kattie y la coyuntura de emergencia nacional de 1955." *Actualidad*. http://hdl.handle.net/11056/19129.

INEGI. *Estadísticas históricas de México*. México: INEGI.

Johnson, Sherry. 2015. "The History and Science of Hurricanes in the Greater Caribbean." *Oxford Research Encyclopedia of Latin American History*.

Jong, Ingrid de, and Antonio Escobar Ohmstede, eds. 2016. *Las poblaciones indígenas en la conformación de las naciones y los Estados en la América Latina decimonónica*. Ciudad de México: El Colegio de México – CIESAS –El Colegio de Michoacán.

Kaltmeier, Olaf. 2024. "¡Cuidado, el Antropoceno! Entre la exaltación de la vida y la necropolítica." In *Los cuidados en y más alla del Antropoceno: Un recorrido interdisciplinario ante las crisis socio-ecológicas*, ed. Philipp Wolfesberger, Olaf Kaltmeier, and Ann-Kathrin Volmer, 29–56. Buenos Aires/Guadalajara: CLACSO – CALAS.

Kepner, Charles D., and Jay Henry Soothill. 1935. *The Banana Empire. A Case Study of Economic Imperialism*. New York: Vanguard Press.

Kouri, Emilio. 2004. *A pueblo divided: Business, property, and community in Papantla, Mexico*. Stanford: Stanford University Press.

Lagos, Patricia, and Antonio Escobar Ohmstede. 1996. "La inundación de San Luis Potosí en 1887." In *Historia y desastres en América Latina*, vol. I, ed. Virginia García Acosta, 325–372. Lima: LA RED – CIESAS – ITDG.

Lasso, Marixa. 2019. *Erased: The Untold Story of the Panama Canal*. Cambridge, MA: Harvard University Press.

Lauria-Santiago, Aldo. 1999. *An Agrarian Republic: Commercial Agriculture and the Politics of Peasant Communities in El Salvador, 1823–1914*. Pittsburgh: University of Pittsburgh.

Leal, Claudia, John Soluri, and José Augusto Pádua, eds. 2022. *Un pasado vivo. Dos siglos de historia ambiental latinoamericana*. Mexico City: Fondo de Cultura Económica.

Leal-Echeverri, Juan Carlos, and Conrado Chobón. 2021. "Water Footprint of Coffee in Colombia." *Revista Facultad Nacional de Agronomía – Medellín* 74, no. 3: 9685–9697.

Lorenzo, María Dolores, Miguel Rodríguez, and David Marcilhacy, eds. 2019. *Historiar las catástrofes*. Mexico City: UNAM – Sorbonne Université.

Lorenzo, María Dolores. 2019. "La prensa ante la inundación de Guanajuato, 1905." In *Historiar las catástrofes*, ed. Maria Dolores Lorenzo, Miguel Rodríguez, and David Marcilhacy, 249–280. Mexico City: UNAM – Sorbonne Université.

Lurtz, Casey Marina. 2019. F*rom the Grounds Up: Building an Export Economy in Southern Mexico*. Stanford: Stanford University Press.

Marino, Daniela, and María Cecilia Zuleta. 2010. "Una visión del campo. Tierras, propiedad y tendencias de la producción, 1850–1930." In *Historia económica general de México*, ed. Sandra Kuntz, 437–472. Mexico City: El Colegio de México–Secretaría de Economía.

Marquardt, Steve. 2002. "Pesticides, Parakeets, and Unions in the Costa Rican Banana Industry, 1938–1962." *Latin American Research Review* 37, no. 2: 3–36.

Martín Gabaldón, Marta, Huemac Escalona, and Raquel Güereca. 2021. *Impacto ambiental y paisaje en Nueva España durante el siglo XVI*. Mexico City: UNAM.

Martínez Laguna, Norma, María Teresa Sánchez-Salazar, and José María Casado Izquierdo. 2002. "Istmo de Tehuantepec: un espacio geoestratégico bajo la influencia de intereses nacionales y extranjeros. Éxitos y fracasos en la aplicación de políticas de desarrollo industrial (1820–2002)." *Investigaciones Geográficas* 49: 118–135.

Maurer, Edwin P., Iris T. Stewart, Kenneth Joseph, and Hugo G. Hidalgo. 2022. "The Mesoamerican mid-summer drought: the impact of its definition on occurrences and recent changes." *Hydrology and Earth System Sciences* 26, no. 5: 1425–1437.

McCook, Stuart. 2017. "Environmental History of Coffee in Latin America." *Oxford Research Encyclopedia of Latin American History*, ed. Ángel Vergara, New York: Oxford Academic Online. https://doi.org/10.1093/acrefore/9780199366439.013.440.

McCreery, David. 1994. *Rural Guatemala, 1760–1940*. Stanford: Stanford University Press.

Méndez, Armando. 2024. "Las reformas liberales en Guatemala y El Salvador, 1824–1900." In *Expresiones políticas, materiales y simbólicas de los procesos reformistas "liberales en Iberoamérica durante el siglo XIX,"* ed. Antonio Escobar Ohmstede, and Guillermo Quinteros, 241–271. La Plata: Universidad Nacional de La Plata. Facultad de Humanidades y Ciencias de la Educación-Universidad de La Plata.

Mentz, Brígida von, ed. 2021. *La relación hombre–naturaleza*. Mexico City: CIESAS–Siglo XXI.

Meyer, Jean. 2007. "Historia, nación y región." In *Historia, nación y región*, ed. Verónica Oikión, 19–40. Mexico City: El Colegio de Michoacán.

Millás, José Carlos. 1968. *Hurricanes of the Caribbean and Adjacent Regions, 1492–1800*. Miami, FL: Academy of the Arts and Sciences of the Americas.

Montero Mora, Andrea. 2023. *Café. Revolución Verde, regulación y liberalización del mercado: Costa Rica (1950–2017)*. Zaragoza: Prensas de la Universidad de Zaragoza.

Morales, Luis Diego. 1989. "Historia del desarrollo de las disciplinas geofísicas en Costa Rica." Cartago: Editorial Tecnológica de Costa Rica.

Offen, Karl H. 2004. "The geographical imagination, resource economies, and Nicaraguan incorporation of the Mosquitia, 1838–1909." In *Territories, Commodities, and Knowledges: Latin America Environmental Histories in the Ninetieth and Twentieth Centuries*, ed. Christian Brannstrom, 50–89. London: Institute for Latin American Studies.

Ortiz Yam, Inés, and María Cecilia Zuleta. 2020. "Asuntos de vecinos: langosta, defensa agrícola y la construcción de la sanidad vegetal en México y Centroamérica, siglo XX." *Historia Mexicana* 70, no. 1: 313–373.

Padilla, Guillermo. 1980. "Las sequías en la época moderna (1822–1910)." In *Análisis histórico de las sequías en México*, 39–45. Mexico City: SRH. Comisión del Plan Nacional Hidráulico.

Parsons, James J. 1955. "The Miskito Pine Savanna of Nicaragua and Honduras." *Annals of the Association of American Geographers* 45, no. 1: 36–63.

Pérez Brignoli, Héctor. 2018. *Historia contemporánea de América Latina*. Madrid: Alianza Editorial.

Raby, Megan. 2017. *American Tropics*. Chapel Hill, NC: University of North Carolina Press.

Rappaport, Edward N., and José Fernández-Partagás. 1995. *The Deadliest Atlantic Tropical Cyclones, 1492–1994*. Coral Gables, FL.

Reina, Leticia. 2013. *Historia del Istmo de Tehuantepec*. Mexico City: INAH.

Revels, Craig S. 2000. "Coffee in Nicaragua: Introduction and Expansion in the Nineteenth Century." *Yearbook (Conference of Latin American Geographers)* 26: 17–28.

Rodríguez Solano, Pablo. 2024. "Pensar la modernidad política en América hispana: El caso del Estado costarricense en las representaciones de su burocracia (1839–1870)," In *Expresiones políticas, materiales y simbólicas de los procesos reformistas "liberales en Iberoamérica" durante el siglo XIX*, ed. Antonio Escobar Ohmstede, and Guillermo Quinteros, 201–240. La Plata-Santander: Universidad Nacional de La Plata. Facultad de Humanidades y Ciencias de la Educación-IdIHCS-Universidad de Cantabria.

Romero, Matías. 1886. *El Estado de Oaxaca*. Barcelona: Tipo-Litografía de Espasa y Compañía.

Ross, Delmer G. 1977. “The Construction of the Interoceanic Railroad in Guatemala.” *The Americas* 33, no. 3: 430–456.

Samper K., Mario. 2003. “The Historical Construction of Quality and Competitiveness: A Preliminary Discussion of Coffee Commodity Chains.” In T*he Global Coffee Economy in Africa, Asia, and Latin America, 1500–1989*, ed. William Gervase Clarence-Smith, and Steven Topik, 120–156. Cambridge: Cambridge University Press.

Santiago, Myrna. 2006. *The Ecology of Oil*. Cambridge: Cambridge University Press.

Serna, Ana María. 2009. “Extranjeros, Petróleo y Revolución en el norte de Veracruz, 1910–1920” *Dimensión Antropológica* 15: 17–55.

Shiva, Vandana. 2003. *Las guerras del agua: privatización, contaminación y lucro*. México: Siglo XXI.

Smith, Crosbie. 2018. *Coal, Steam and Ships*. Cambridge: Cambridge University Press.

Solano Chaves, Flora J., Ronald E. Díaz Bolaños, and Jorge A. Amador Astúa. 2013. *La institucionalización de la meteorología en Costa Rica (1860–1910)*. San José: Editorial Nuevas Perspectivas.

Soluri, John. 2021. *Banana Cultures*. 2nd ed. Austin, TX: University of Texas Press.

Soluri, John; Leal, Claudia y Pádua, José Augusto. 2019. “Introducción.” In *Un pasado vivo. Dos siglos de historia ambiental latinoamericana*, ed. Claudia Leal, John Soluri, and José Augusto Pádua. 11–34 Bogotá/Mexico City: Universidad de los Andes/Fondo de Cultura Económica.

Tannehill, Ivan Ray. 1938. *Hurricanes*. Princeton, NJ: Princeton University Press.

Tutino, John. 2016. *Creando un nuevo mundo*. Mexico City: FCE–El Colegio de Michoacán.

Uhthoff López, Luz María. 2010. “La industria del petróleo en México, 1911–1938: del auge exportador al abastecimiento del mercado interno. Una aproximación a su estudio.” *América Latina en la Historia Económica* 33: 7–30.

United States. National Oceanic and Atmospheric Administration. “Inter-Tropical Convergence Zone.” https://www.noaa.gov/jetstream/tropical/convergence-zone.

Urroz, Raquel. 2012. *La formación del territorio del Estado de México*. Mexico: El Colegio de México /Mexico.

Viales Hurtado, Ronny José. 1998. *Después del enclave*. San José: Editorial de la Universidad de Costa Rica.

Viales Hurtado, Ronny J., and Andrea Montero M. 2010. *La construcción sociohistórica de la calidad del café y del banano de Costa Rica (1890–1950)*. San José: Alma Máter.

Ward, Paul C. 1945. “Industrial Coffee Wastes in El Salvador.” *Sewage Works Journal* 17, no. 1: 39–45.

Waylen, Peter R., Marvin E. Quesada, and César N. Caviedes. 1996. "Temporal and Spatial Variability of Annual Precipitation in Costa Rica and the Southern Oscillation." *International Journal of Climatology* 16, no. 2: 173–193.

White, Sam, Christian Pfister, and Franz Mauelshagen, eds. 2018. *The Palgrave Handbook of Climate History*. London: Palgrave Macmillan.

Wolfe, Mikael D. 2017. *Watering the Revolution*. Durham: Duke University Press.

Wolfesberger, Philipp, and Olaf Kaltmeier. 2024. "Introducción: Rupturas en el Antropoceno y fusiones de los cuidados." In *Los cuidados en y más alla del Antropoceno: Un recorrido interdisciplinario ante las crisis socio-ecológicas*, ed. Philipp Wolfesberger, Olaf Kaltmeier, and Ann-Kathrin Vollmer, 9–25. Buenos Aires/Guadalajara: CLACSO–CALAS.

Yáñez, César, María del Mar Rubio, Josee Jofré, and Albert Carreras. 2013. "El consumo aparente del carbón mineral en América Latina, 1841–2000. Una historia de progreso y frustración." *Revista de Historia Industrial* 22, no. 53: 25–77.

Climate Change in the Caribbean from the Mid-Nineteenth Century to 1950

Climate Events, Meteorological Science, and Ideas of Tropicality in the Insular Caribbean

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Introduction

During the nineteenth century and the first half of the twentieth century, the insular Caribbean was characterized by a significant concentration of tropical plantations primarily focused on exports to European metropolitan centers and the United States. This trend resulted from a shift in production towards the larger islands of the Greater Antilles, especially Cuba. Sugar continued to be the predominant export, although there was notable growth in the cultivation of other crops, including bananas, cocoa, tobacco, and coffee. Additionally, cattle ranching and international tourism began to emerge as alternative economic activities. The region's warm and humid climate was an important factor underpinning the plantation economy, despite challenges posed by meteorological events such as storms and droughts.

Although there has been substantial discourse concerning the medium- and long-term environmental impacts associated with recent Antillean plantation expansion, establishing a direct correlation between ecosystem degradation processes and contemporary definitions of climate change remains challenging. The concept of climate change emerged after the Second World War, following notable advances in meteorology and climate science (Moore 2010). Currently, Caribbean islands are consistently identified among the region's most susceptible to climate change, as indicated by their inclusion in the Small Island Developing States (SIDS) category established by the United Nations in 1994. This vulnerability is partially due to increased reliance on "sun and sand" tourism since the mid-twentieth century, which has perpetuated historical patterns of coastal zone occupation and heightened infrastructure exposure to rising sea levels and intensified meteorological events. Nonetheless, it is noteworthy that the incidence of human fatalities has significantly decreased compared to previous periods.

Human activities in the Caribbean between 1820 and 1950 were significantly shaped by regional climate events – including tropical cyclones, hurricanes, droughts, floods, and recurring phenomena such as El Niño and La Niña. This period saw pivotal developments: the rise of scientific inquiry into meteorological phenomena and the establishment of meteorology as a discipline enabled more accurate forecasting of storm paths and assessment of potential impacts. Concurrently, the early twentieth century marked substantial progress in controlling endemic diseases like yellow fever and malaria, both closely linked to the region's tropical climate. The successful mitigation of these diseases facilitated new opportunities for colonial and neocolonial initiatives within the Caribbean.

The period in question was marked by complex and often conflicting perspectives on the tropics and tropicality. European metropolitan powers, principally in Africa and Asia, instituted a new colonial division that facilitated increased trade and extraction of colonial products. This process not only encouraged a greater movement of people in both directions but also stimulated scientific investigation into the climates of intertropical zones. Conversely, the expansion of commercial and economic interests into tropical regions increased discourses of negative tropicality, based on the assumption that hot and humid climates were inherently unsuited to the development of independent and "civilized" nations. These narratives functioned as ideological tools to legitimize colonial domination by linking climate to levels of civilization. Although they took different forms across colonial and neocolonial contexts, they became a central component of imperial control in parts of Africa, Asia, and Latin America from the late nineteenth century onward (Peet 1985; Driver and Martins 2013). This era of colonialism coincided with the emergence of Social Darwinism and white supremacist ideologies, which asserted the dominance of Europe and the United States over other regions.

In the Caribbean context, arguments about climate and tropicality were used as part of the ideological tools supporting United States hegemony and its economic, commercial, and political ambitions. Yet, there is often little focus on how these racist and imperialist ideas were tied to a renewed form of environmental determinism, which had existed since the nineteenth century during U.S. continental expansion. After 1898, beliefs in the superiority of temperate climates intensified with the rise of U.S. influence over Latin America, the Caribbean, and farther territories like Hawaii and the Philippines (Frenkel 1992). Fundamentally, proponents asserted that temperate regions achieved higher levels of civilization, whereas warmer areas were portrayed as being less advanced, lazy, and lacking the ability for self-governance.

During the competition among imperial powers for direct or indirect influence over tropical regions, the strategic interests of the dominant northern republic increasingly focused on the Caribbean basin, often referred to using terms such as the American Mediterranean (Bonsal 1912). Prominent United States geostrategist Nicholas J. Spykman (1942) further delineated this area by dividing it into the Western Mediterranean (Gulf of Mexico) and the Eastern Mediterranean (Caribbean Sea). According to Spykman, the latter encompassed the coastal lowlands stretching from Yucatan to Panama, Colombia, and Venezuela, with economic ties oriented primarily toward the north. He identified the Andes and Amazon rainforest as constituting the actual frontier between the United States and South America. Due to their geographical and ecological similarities, this "(North) American Mediterranean" was deemed vital to the United States, serving as a significant source of raw materials, including tropical crops and minerals crucial for American industries.

When discussing the Anthropocene concept, it is important to recognize that ideas of climate and civilization – unlike their earlier expressions – became intertwined with the industrial society in Europe, the United States, and a few localized regions of Asia, Africa, and the Americas. The arrival of steam technology and improved maritime and later aerial communication expanded the divide between industrial metropolitan areas of the North and intertropical regions, which continued to supply essential plant, animal, and mineral resources, including fossil fuels. Caribbean islands played a key role in providing these materials, whether as colonies owned by Great Britain, France, Holland, or Denmark (sold to the United States in 1917), Spain's holdings until 1898 like Cuba and Puerto Rico, or the two independent countries sharing Hispaniola (Haiti and the Dominican Republic) since the nineteenth century.

This chapter explores how climate and society interacted in the Caribbean amid the process of the region's integration into the industrial expansion led by the United States. It begins by examining some of the most notable storms of the time, highlighting their social and economic effects, particularly those that had a lasting impact on collective memory. Unlike earlier times, this period saw the rise of meteorological science and new technologies aimed at predicting or addressing these natural events, although their effectiveness was initially limited. The chapter then focuses on prevailing climate theories that shaped Caribbean societies – including the argument that high temperatures and humidity justified slavery (which persisted in Cuba until the 1880s) and later supported ongoing racialized labor. Finally, it considers the concept of "conquest of the tropics," which became influential in major power centers from the late nineteenth century through World War II. This idea was linked to efforts to eliminate tropical diseases and the emergence of tourism as a replacement for plantation economies, both of which played significant roles in historical debates about climate and climate change.

Hurricanes and Meteorology in the New Industrial Era

Hurricanes represent a significant focus of Antillean climate research during the period addressed in this chapter. Stuart Schwartz's 2018 publication offers comprehensive analysis of the economic, social, political, and environmental effects of major Caribbean storms, from Columbus's arrival through Hurricane Maria's impact on Puerto Rico in 2017. Additionally, there are various studies examining hurricane occurrences in specific nations or cities, including Cuba (Ramos 2009), Puerto Rico (Caldera 2017), and the United States (New Orleans) (Rohland 2019). In contrast, other meteorological events such as droughts have been less extensively studied, although targeted analyses exist – such as Picó's 2015 study on the 1847 drought in Puerto Rico.

Traditionally, much attention has been given to the destructive potential of hurricanes and the significant social challenges they cause. It is important to note, however, that since the 1830s, considerable advancements have taken place in scientific understanding, forecasting capabilities, and the development of institutions and technologies dedicated to hurricane research. Schwartz describes this period as marking the end of the first modern hurricane era, following the widespread destruction caused by the Great Hurricane of 1831 in Barbados, Saint Vincent, and Grenada. This hurricane passed through Bridgetown, Barbados's capital, on the night of August 10 and the early morning of August 11, reaching an estimated intensity of category HSS-4, resulting in approximately 1,500 fatalities – two-thirds of whom were from the enslaved population. On Saint Vincent, the storm was responsible for damage to 92 out of 96 sugar plantations.

Schwartz notes that this storm arose amid a crisis in the slave system, highlighting the antagonistic dynamics between masters and enslaved individuals during natural disasters. Upon receiving news of the catastrophe, the British Crown appointed Lieutenant Colonel of Engineers William Reid to Barbados to contribute to the reconstruction efforts for the damaged infrastructure. During his tenure, Reid undertook an extensive review of meteorological literature, which culminated in the publication of his 1838 book on storm laws – a work that proved highly influential in subsequent research on tropical cyclones (Schwartz 2018: 166). In reference to the Great Barbados Hurricane – also known by sailors as the "Barbada" island hurricane – Lieutenant Colonel Reid reported that "1,477 residents perished either from injuries sustained during structural collapses or were drowned and carried away by the storm surge, which rose more than five meters above mean sea level" (Reid 1850).

Reid's research complemented the earlier work conducted in Connecticut (United States) by William Redfield, who had noted as early as 1821 that hurricane winds followed a circular pattern and moved counterclockwise in the Northern Hemisphere. The findings from these studies were published in the American Journal of Science in 1831. Reid's publications substantiated Redfield's theories and jointly advanced the identification of key storm characteristics, such as seasonality and rotary motion – Reid noting clockwise movement in the Southern Hemisphere. Owing to the significant influence of his contributions to hurricane science, Reid was elected to the Royal Society in 1839. Additionally, the collaboration between Redfield and Cuban meteorologist Andrés Poey is noteworthy; in 1850, Poey released the most comprehensive synthesis of hurricane research to date, which included a catalog of documented storms and a bibliography encompassing 450 secondary sources (Johnson 2015; Fleming 1990).

The development of the telegraph commenced during this period, introducing a technology with significant impact on the emerging hurricane era. Samuel Morse, its inventor, obtained support from the U.S. Congress, leading to the transmission of the first telegram in 1844. In 1858, Morse brought his invention to Puerto Rico while visiting his daughter, who was married to an estate owner. He established a telegraph line between their property and the nearest town, spanning one mile. The expansion of large sugar cane plantations and other agricultural enterprises on the islands, supported by Steam Age industrial infrastructure, heightened concerns regarding the protection of substantial investments from tropical storms. The creation of new vulnerabilities gave rise to a new disaster scenario – once limited to maritime contexts – but now increasingly affecting land areas, where plantations and urban areas could be devastated within hours (Webber 2018).

Between the 1830s and 1860s, numerous hurricanes resulted in significant human and material losses. A particularly notable event occurred on July 26, 1825, when a hurricane struck Puerto Rico, leading to 370 fatalities and the destruction of 7,000 homes (Tannehill 1938: 150). On September 21, 1834, a severe hurricane devastated Dominica before impacting Hispaniola two days later, where it is referred to as "Father Ruiz's Hurricane." In Cuba, major hurricanes affected the western region on October 4, 1844 (HSS-4), and October 10, 1846 (HSS-5), causing extensive damage to both rural and urban areas. According to Pérez (2001), these storms played a central role in precipitating the collapse of the coffee economy in western Cuba and contributed to the migration of economic capital and enslaved labor towards the expanding sugar industry.

Ramos (2009) observes that the occurrence of two significant hurricanes in 1844 and 1846 within the same regions notably influenced Cuban society's perception of such events, prompting the recognition of the need for systematic research following substantial damage to plantation agriculture, the cornerstone of the colonial economy. In response, the Royal Economic Society and the Development Board initiated the first project to establish a meteorological observatory in Havana. These efforts resulted in the founding of the Physical-Meteorological Observatory of Havana in 1861 under the leadership of distinguished meteorologist Andrés Poey, although the institution's tenure was brief.

In 1857, the Jesuit religious order founded a comparable institution within the same city to support physics instruction and advance its commitment to societal service. The Belén College Observatory distinguished itself through globally significant contributions to the understanding and prediction of tropical cyclones. Its methodologies were adopted well beyond the Antilles, serving other cyclogenetic regions across all oceans. Additionally, both the Piarist and Lasallian Brothers orders established meteorological observatories.

Starting in 1870, the Belén College Observatory engaged the Catalan Jesuit José Benito Viñes Martorell (1837–1893), who served as director for an extended period. His research contributed significantly to the field, especially in forecasting hurricane trajectories. On September 11, 1875, Viñes produced the world's first tropical cyclone forecast and warning in Havana, fundamentally changing the prevailing belief that storm paths could not be predicted (Ramos 2023).

After issuing an initial warning, Viñes embarked on a comprehensive four-stage expedition aimed at conducting in situ analyses of the effects generated by three hurricanes. Notably, he investigated San Felipe, which traversed Puerto Rico on September 13, 1876, following its passage through the northern Lesser Antilles. The storm's center crossed into the Dominican Republic the next day, proceeding through the Windward Passage. Due to the rugged Cibao massif, it lost cohesion, but on September 15th and 16th, the hurricane impacted eastern and central Cuba, becoming the focal point of Father Viñes's meteorological research. His investigations began in western Cuba and included data collection in Puerto Plata, Santo Domingo, as well as San Juan, Mayagüez, Aguadilla, and Humacao in Puerto Rico. This represented the first scientific inquiry undertaken in the Americas concerning a hurricane with regional impacts.

Viñes's contributions facilitated the establishment of a meteorological observatory network funded by private entities, including steamship and telegraph companies, which initially partnered with the United States Signal Service. Similarly, the Dominican Republic began meteorological observations in 1871, and by 1888, twenty climatological stations had been founded. Additional observatories were implemented throughout Trinidad, Barbados, Antigua, Martinique, Puerto Rico, Jamaica, and Santiago de Cuba (Rohland 2019: 107; Drum 1905: 19). The Havana Chamber of Commerce, along with other private stakeholders, acknowledged the value of Viñes's forecasts in mitigating economic and human losses, ultimately providing his network complimentary telegraphic service. With access to a communication system capable of transmitting messages faster than hurricane speeds, the network operated effectively to alert island residents to impending storms. Notably, Viñes issued his first documented hurricane forecast – the earliest known official prediction – on September 11, 1875, for a storm that struck Havana on September 13, prior to the network's full development as an alert system.

The meteorological service operating under the United States Army Signal Corps, which commenced activities in 1870, quickly recognized the significance of hurricane forecasting for the Gulf Coast region. Between 1873 and the onset of the Spanish-American War in 1898, the Signal Corps collaborated with Viñes's observation network and relayed hurricane warnings via telegraph from the Belén Observatory to its central office in Washington D.C. The office subsequently disseminated these warnings to local stations nationwide. The high regard in which the Signal Corps held the Jesuit meteorologist is reflected by the partial translations of Viñes's work on hurricane observation in the Antilles, published by the United States Hydrographic Office in 1886 and the Weather Bureau in 1898.

However, as a consequence of the Spanish-American War's outbreak, these friendly relations ended, and the Weather Bureau began training its own observers and establishing its own stations in the Caribbean. Simultaneously, observations at Belén College were hampered by the fall of Spanish supremacy and the subsequent transfer of its privileges to new Cuban government institutions. Following the end of the United States occupation in 1902, U.S. hurricane forecasting activities moved from Havana to Washington D.C., from where the Weather Bureau continued sending hurricane warnings until 1935. That year, the Weather Bureau determined it was logical to issue alerts "closer to the scene" and opened three hurricane warning centers: in San Juan (Puerto Rico), New Orleans (Louisiana), and Jacksonville (Florida) (Rohland 2019: 107–8).

In the city of Cienfuegos, in southern Cuba, an observatory was founded in 1866 at the Colegio de Nuestra Señora de Montserrat, providing invaluable services for Caribbean Sea navigation. The Kempshot Astronomical Observatory in Montego Bay, Jamaica, was directed by Maxwell Hall (1845–1920), a British astronomer and meteorologist who dedicated his work to the rainfall, droughts, hurricanes, and earthquakes that affected the island. Hall strove to promote cooperation with the U.S. Weather Bureau, albeit without positive results, and authored a pioneering work on Jamaican meteorology (Hall 1904). He was granted the status of "Government Meteorologist," a tradition maintained on the island throughout the twentieth century.

Between September 1888 and 1900, seven intense hurricanes traversed the Caribbean, causing considerable damage across most of the islands. The last of these was Hurricane San Ciriaco which, after striking the islands of Guadeloupe, Saint Kitts, and Saint Thomas, diagonally crossed Puerto Rico over a six-hour period on August 8, 1899. Less than a year into the military occupation by U.S. troops following the war against Spain, the hurricane left extensive devastation and, in turn, presented the new occupiers with an opportunity to demonstrate their administrative superiority in reconstruction and the recovery of the victims. The destruction was staggering; in Ponce alone – the country's second-largest city – there were 500 deaths. The entire coffee-growing region of the mountain range was devastated. Despite the severe wreckage, the efficient data collection and the actions undertaken by U.S. authorities yielded positive results. At that time, the Jamaican press highlighted how quickly the United States responded to help Puerto Rico, using it as a criticism of the slow British response to disasters in its Caribbean colonies (Schwartz 2018: 233).

At the same time, the lack of coordination between the Jesuit forecasting network and the U.S. Weather Bureau during the Galveston Hurricane on September 8, 1900, sadly highlighted weaknesses in the American observation system. The Weather Bureau's director had banned telegraphed forecasts from Cuba to prevent competition with the U.S. meteorological service. On September 6, the Belén Jesuits announced in the local press that a hurricane had moved through Cuba and was now in the Gulf of Mexico, just southwest of Tampa, Florida. They issued another warning on September 7, and on September 8, published a report stating that the hurricane had hit the Texas coast – which proved accurate. Tragically, around 8,000 people lost their lives when the storm struck Galveston Island. Isaac Cline, the Weather Bureau's Galveston meteorologist, failed to foresee the hurricane and lost his wife during the storm surge that devastated the island. On September 10, before news of Galveston's destruction had spread, the Washington office of the Weather Bureau released a statement – ironically in hindsight – claiming they had noticed only minor indications of an atmospheric disturbance forming in the WNW (West-Northwest) that was "scarcely worth mentioning" (Drum 1905: 27; Cline 1945: 98; Rohland 2019: 108).

In the twentieth century, specific interests emerged that stimulated the allocation of resources for meteorological research and forecasting. The rise of steam navigation and diesel-powered vessels, alongside the birth of aviation, were significant drivers of this trend. Expanding United States hegemony over the Caribbean contributed to the enlargement of the hurricane warning network across several basin cities, in cooperation with respective governments and the companies investing in the region.

In 1916, five hurricanes traversed the western Caribbean, reinforcing the need to expand the infrastructure of meteorological and radiotelegraphic stations. One of the companies participating in these efforts was the United Fruit Company (UFCo) which, through its famous "Great White Fleet" of refrigerated fruit vessels, held substantial interests in banana plantations within the zone. Intense hurricanes struck Cuba in 1924 (HSS-5) and 1926 (HSS-4). The latter, in particular, generated extraordinary losses by directly impacting Havana, which was then the premier city of the insular Caribbean.

In September 1928, a powerful hurricane hit Guadeloupe, resulting in over a thousand deaths. It then moved on to Saint Kitts, Puerto Rico, the Bahamas, and Florida. In Puerto Rico, about 300 people died, and one-third of the sugar cane harvest, along with almost the entire coffee crop, was destroyed – this was viewed as the final blow to the to the coffee sector of the agricultural economy. The Bahamas experienced no loss of life during this storm, but the following year, the Great Andros Hurricane led to fifty fatalities and caused significant economic damage, worsening the crisis in the sponge fishery, which was already suffering from overuse. From 1926 to 1935, the Bahamas endured major storms every two or three years, making it the most vulnerable region in the North Atlantic at that time.

The first half of the 1930s was a period of high cyclonic activity in the Caribbean and North Atlantic, featuring several HSS-category 4 and 5 hurricanes. This phase began in 1930 with one of the deadliest known storms, San Zenón, which struck Hispaniola, southern and western Cuba, and Florida. The greatest devastation occurred in the Dominican Republic, specifically in its capital, which took a direct hit on September 3. The death toll reached 8,000, half of which occurred in Santo Domingo, a city of approximately 50,000 inhabitants at the time. Considering there were also some 19,000 injured in the city, nearly half of its residents were affected by the storm. Authors such as Moya (2017) and Schwartz (2018) offer detailed accounts of San Zenón's impacts and its political instrumentalization by Rafael Leonidas Trujillo to consolidate his absolute power through reconstruction efforts and victim relief – to the point that the capital was renamed "Ciudad Trujillo" in his honor in 1936.

During this decade, another devastating hurricane struck the southern part of Cuba's Camagüey province on November 9, 1932, causing a powerful storm surge that swept several kilometers inland, destroying everything in its path. The coastal town of Santa Cruz del Sur suffered the greatest losses: out of approximately four thousand residents, 2,870 died, making it the deadliest natural disaster in Cuban history. That same year, Hurricane San Ciprián hit Puerto Rico, resulting in fifty fatalities and leaving half a million people without homes.

The context of World War II served as a catalyst for advancements in hurricane and climate research, accompanied by increased institutional support for the field. By 1950, meteorological services in the Anglophone Caribbean had been centralized under a Meteorological Service based in Trinidad, significantly enhancing the region's capacity to observe, track, and forecast storms. The first recorded flight into the eye of a hurricane occurred off the Texas coast in 1943; within a decade, such reconnaissance missions became routine during every cyclonic season. This era also yielded the inaugural images illustrating the structure of a hurricane's eye and eyewall. By the late 1940s, radar technology provided the first visualizations of a hurricane's spiral rainbands and central eye, features now widely recognized as typifying tropical cyclones. Radar further established that hurricanes possess a warm-core structure extending from the Earth's surface through the troposphere and into the lower stratosphere (Rohland 2019: 111). These technological developments reinforced confidence in the potential to control or at least mitigate the destructive effects of hurricanes, paralleling the introduction of early cloud-seeding initiatives employing dry ice to stimulate rainfall (Schwartz 2018: 298–299).

These innovations in meteorological science and associated technologies did not, however, prevent the persistence of entrenched ideas regarding the interrelation between climate and Caribbean societies. Throughout most of the period analyzed, a negative image of the tropics was maintained or even reinforced, largely as a means to justify the exploitation of racialized labor (including the enslavement of Africans in Cuba until the 1880s) and the dominance of colonial powers over the region. Therefore, the next sections provide a concise look at how climate concepts have evolved in the Caribbean. This perspective is essential for understanding the material aspects of climate-driven events, the progression of scientific knowledge about them, and the technological changes of the industrial era, all of which ultimately helped create a more favorable view of Caribbean tropicality.

Climate, Slavery and Racialized Labor

During the first twenty years of the nineteenth century, the legal African slave trade to the Caribbean islands ended – beginning in British territories in 1807 and concluding in Spanish colonies by 1820. Despite this, illegal slave trading continued for many years, with the last recorded arrivals in Cuba occurring as late as 1866. Likewise, the abolition of slavery started in English colonies in 1834 and was completed in Cuba between 1880 and 1886. Throughout this gradual decline of the slave trade and slavery in the Caribbean, discussions about race and climate continued to be closely linked to the tropical plantation system.

Discussions concerning the appropriate labor force for tropical plantations played a significant role both in defending slavery where it persisted and shaping racially defined labor practices in regions transitioning to wage employment. Scholars have noted the prominence of the "climatic theory" within the plantation system, an idea that retained considerable influence until the mid-twentieth century (Thompson 1941; Waibel 1942). Even as tropical medicine advanced, particularly with improved methods to control disease vectors such as mosquitoes responsible for transmitting yellow fever, the dominant perception persisted that solely individuals with darker skin native to the tropics were suited for manual plantation labor, due to presumed greater resilience to local environmental conditions.

In Cuba, the center of the Caribbean slave system since 1830, the climatic argument was maintained to justify forced labor on plantations and in various rural and urban activities. In a treatise intended to regulate the operation of sugar mills, the planter José Montalvo y Castillo (1856) referred to the necessity of introducing "Indians, Asians, and Blacks" – the "laboring castes" – since, in his view, "the Spanish, German, Belgian, or Irish white [caste] could not, despite its cheapness, be driven [to such work] due to religion, climate, food, and customs" (53). Therefore, the choice would favor "the African because they have served the island for more than 250 years, being the strongest, most docile, and obedient for the harsh labor demanded by our agriculture" (Montalvo y Castillo 1857: 54).

Arguing the supposed harms of ending slavery, an 1863 pamphlet titled *La verdad y la teoría: Efectos que ha producido en América el cambio del sistema de trabajo* (*Truth and*

Theory: Effects Produced in the Americas by the Change in the Labor System), written under the pseudonym Germán, cited examples of post-independence Haiti and of Jamaica and other Antilles after the abolition of forced labor. Regarding Haiti, it stated that in a fertile country with vast natural resources and a climate so adapted "to the physical peculiarities of the race," and which was handed over as "an already cultivated garden," the results showed a precipitous drop in production and a retreat into barbarism. For its part, Jamaica was moving toward the "total destruction" of the island following abolition, as sugar mills and coffee plantations turned into scrubland. After presenting other examples from Ibero-America, the Antilles, and the United States, the author concluded in reference to the concept of comparative advantage:

> It is proven by the universal law of nature that cultivation in tropical climates through the labor of the Black race produces a considerable surplus over consumption, while white men in temperate zones consume almost everything they produce. Destroy this cultivation, and the commerce, labor, mechanics, manufactures, etc., of the North are destroyed [...].

These pro-slavery climatic arguments were countered in various ways by those advocating for the end of the slave trade and slavery. Among the first to do so was the German naturalist Alexander von Humboldt, who directly witnessed this system of forced labor during his travels through the Americas and stayed in Cuba in 1800 and 1804. In the famous chapter dedicated to the subject within his *Political Essay on the Island of Cuba*, he wrote:

> We are far from adopting maxims that the nations of Europe, which boast of their civilization, have regarded as undeniable – for example, that without slaves there can be no colonies. We declare, on the contrary, that without slaves and even without Blacks, colonies could have existed, and the entire difference would have consisted in greater profits and a less rapid increase in products." (Humboldt, 1840: 26)

In the 1820s, a movement arose against the slave trade in Cuba, concerned about its harmful impact on the island's future—though it defined "the Cuban people" narrowly as Creoles of European descent. Advocates argued against relying on African or tropical workers for agricultural labor (Piqueras 2012). José Antonio Saco, an influential voice, stated in his 1830 *Memorias sobre la vagancia* (Memoir on vagrancy)

> that, regardless of government, religion, or education, people from warm countries are doomed to weakness, laziness, cowardice, ignorance, vice, and slavery; while those from cold climates are naturally strong, active, brave, wise, virtuous, and free – is one of those illusions that best demonstrates the vulnerability of human judgment. (Saco 2001: 302)

In his essay *The Suppression of the African Slave Trade on the Island of Cuba*, Saco (1845) argued that the three most common errors maintained by defenders of slavery were the ideas that labor in the sugar mills was so grueling that only African Blacks could withstand it, that they were the only ones who could endure the island's climate, and that daily wages were too high. Regarding the second point, he focused on the adaptation to the Cuban climate by white Creoles and Canarian immigrants, asserting that: "the Cuban climate does not oppose the introduction of white men, nor does it prevent them from engaging in labor at the sugar mills" (Saco, 2001: 98).

Another author who addressed agricultural labor in Cuba was Francisco de Frías y Jacott, Count of Pozos Dulces. In *The Question of Agricultural Labor and Population on the Island of Cuba* (1860), he identified two positions: one concerning the enervating effect of the tropical climate on the white population, and another denying such effects on acclimated workers. In his view, the truth lay between these extremes. He admitted that in the island's plantation agriculture, especially in sugar production, the "man of color" – both African and Asian, originating from tropical regions – was better suited for the work. However, the rejection of labor in the sugar industry by potential European immigrants and white Creoles was not due to the rigors of tropical heat or humidity, but rather to the fact that Cuban sugar mills provided no room "for the strength, intelligence, and activity of the white man" (Frías y Jacott 1860: 3). Therefore, the climate was, for the most part, not to be blamed for the bias attributed to the labor and population of Cuba and other tropical countries (8). His critique was directed at the so-called "tropical agriculture," born in an era of "insatiable greed and not very refined morality" (Frías y Jacott 1860: 15).

From the late nineteenth to the early twentieth century, the defense of Cuba's climate became a central argument for attracting European immigrants. The island's influential medical community took an active part in these debates, providing a scientific – or rather, pseudoscientific – foundation for ideas linking climate, race, labor, and nationality. Carlos J. Finlay, who would achieve global fame years later for identifying the mosquito as the vector for yellow fever, published several articles between 1878 and 1879 to refute the views expressed in the book *Aclimatación e higiene de los europeos en Cuba* by Ramón Hernández Poggio. That work had characterized the Cuban climate as "insane" and "deadly" (Hernández Poggio 1874, 5–7) claiming that Europeans could never establish their race in a solid and definitive manner there (Hernández Poggio 1874: 15).

In addition to citing his own experience as the son of foreigners settled on the island, Finlay sought to address the issue "in a scientific manner" to demonstrate the excellent sanitary conditions the country offered white immigrants. To this end, he utilized statistics from the 1862 census and Havana's meteorological records, in order to show that the climate did not match that of the hottest and most humid countries. Furthermore, demographic data indicated that the island – and specifically its eastern department – provided exceptional living conditions and fertility for the “white race.” Based on these elements, Finlay concluded the following: first, that Cuba’s climate should be considered among the healthiest in the world; second, that while it was true that white immigrants were affected by yellow fever in Havana and other coastal towns, once the initial danger had passed, they had a higher life expectancy – “at least until age 60” – than they would have had in their native countries; and third, that the “colored race,” by contrast, could hardly sustain itself over time and would decline “without interbreeding with European races” (Finlay 1878: 3).

In *Apología del clima de Cuba*, Carlos Finlay explicitly countered the prevailing negative tropes of “tropicality” that stigmatized his homeland. However, his defense was inherently exclusionary, prioritizing the health and resilience of European-descended Creoles and Spanish migrants. Writing during the final years of Cuban slavery (which ended in 1886), Finlay employed racist logic to argue that the “white race” was biologically superior in its adaptation to the island’s environment. By asserting that Cuba was an exceptional case rather than a “typical” tropical country, he attempted to distance the island from the perceived “degrading” effects of the Torrid Zone to make it more attractive for white settlement and capital

The reassessment of the Caribbean climate occurred frequently following the end of the slave trade and slavery in other Antillean colonies. As noted by Carey (2011), this transition was shaped by factors including local geographical features, advancements in medicine, and early efforts to promote the Caribbean as a destination for tourism. Both resident writers and visiting observers highlighted the perceived superior health benefits of mountainous regions compared to lowland areas – for example, the Blue Mountains in Jamaica – and commended the purported therapeutic qualities of the winds common to Barbados and other Windward Islands. Numerous locations throughout the Antilles developed reputations as health retreats, particularly attractive to convalescents during the European or North American winter. Contributing to this appeal was the establishment of medicinal spas that gained prominence in the nineteenth century, as occurred in the French colony of Guadeloupe (Jennings 2006: 64–89).

Officials, clergy, and military personnel contributed to the construction of this more positive image of the insular Caribbean, seeking to attract their counterparts to the colonies. However, the most notable shift occurred following the control or eradication of the tropical diseases with the highest regional incidence. Yellow fever was the most emblematic case, following Carlos J. Finlay’s aforementioned theory, proposed in 1881, regarding its vectorial transmission via the female *Aedes aegypti* mosquito. During the initial United States occupation of Cuba (1898–1902), military authorities were unsuccessful in decreasing the incidence of the disease until a commission was formed to evaluate Finlay’s thesis. This initiative led to the first effective eradication of the illness in Havana, which had persisted in an almost endemic manner for more than two centuries.

As head of the Department of Sanitation in Havana, American physician William Gorgas played a central role in controlling the epidemic. A few years later, he led sanitation efforts during the construction of the Panama Canal. The effectiveness of his epidemiological work has been credited as a key factor in the success of this major modern engineering project. Gorgas (1909; 1969) later wrote that advancements in tropical sanitation over the previous fifteen years had demonstrated that the "white man" could thrive in the tropics and enjoy health as robust as if he lived in a temperate zone. According to Gorgas, the work of U.S. Americans in Cuba and Panama to eradicate yellow fever should be viewed as "the starting point for the effective settlement of the Caucasian race in those regions" (see also Engelschalt 2023).

This did not, however, dispel the notion that "natives" of the intertropical zone – specifically those of non-European descent – remained uniquely suited for manual labor under Caribbean climatic conditions. Alongside traditional racist arguments, references were almost always made to their greater resistance to heat and humidity for agricultural tasks, which generally corresponded to the type of labor required by tropical fruit plantations. Conversely, Europeans or their descendants were expected to handle supervision, administrative tasks, or work requiring technical knowledge. These roles were also the best compensated, based on another idea related to tropicality: that the inhabitants of these regions had fewer material needs because the natural environment provided food more easily, and there was no need for significant expenditures on clothing or housing.

This surge in environmental determinism can be linked to intra-Caribbean migrations for labor on the Panama Canal works, or toward other territories where European or U.S. companies began investing in railroads and plantations. The primary points of origin were the British Antilles and Haiti. It is estimated that more than 450,000 people of African descent moved to Mesoamerica between 1850 and 1950, primarily to Panama and Costa Rica (Soto-Quirós 2021: 317). Under similar criteria, workers from more distant locations were transported to the Caribbean starting in the mid-nineteenth century. Approximately 103,000 indentured laborers were introduced to Trinidad from India, and more than 130,000 from China to Cuba between 1848 and 1874. The Dutch also brought workers from their colony in Indonesia to Surinam (previously Dutch Guiana).

Another large contingent headed to Cuba and the Dominican Republic to supply a significant portion of the cane cutters required for the sugar plantations. It is estimated that between 1912–1915 and the early 1930s, approximately 200,000 Haitian *braceros* arrived in Cuba (Ayala 1999: 168–173), and between 1902 and 1932, around 120,000 Jamaicans arrived (Higman 2021: 221). Notably, in the Hispanic Antilles, the largest migratory flow came from Spain – especially from the Canary Islands – but these immigrants mostly settled in cities and never predominated among agricultural plantation workers.

The Conquest of the Tropics and the Insular Caribbean

The Industrial Revolution's progress in Europe and the United States bolstered the hegemony of these nations over their Caribbean colonies. Building on this dominance, these powers spearheaded a new imperialist phase of global partitioning – colonizing Africa and Asia while simultaneously expanding their reach into Latin America. Great Britain and France led the occupation of territories previously regarded as "the white man's grave" due to vulnerability to tropical diseases or the supposed "degeneration" resulting from contact with indigenous populations and local climatic conditions. Although these ideas began to lose ground owing to advancements in so-called tropical medicine, Western European triumphalism during these years also contributed to reinforcing discourses of environmental and climatic determinism.

At the end of the nineteenth century, reservations still prevailed regarding the actual possibilities of settling large masses of Europeans in the intertropical zone. This is evident in the work of the influential Anglo-Irish social Darwinist Benjamin Kidd and his 1898 publication, *The Control of the Tropics*, where he highlighted the region's importance for Western civilization. One reason was the theory of free trade (and consequently that of comparative advantage), based on the exchange of products between the tropics and temperate zones. This ideology was predicated on the assumption that tropical development could only be achieved through the "civilizing influence" of white Europeans or North Americans, as opposed to autonomous local governance. However, this created a persistent colonial paradox: while white intervention was deemed necessary for progress, a complete "acclimatization" –physical, moral, and political – was considered biologically and culturally impossible. This tension framed the tropics as a space that required Western management yet remained a permanent threat to the integrity of the "civilized" body. For Kidd, the alternative was for these regions to be administered from temperate zones, whose "civilized" nations represented the pinnacle of social order (Kidd 1898).

The control of tropical diseases with a high incidence among European immigrants, such as yellow fever, malaria, or parasites (with particularly notable efforts in Puerto Rico led by U.S. physician Bailey Ashford against hookworm, which caused high rates of anemia), contributed to more optimistic views. It was then that the phrase "conquest of the tropics" began to take hold. Nonetheless, this did not signal the end of negative notions regarding these regions by those who defended a supposed causal relationship between climate and civilization. The underlying idea was that in temperate climates, man dominated nature, while in tropical climates, nature dominated man.

The foremost exponent of climatic determinism was geographer and eugenist Ellsworth Huntington, author of the book *Civilization and Climate* (1915) and many other works that wielded great influence until the 1940s. In a previous article on tropical America, Huntington (1914) pointed out that this region and Africa were the richest and most unexploited portions of the globe, but that the "native races" were incapable of developing them on their own. He attributed this to the hot and humid climate, which he believed induced a "tropical inertia" characterized by a lack of will affecting both body and mind. Although he acknowledged the medical achievements that were allowing colonizers to control tropical diseases, as well as other lessons learned to overcome climatic disadvantages, obstacles still remained – such as the unequal distribution of rainfall – which limited the development of modern agriculture. But the principal obstacle was the degeneration of European descendants, who saw their physical and mental energy diminish or who rejected manual labor because it was reserved for "inferior races" (Huntington 1914).

Huntington's climatic thesis, intertwined with the era's widespread racist and misogynistic ideologies, converged with broader tenets of geographic determinism. One of these was the positioning of tropical lowlands as the areas least conducive to civilization – which coincidentally were also the primary setting for the new boom in plantations in the insular Caribbean and Central America during the first decades of the 20th century. This was attributed to the uniformity of the climate and, therefore, to the lack of stimulus provided by the changing seasons. This led to Huntington's imaginative proposal of moving inhabitants *en masse* between the lowlands and the mountains to provide them with the climatic variety they needed. Furthermore, he recognized that the attitude of U.S. Americans toward the less favored tropical regions was similar to that of Europe toward all the Americas three centuries earlier. Finally, he did not fail to mention the technological advances that had allowed for the conquest of low temperatures in temperate countries, suggesting that the next great task would be the conquest of the uniform heat of the intertropical zones.

Of course, the true conquest of the Caribbean tropics took place through the increasing exploitation of the region's natural resources by large U.S. corporations from the early twentieth century onward. In this new stage, there was no better symbol than the expansion of banana companies through the lowlands of Central America and several of the Antilles. The banana fruit itself became the epitome of tropicality – a representation of fertility and the "easy life," as well as native indolence and racialized labor. Its commercialization was made possible through the mediation of the new technologies of the Second Industrial Revolution, which allowed for unprecedented control over all phases of the product's marketing (Soluri 2006).

The most representative banana firm was the United Fruit Company (UFCo), founded in 1899. In 1926, its president, Victor M. Cutter, stated in an article on economic geography that this industry began with the cultivation of the fruit in the tropics and ended with its consumption in the temperate zone and even further north, in subarctic regions. This was made possible through the combination of advances in transportation, refrigeration, sanitation, radio, and the maintenance of hotels. The company possessed an extensive network of its own railroads and a shipping line, the Great White Fleet. In this way, through the application of modern inventions, the UFCo had succeeded in making the tropical jungle contribute to the global food supply (Cutter 1926).

After the bunches were harvested in the fields, they were transported to the shipping ports in under twelve to fifteen hours. On ships equipped with refrigeration systems even more powerful than those used for transporting frozen meat, the journey from Central America or Jamaica took between three and five days to New Orleans, Galveston, or Mobile; seven to eight days to Baltimore, Philadelphia, New York, and Boston; and fifteen to sixteen days to Great Britain or Europe. Bunches destined for more distant markets required an earlier harvest. During the winter months, heating was necessary to maintain proper fruit temperatures in northern latitudes. The coordination between production and consumption zones required an extensive infrastructure of hospitals, hotels, and telegraph and radio stations. The Great White Fleet connected nearly ten ports in the Americas, and its radio network helped establish a tropical storm warning system for vessels transiting the Caribbean Sea and the Gulf of Mexico.

Cutter noted that the UFCo operated two modern hotels in Jamaica, located in San Antonio and Kingston. Indeed, this new plantation boom in the Caribbean contributed to the region's tourism takeoff. As part of the construction of a new stereotype of "positive tropicality" in the early decades of the twentieth century, the Caribbean Basin was promoted as an exotic destination for Northern elites, who could travel on the same ships used to transport tropical fruit or on steam-powered passenger cruises. As early as 1898, reports identified tourism as the second-largest source of income for Barbados, surpassed only by sugar. To this end, the colonial government began promoting the island's climate as one of the healthiest in the world – a kind of "sanatorium in the West Indies" (Carey 2011: 139–140). However, due to their larger territorial size and the presence of foreign interests, Jamaica and Cuba became the primary destinations for American and European travelers in the first half of the 20th century (Scott 2022).

By the mid-twentieth century, views on the tropical condition remained ambivalent. On one hand, perspectives emphasizing "negative tropicality" persisted due to the hot and humid climate. As late as 1947, French geographer Pierre Gourou wrote that in this belt, humanity was "limited in its physical activity, its psychic activity, and its multiplication by disease" because of said climate (Gourou 1959: 23) Nevertheless, when mentioning the Antilles, the same author highlighted their high population density, made possible by an advanced commercial economy based on the sale of tropical products. In his view, countries such as Cuba and Puerto Rico were prime examples of the success of "white colonization" in hot and rainy climates (Gourou 1959: 186).

Finally, the same naturalists and experts who arrived in the region as part of commercial plantations or to lead infrastructure projects, such as the Panama

Canal, began to reevaluate tropical nature (Raby 2017). One such figure was Marston Bates, who served as a UFCo entomologist in Central America between 1928 and 1931 and later worked with the Rockefeller Foundation in Colombia from 1935 to 1952. According to Bates, these experiences led him to rebel against the disdainful attitude toward the tropics adopted by the Western world. In his book *Where Winter Never Comes: A Study of Man and Nature in the Tropics* (1952), he refuted the ideas expressed by authors like Huntington. Bates argued that the true "burden" weighing on the "white man" in the tropics was that of his own culture and civilization. He suggested that they should stop assuming superiority and worrying about maintaining a higher status "as a minority detached from the environment." While this burden might include valuable elements like science and technology, it also carried "a bundle of useless nonsense that should have been discarded long ago." (Bates 1952: 141)

Conclusions

The period analyzed in this chapter can be considered a transitional stage regarding hydrometeorological events in the insular Caribbean and the evolution of ideas concerning the impact of climate on society. Among the variables analyzed here, we can highlight three key developments: the growing role of science from the 1830s and 1840s onward in understanding the behavior of hydrometeorological phenomena, the creation of institutions tasked with studying weather or climate variations, and the emergence of new technologies that contributed to predicting cyclone trajectories. In contrast to the early modern era – when providentialist interpretations dominated and storms or droughts were viewed as divine acts – the mid-19th century witnessed a strengthening of the government's role in addressing the aftermath of hurricanes and seeking more effective ways to mitigate their damage. As Schwartz (2018, 139) notes, "the response to recurrent natural disasters became a sort of statecraft."

Despite these shifts, ideas about the influence of climate on society maintained a deterministic bias and served as a justification for sustaining slavery and a racialized labor regime. The pseudoscientific argument held that only populations originating from the tropics could perform the manual labor required by the plantations that dominated the Caribbean economy, due to their greater resistance to heat and humidity. These ideas were emphasized most strongly in territories where the slave system persisted longest, such as the Spanish colonies – particularly Cuba, where it lasted until the 1880s. However, they were also present in the colonies of other European metropoles where abolition had occurred earlier. Indeed, the link between racist and climatic conceptions strengthened between the late 19th and early 20th centuries, amidst the new imperialist expansion into Africa and Asia and the consolidation of U.S. hegemony in the Caribbean Basin and Latin America.

The phrase "conquest of the tropics," popular among elites, intellectuals, and the public in imperialist nations, epitomizes this resurgence of ideas about climate and civilization. The achievements of medical science in controlling diseases like yellow fever, malaria, and parasites, combined with the successes of modern engineering and industrial technology, fueled new forms of colonial occupation. The insular Caribbean, already highly transformed, was one of the first settings for the construction of a new paradigm of tropicality. Here, negative perceptions began giving way to a paradisiacal vision of the islands as healthy retreats and attractive tourist destinations for American and European elites.

The persistence of the plantation economy in the Antilles during this period offers an emblematic case study for proponents of the "Plantationocene" (Restrepo 2021). Instead of focusing on the grand narratives of the Anthropocene, centering the insular Caribbean allows for a more precise geographical localization and a deeper look into the socio-environmental consequences of the plantation system and its links to metropolitan industrialization. Beyond global climate change, studying specific sites like Caribbean plantations helps investigate the historical interactions between territory and climate. This chapter has emphasized how ideas about tropicality formed the basis of environmental injustice, colonialist resource exploitation, and racialized labor. These long-term consequences are often sidelined in current climate change debates, despite being central to the reparations claims made by many Caribbean nations regarding the legacy of slavery (Beckles 2021).

Translated by Luisa Raquel Ellermeier.

References

Adams, Frederick Upham. 1914. *The Conquest of the Tropics. The Story of the Creative Enterprises Conducted by the United Fruit Company*. New York: Doubleday Page & Co.

Ayala, César. 1999. *American Sugar Kingdom. The Plantation Economy of the Spanish Caribbean, 1898–1934*. Chapel Hill: The University of North Carolina Press.

Bates, Marston. 1952. *Where Winter Never Comes: A Study of Man and Nature in the Tropics*. New York: Charles Scribner's Sons.

Beckles, Hilary. 2021. *How Britain Underdeveloped the Caribbean: A Reparation Response to Europe's Legacy of Plunder and Poverty*. Kingston: University of the West Indies Press.

Bonsal, Stephen. 1912. *The American Mediterranean*. New York: Moffat Yard.

Caldera Ortiz, Luis. 2017. *Historia de los ciclones y huracanes tropicales en Puerto Rico*. North Charleston: CreateSpace Independent Publishing Platform.

Carey, Mark. 2011. "Inventing Caribbean Climates: How Science, Medicine, and Tourism Changed Tropical Weather from Deadly to Healthy." *Osiris* 26, no. 1: 129–141.

Cline, Isaac M. 1945. *Storms, Floods and Sunshine*. New Orleans: Pelican Publishing Company.

Cutter, Víctor M. 1926. "Caribbean Tropics in Commercial Transition." *Economic Geography* 2, no. 4: 492–507.

Driver, Felix, and Luciana Martins, eds. 2013. *Tropical Visions in the Age of Empire*. Chicago: University of Chicago Press.

Drum, Walter M. 1905. *The Pioneer Forecasters of Hurricanes*. Havana: Published for the Observatory of Belén, Stormont & Jackson.

Engelschalt, Julia. 2023. "The Great Obsession: Tropicality in US-American Colonial Medicine and Domestic Public Health, 1898–1924." PhD diss., Bielefeld University.

Finlay, Carlos J. 1878. "Apología del clima de Cuba." *Gaceta Médica de La Habana* 1, no. 2: 1–3.

Fleming, James R. 1990. *Meteorology in America, 1800–1870*. Baltimore: Johns Hopkins University Press.

Frenkel, Stephen. 1992. "Geography, Empire, and Environmental Determinism." *Geographical Review* 82, no. 2: 143–153.

Frías y Jacott, Francisco de. 1860. *La cuestión del trabajo agrícola y de la población en la isla de Cuba, teórica y prácticamente examinada por el conde de Pozos Dulces*. Paris: Imprenta de Jorge Kugelmann.

Gorgas, William. 1909. "The Conquest of the Tropics for the White Race." *Journal of the American Medical Association* LII, no. 25: 1967–1969.

Gourou, Pierre. 1947. *Les pays tropicaux*. París: Presses universitaires de France.

________. 1959. *Los países tropicales*. Xalapa: Universidad Veracruzana.

Hall, Maxwell. 1904. *The Meteorology of Jamaica*. Kingston: The Institute of Jamaica.

Hernández Poggio, Ramón. 1874. *Aclimatación e higiene de los europeos en Cuba*. Cádiz: Imp. de la Rev. Médica, de Federico Joly y Velasco.

Higman, Barry W. 2021. *A Concise History of the Caribbean*. Cambridge: Cambridge University Press.

Humboldt, Alexander von. 1840 [1826]. *Ensayo político sobre la Isla de Cuba*. Paris: Lecointe & Lasserre.

Huntington, Ellsworth. 1914. "The Adaptability of the White Man to Tropical America." *The Journal of Race Development* 5, no. 2: 185–211.

________. 1915. *Civilization and Climate*. New Haven: Yale University Press.

Jennings, Eric T. 2006. *Curing the Colonizers: Hydrotherapy, Climatology, and French Colonial Spas*. Durham: Duke University Press.

Johnson, Sherry. 2015. "The History and Science of Hurricanes in the Greater Caribbean." In *Latin American History: Oxford Research Encyclopedias*. Oxford: Oxford University Press. https://doi.org/10.1093/acrefore/9780199366439.013.57.

Kidd, Benjamin. 1898. *The Control of the Tropics*. London: The Macmillan Company.

Montalvo y Castillo, José. 1857. *Tratado general de Escuela teórico-práctica para el gobierno de los ingenios de la Isla de Cuba en todos sus ramos….* Matanzas: Imprenta de La Aurora.

Moore, Amelia. 2010. "Climate Changing Small Islands. Considering Social Science and the Production of Island Vulnerability and Opportunity." *Environmental and Society: Advances in Research* 1: 116–131.

Moya Pons, Frank. 2017. *El ciclón de San Zenón y la patria nueva. Reconstrucción de una ciudad como reconstrucción nacional*. Santo Domingo: Academia de la Historia Dominicana.

Peet, Richard. 1985. "The Social Origins of Environmental Determinism." *Annals of the Association of American Geographers* 75, no. 3: 309–333.

Pérez Jr, Louis A. 2001. *Winds of Change. Hurricanes and the Transformation of Nineteenth Century Cuba*. Chapel Hill: University of North Carolina Press.

Picó, Fernando. 2015. *Puerto Rico y la sequía de 1847*. San Juan: Ediciones Huracán.

Piqueras, José A. 2012. *La esclavitud en las Españas. Un lazo transatlántico*. Madrid: Los libros de la Catarata.

Raby, Megan. 2017. *American Tropics. The Caribbean Roots of Biodiversity Science*. Chapel Hill: The University of North Carolina Press.

Ramos Guadalupe, Luis E. 2009. *Huracanes. Desastres naturales en Cuba*. Havana: Editorial Academia.

________. 2023. *De Meteorología y Huracanes. Benito Viñes, un científico español en Cuba*. Madrid: Instituto Juan Andrés de Comparatística y Globalización.

Reid, William. 1850. *An Attempt to Develop the Law of Storms*. London: John Weale.

Redfield, William C. 1831. "Remarks on the Prevailing Storms of the Atlantic Coast, of the North American States." *American Journal of Science and Arts* 20, no. 1: 17–51.

Restrepo, Juan Pablo. 2021. "Sobre el plantacioceno." *Avá* 39, 85–100.

Rohland, Eleonora. 2019. *Changes in the Air. Hurricanes in New Orleans from 1718 to the Present*. New York: Berghahn Books.

Saco, José Antonio. 2001 [1834]. "Memoria sobre la vagancia en la Isla de Cuba." In *Obras*, vol. I. Havana: Ediciones Imagen Contemporánea, 264–306.

________. 1845. *La supresión del tráfico de esclavos africanos en la Isla de Cuba, examinada con relación a su agricultura y su seguridad*. Paris: Imprenta de Panckoucke.

Schwartz, Stuart B. 2018. *Mar de tormentas. Una historia de los huracanes en el Gran Caribe desde Colón hasta María*. San Juan: Ediciones Callejón.

Scott, Blake C. 2022. *Unpacked. A History of Caribbean Tourism*. Ithaca and London: Cornell University Press.

Soto-Quirós, Ronald. 2021. "Paisajes racializados y fronteras identitarias en Costa Rica: relatos de viajeros y el ferrocarril del Caribe (1885–1930)." *Anuario de Historia Regional y de las Fronteras* 26, no. 2: 311–351.

Soluri, John. 2006. *Banana Cultures: Agriculture, Consumption, and Environmental Change in Honduras and the United States*. Austin: University of Texas Press.

Spykman, Nicholas J. 1942. *Americas Strategy in World Politics. The United States and the Balance of Power*. New York: Harcourt, Brace and Co.

Tannehill, Ivan Ray. 1938. *Hurricanes. Their Nature and History*. Princeton: Princeton University Press.

Thompson, Edgar T. 1941. "The Climatic Theory of Plantation." *Agricultural History* 15, no. 1: 49–60.

Waibel, Leo. 1942. "The Climatic Theory of the Plantation: A Critique." *Geographical Review* 32, no. 2: 307–310.

Webber, Oscar. 2018. "The Plantations role in enhancing hurricane vulnerability in the nineteenth-century British Caribbean." *Alternautas* 5, no. 2, 29–41.

From 1950 to the Present

Source: Fernando Efrén Sandoval Herrera (2021)

Introduction: Climate Change and the Anthropocene in Latin America from 1950 to the Present

Javier Taks, Virginia García Acosta, Anthony Goebel McDermott, and Eleonora Rohland

The period of the Great Acceleration, from 1950 to the present, aligns with two distinct phases of social and economic development in Latin America, as outlined by Bértola and Ocampo (2013). Until the 1980s, the region underwent an uneven industrialization process geared towards import substitution, which was subsequently undermined during various civic-military dictatorships. From the mid-1980s onwards, there has been a notable shift towards the (re)primarization of national economies, reinforcing the region's long-standing role over the past 45 years as a supplier of raw materials to industrialized Northern countries and, more recently, to China, now a major importer of such commodities.

The rapid expansion of extractive industries and accelerated economic growth centered on commodity exports have led to significant environmental and social consequences in Latin America and the Caribbean. These include severe ecosystem degradation, a high incidence of socio-environmental conflicts, and a tragic record of murders of environmental defenders. Despite these challenges, resistance and socio-environmental advocacy have successfully influenced institutional frameworks. This is evidenced by the implementation of the Escazú Agreement in 2021, a groundbreaking regional accord that promotes access to information, citizen participation, and justice in environmental matters.

As shown in the chapters in this section, Latin America and the Caribbean have contributed to the Climate Change discussion over the past seventy years in various ways, reflecting socio-territorial diversity. One dimension involves biophysical and economic aspects related to greenhouse gas (GHG) emissions and carbon sinks, which are key drivers of global Climate Change. Another dimension focuses on how societies have studied their climate systems and organized for adaptation to climate variability and change since the climate turn of the 1980s. This is particularly relevant in large cities, coastal areas, small islands, and diverse rural areas ranging from humid to arid and desertified regions. In both mitigation and adaptation efforts, the narratives and discourses on Climate Change mobilized by different actors have influenced the development of climate science, public policy formulation and implementation, business investments, actions by social organizations and movements, and citizen demands.

Since the late 1960s, there has been systematic research and reflection on local climate conditions and their connections to broader scales, particularly in Brazil and the Caribbean, where international research groups and climate lobbying emerged. The 1992 Rio Summit was a significant milestone for both the region and the world, signifying a clear intention by governments, academia, and civil society to limit greenhouse gas emissions with the signing of the United Nations Framework Convention on Climate Change (UNFCCC). All Latin American and Caribbean countries ratified the UNFCCC between 1994 and 1998.

In the twenty-first century, Latin America positioned itself at the forefront of addressing the socio-economic causes of global climate chaos, as demonstrated at the 2010 World People's Conference on Climate Change and the Rights of Mother Earth in Cochabamba, Bolivia – an alternative event to the unsuccessful UN COP15 held the previous year in Copenhagen. However, the failures of progressive governments to implement effective environmental protection policies during the first two decades of the twenty-first century (Svampa and Viale 2020) have led to the region gaining media attention today for climate denial discourses promoted by ultraconservative political leaders and their allies. For example, the total denial of Climate Change during Bolsonaro's administration in Brazil (2019–2023) justified the partial dismantling of the country's robust environmental institutions and promoted illegal deforestation – policies that the current coalition government, led once again by Lula, is attempting to reverse. Meanwhile, skepticism about the anthropogenic origin of new climate conditions is being encouraged in Argentina under Milei, within the broader context of a neoconservative attack on multilateralism represented by the United Nations.

Despite these fluctuations in official discourse, in the third decade of the twenty-first century, it is common to encounter news across a wide range of mass media outlets as well as on social media platforms that highlights the significant impact of extreme weather events in the region. These events are frequently linked by journalists, politicians, activists, and academics to the phenomenon of global Climate Change. Notable examples include extraordinary floods in the state of Rio Grande do Sul, Brazil, in 2024; the Paraná River experiencing its lowest water levels in 150 years during 2020–21 due to prolonged drought in much of the Southern Cone; and in 2023, many individuals in the Amazon were isolated due to dry rivers rendering navigation impossible. Meanwhile, in Mesoamerica and the Caribbean, droughts, storms, and hurricanes – intensifying and causing increasingly severe damage – continue to make global headlines. Through the narrative of global Climate Change, local or regional events acquire a planetary scale, raising concerns among Latin Americans, particularly women, about the impact of changes in climate systems on their daily lives (UNDP and University of Oxford 2024).

Undoubtedly, from a Latin American perspective, the Anthropocene marks Climate Change as one of its principal phenomena during this period of the Great Acceleration. As evidenced by this Handbook volume, historical precedents reveal multiscale interactions between society and climate across all historical stages, exhibiting significant continuities over the long-term concerning the development of vulnerability and resilience to climatic events. Consequently, consideration of anthropogenic actions that influence microclimates – such as those in urban areas or tropical forests – should remain at the forefront of research endeavors. Furthermore, it is crucial to underscore the various forms of social organization, scientific and technological advancements, and institutional developments emerging from the continuous quest for harmony with natural climate variability, as these constitute the experiential foundation for adapting to a changing climate.

However, "climate" has never before been as significant in fostering connections between Latin America, the Caribbean, and the rest of the world as it has during the Great Acceleration. This is exemplified by the international demand to protect the Amazon rainforest due to its critical role as a major CO_2 sink and climate regulator in South America and globally. Additionally, discussions surrounding extractive lithium mining for electromobility in the North and the potential production of green hydrogen for European and North American industries to achieve carbon neutrality, as outlined in their nationally determined contributions (NDCs) under the 2015 Paris Agreement, further highlight these connections.

According to a recent report by the International Monetary Fund (Ivanova, Kozack, and Muñoz 2024), Latin America and the Caribbean contribute 8.3 percent to global greenhouse gas (GHG) emissions, a figure consistent with the region's demographics and global GDP ranking. Notably, a significant portion of these emissions originates from the agricultural sector, land use, land-use change, and forestry (LULUCF), accounting for 49 percent of the total net GHG emissions, compared to the global average of 15 percent. This is attributed to rapid deforestation in the Amazon and other regions, primarily for beef and soybean production (Ivanova, Kozack, and Muñoz 2024: 14). Deforestation in tropical areas impacts the local climate by increasing average temperatures due to the loss of "cooling services" provided by surface water evaporation, photosynthesis, increased cloud cover, and wind turbulence from trees (Lenaker and Seymour 2023). It is estimated that the local impact of deforestation on temperature and the transformation of the Amazon into savanna-like conditions is equal to or greater than the greenhouse effect, with severe repercussions on the health of the region's inhabitants, particularly rural workers engaged in outdoor activities (Alves de Oliveira et al. 2021). The climate issue has only recently begun to be included in discussions on labor conditions and relations.

Furthermore, it is estimated that deforestation in the tropics significantly impacts regional climates, particularly affecting the hydrological cycle and rainfall patterns. The drought experienced from 2020 to 2023 in the Southern Cone has been attributed, among other factors, to reduced rainfall resulting from decreased humidity transported by aerial flows due to lower evapotranspiration in Amazonian forests (Arraut et al. 2012). Additionally, the occurrence of mega-fires across the continent over the past two decades – intensified by the interaction between Climate Change and agro-industrial and mining activities, often associated with organized crime – has led to increased GHG emissions, degradation of key ecosystems functioning as carbon sinks, and threats to both wildlife and human health (Neger et al. 2022; Tomas et al. 2021; Vidal-Riveros et al. 2024).

Another anthropogenic process characterizing the region from the mid-twentieth century to the present in terms of climate alteration is rapid urbanization. Urban growth and development during this period have been significant drivers of Climate Change at both local and global levels. This is linked to changes in land use, such as deforestation and hydraulic modifications, soil sealing, and increased absorption of solar radiation. Latin America is the most urbanized region in the world, with approximately 80 percent of its population residing in cities. Additionally, 14 percent of this urban population lives in megacities – metropolitan areas with over 10 million inhabitants – although medium-sized cities have exhibited higher growth rates since the beginning of the twenty-first century. Latin American cities show the highest levels of economic, racial, and gender inequality, forming what Mendieta (2019) describes as "anthropocentric urbanism" which encompasses a continuous "climate apartheid" (Dawson cited in Mendieta 2019: 87). Urban development in the region is marked by at least one-fifth of the population living in informal settlements, lacking sufficient access to essential services such as water, sanitation, modern energy, and transportation, as well as healthcare and education. Differences in social responsibilities and adaptation capacities among social classes and groups contribute to varying impacts of urban climate modification. This variation includes the ability to cope with gradual changes and extreme weather events (Duque Franco et al. 2021).

The negative impacts of urbanization at a local level include the "urban heat island effect" in megacities and large cities, where average temperatures can be up to 8°C higher than in peri-urban areas. This exacerbates the increasingly frequent heatwaves (Sarricolea and Meseguer-Ruiz 2019). Additionally, the design of megacities often overlooks natural wind patterns, leading to elevated levels of air pollution (Henríquez and Romero 2019). On a global scale, urban areas in Latin America and the Caribbean are significant sources of concentrated greenhouse gas emissions from industrial activities, the construction sector, and transportation (Henríquez and Romero 2019). Ironically, while deforestation continues in the tropical, coastal, and mountain forests of Latin America, the primary technical response at the urban level to mitigate the adverse effects of rising temperatures and flood exposure has been the implementation of green infrastructure. This includes urban tree planting and the development of parks, which also contribute to biodiversity restoration (Kaltmeier et al. 2024).

The Intergovernmental Panel on Climate Change (IPCC) has outlined various scenarios indicating that the Caribbean and Central and South America are increasingly exposed to extreme events associated with climate-related threats: floods, prolonged droughts, storms, and stronger winds (Castellanos et al. 2023). These events lead to disasters due to the historical socio-economic vulnerability of populations, which includes their material living conditions and exposure to risk, causing significant damage. Additionally, countries in Latin America and the Caribbean are expected to face higher temperatures, rising sea levels, and changes in rainfall patterns (Ivanova, Kozack, and Muñoz 2024). The retreat of glaciers, primarily in the Andes, poses a threat to the primary source of freshwater for urban and rural populations and is linked to an increase in landslides.

Climate-dependent agroecosystems are particularly affected, especially small-scale family and peasant farming. The gradual shift towards more relational forms of animal husbandry and crop cultivation, such as agroecology in countries where it has received public support (e.g., Argentina, Brazil, Mexico), represents a sustainable adaptation strategy for family farming. Conversely, the techno-economic response of agribusiness involves the monopolistic introduction of drought-resistant seeds, new chemical and biological input packages, as well as large-scale irrigation systems. This occurs precisely when water resources are declining in both quantity and quality in certain areas, creating competition with family farming and direct human water consumption. Additionally, agribusiness (or at least some of its factions) has adopted "green" initiatives in response to strong criticism of its social and ecological impacts. These initiatives include the adoption of best agricultural practices, sustainability certifications, compensatory measures, and the commodification of ecosystem services.

The tourism and health sectors are identified as particularly vulnerable to the region's climate scenarios. The increased spread and movement of tropical disease vectors, along with heat stress, significantly affect children and the elderly. Human climate migrations, regarded as an adaptation strategy, are increasingly receiving attention at both national and transnational levels. However, in comparison to regions such as Africa and Southeast Asia, climate migration in Latin America is less pronounced, with the exception of coastal cities and Caribbean islands impacted by rising sea levels.

In terms of institutional responses to Climate Change, Latin America and the Caribbean have experienced significant developments during the period of the Great Acceleration. There has been a notable increase in state offices dedicated to drafting GHG reports, developing mitigation roadmaps, and creating national, municipal, and sectoral adaptation plans. Environmental education and Climate Change programs have become more prevalent in schools, and there has been growth in higher education careers within the natural and social sciences focused on climate issues.

However, it remains to be seen whether there are clear signs or robust countertrends within Latin American and Caribbean societies that indicate a profound socio-ecological transformation in response to Climate Change. Amid the multiple crises of the Anthropocene, this Handbook seeks to contribute to a better understanding of the drives and impediments to such transformative potential.

Following the above description of GHG contributions, mitigation of, and adaptation to Climate Change in Latin America and the Caribbean, this introduction highlights four key thematic areas relevant to understanding the climatic Anthropocene from a regional perspective: climate economies, the energy transition, the multiscalar nature of environmental activism, and Indigenous and community perspectives on climate chaos.

During the Great Acceleration, Climate Change was often regarded as a significant market failure and a potential hindrance to capitalist economic development. However, the prevailing view among capitalists today is that addressing Climate Change presents an opportunity for economic growth. In particular, financial capital is developing new instruments to expedite GHG emission mitigation and adapt to the effects of Climate Change. It is estimated that Latin America and the Caribbean require $132 billion annually to finance mitigation and adaptation measures. Although the global market for green or sustainable debt has expanded, the region accounts for only 2.5 percent of this capital movement, with most concentrated in developed countries and the Asia-Pacific region. Green finance in the region, sourced from both public and private entities, has primarily focused on GHG emission mitigation projects, especially in the energy sector (Bull 2024; Walker and Cevik 2024). Despite the issues of measurement and transparency in projects financed by green bonds or similar mechanisms, there is a notable disconnect between green financing and traditional national or multilateral financial capital. The latter remains heavily invested in conventional growth investments such as mineral extraction, conventional and unconventional oil, and natural gas, with minimal consideration for environmental or social impacts (Bull 2024).

In a scenario of green capitalism and the development of a planetary climate regime – which Mann and Wainwright (2018) describe as a possible "climate Leviathan" – Latin America and the Caribbean play a significant role in the energy transition needed to stabilize GHG emissions. Developed or emerging societies of the Global North, historically the largest contributors to GHG emissions, require new raw materials such as lithium and rare earth elements for batteries that enable electromobility, which is a key response to maintaining their imperial lifestyles in urban centers (Brand and Wissen 2017). Similarly, the production of green or low-emission hydrogen involves Latin America providing its resources and territories to support technological solutions aimed at achieving carbon neutrality in industry, agriculture, and freight transport. Conversely, some of the region's oil and natural gas-exporting countries may face reduced revenues if these energy transitions progress (Ivanova, Kozack, and Muñoz 2024). A primary challenge for the region is whether it can contribute to slowing Climate Change while addressing dependency and climate colonialism. This raises the question whether Latin America and the Caribbean will transition to greater economic and technological autonomy, building shorter and more symmetrical value chains, or reinforce the extractive export-oriented focus of its economies to the benefit of other global market actors.

Latin America and the Caribbean have nurtured social and environmental movements that advocate for Climate Change initiatives, cultural identity recognition, and the defense of land and territories against neo-extractivism (Svampa and Viale 2020). Numerous localized climate actions emphasize participatory approaches, sustainability, self-sufficiency, equity, strengthening local economies, and fostering social cohesion (Cisneros et al. 2024). Additionally, there are locally rooted actions with international and global impact. A notable example is Peruvian farmer Saúl Luciano who, with support from the German NGO Germanwatch, filed a lawsuit in the Higher Regional Court of Hamm in Germany against *Rheinisch-Westfälisches Elektrizitätswerk AG* (RWE), a company generating electricity using coal and other sources in Europe. As outlined in the doctoral thesis of anthropologist Walker-Crawford (2021), Saúl Luciano and his legal team presented scientific evidence linking the company's activities to Climate Change, which is accelerating the retreat of the Palcaraju glacier and increasing the risk of a glacial lake outburst flood from Lake Palcacocha over the city of Huaraz. The potential disaster could endanger an estimated 7,000 to 20,000 lives and destroy property owned by the claimant – a central argument of the lawsuit that skillfully utilizes existing German legal norms. Beyond the symbolic nature of the request to cover 0.5 percent of the costs for preventing the avalanche event (representing the company's global contribution to GHG emissions), the most critical aspect of the case is the establishment of an anthropogenic climate connection by a subaltern actor. This connection enables greater empowerment and representation of more vulnerable groups in Latin America and the Caribbean.

Finally, and importantly, throughout this period, there has been a notable political and cultural strengthening of Indigenous, Afro-descendant, and other traditional communities in both rural and urban areas. In terms of climate issues, Indigenous, caboclo, and community-based organizations, movements, and networks have gained representation in multilateral forums and some nation-states. They advocate for traditional and ancestral knowledge and practices to address Climate Change and related food and health crises. Some have developed practices described as "alternative geoengineering" (Taddei 2017), which include shamanic rituals and other practices considered irrational from a modernist perspective, aimed at positively modifying the climate. According to Danowski and Viveiros do

Castro (2019), based on statements from indigenous leaders like Davi Kopenawa Yanomami, Amerindians have survived several "ends of the world" and "falling skies," proposing relational cosmologies to avoid climate collapse and other crises. Intellectuals of indigenous and Afro-Caribbean roots, along with non-indigenous academics, religious figures, and politicians, critically assess modernity and capitalism, and conservative stances of regional and global elites, as contributors to climate issues affecting indigenous peoples and vulnerable populations. Latin America and the Caribbean provide perspectives from indigenous, and mestizo thought that offer a "figuration of their future" (Danowski and Viveiros do Castro 2019), addressing the Anthropocene in unconventional ways.

The chapters in this section of the volume on The Great Acceleration provide climatic, economic, social, and political information on the continuities and ruptures experienced by various subregions in Latin America and the Caribbean, their peoples, social actors, and institutions, as they understand, engage with, and coexist with the causes and effects of Climate Change, a multi-scalar and multi-temporal human and more-than-human phenomenon. The texts indicate that the climate crisis requires the region to reconsider its development models, notions of well-being, epistemic frameworks, forms of social organization, and political expressions. This reconsideration must begin with recognizing its significant geographic, cultural, and socio-territorial diversity, and acknowledging the limited cosmopolitical alternative climatic experiments to date, whether from above or below, in a socio-ecological context shaped by colonial heritage and dependent capitalist insertion. Latin America and the Caribbean produce pluriversal critical thought, arising from the tensions between awareness of the unequal effects of the climate crisis and the continuation of its causes.

References

Alves de Oliveira, Beatriz Fátima, Marcus J. Bottino, Paulo Nobre, et al. 2021. "Deforestation and climate change are projected to increase heat stress risk in the Brazilian Amazon." *Communications Earth & Environment* 2, no. 1: 1–8.

Moraes Arraut, Josefina, Carlos Nobre, Henrique M. J. Barbosa, et al. 2012. "Aerial Rivers and Lakes: Looking at Large-Scale Moisture Transport and Its Relation to Amazonia and to Subtropical Rainfall in South America." *Journal of Climate* 25, no. 2: 543–556.

Bértola, Luis, and Jose Antonio Ocampo. 2013. *El desarrollo económico de América Latina desde la Independencia*. Mexico City: Fondo de Cultura Económica.

Brand, Ulrich, and Markus Wissen. 2017. *Modo de vida imperial. Sobre la explotación del hombre y de la naturaleza en el capitalismo global.* Mexico City: Friedrich Ebert Stiftung.

Bull, Benedicte. 2024. "China and the New Geopolitics of Climate Multilateralism in Latin America." *Iberoamericana – Nordic Journal of Latin American and Caribbean Studies* 53, no. 1: 44–58.

Castellanos, Edwin J., Maria Fernanda Lemos, Laura Astigarraga, et al. 2023. "Central and South America." In *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. Intergovernmental Panel on Climate Change: 1689–1816. Cambridge: Cambridge University Press.

Cisneros, Paul, Israel Solorio, and Micaela Trimble. 2024. "Thinking climate action from Latin America: A perspective from the local." *npj Climate Action* 3, no. 1: 1–5.

Danowski, Débora, and Eduardo Viveiros do Castro. 2019. *¿Hay mundo por venir? Ensayos sobre los miedos y los fines.* Buenos Aires: Caja Negra.

Duque Franco, Isabel, and Jhon Williams Montoya Garay. 2021. "Cambio climático y urbanización." *Cuadernos de Geografía: Revista Colombiana de Geografía* 30, no. 2: 274–279.

Henríquez, Cristián, and Hugo Romero, ed. 2019. *Urban climates in Latin America*. Cham: Springer.

Ivanova, Anna, Julie A. Kozack, and Sònia Muñoz, ed. 2024. *Climate Change Challenges and Opportunities in Latin America and the Caribbean*. Washington, D.C.: International Monetary Fund.

Kaltmeier, Olaf, Antoine Acker, León Enrique Ávila Romero, et al., eds. 2024. *Biodiversity – Handbook of the Anthropocene in Latin America II*. Bielefeld: Bielefeld University Press.

Lenaker, Anna, and Frances Seymour. 2023. "Agrava deforestación local el estrés por calor en los trópicos." *World Resources Institute*, March 13. https://es.wri.org/insights/agrava-deforestacion-local-el-estres-por-calor-en-los-tropicos.

Mann, Geoff, and Joel Wainwright. 2018. *Leviatán climático. Una teoría sobre nuestro futuro planetario.* Madrid: Biblioteca Nueva.

Mendieta, Eduardo. 2019. "Edge City: Reflections on the Urbanocene and the Plantatiocene." *Critical Philosophy of Race* 7, no. 1: 81–106.

Neger, Christoph, José Francisco León-Cruz, Leopoldo Galicia Sarmiento, et al. 2022. "Dinámica espaciotemporal, causas y efectos de los megaincendios forestales en México. *Madera y bosques* 28, no. 2: 1–21.

Sarricolea, Pablo, and Oliver Meseguer-Ruiz. 2019. "Urban Climates of Large Cities: Comparison of the Urban Heat Island Effect in Latin America." In *Urban climates in Latin America*, ed. Cristián Henríquez, and Hugo Romero, 17–32. Cham: Springer.

Svampa, Maristella, and Enrique Viale. 2020. *El colapso ecológico ya llegó. Una brújula para salir del (mal)desarrollo*. Buenos Aires: Siglo XXI.

Taddei, Renzo. 2017. *Meteorologistas e profetas da chuva. Conhecimentos, práticas e políticas da atmosfera*. São Paulo: Terceiro Nome.

Tomas, Walfrido Moraes, Christian Niel Berlinck, Rafael Morais Chiaravalloti, et al. 2021. "Distance sampling surveys reveal 17 million vertebrates directly killed by the 2020's wildfires in the Pantanal, Brazil." *Scientific Reports* 11, no. 1: 1–8.

UNDP, and University of Oxford. 2024. "People's climate vote 2024." United Nations.

Vidal-Riveros, Cristina, Bryce Currey, David B. McWethy, et al. 2024. "Spatiotemporal analysis of wildfires and their relationship with climate and land use in the Gran Chaco and Pantanal ecoregions." *Science of The Total Environment* 955: 1–13.

Walker, Chris, and Serhan Cevik. 2024. "Financing Climate Policies in Latin America and the Caribbean." In *Climate Change Challenges and Opportunities in Latin America and the Caribbean*, ed. Ivanova, Anna, Julie A. Kozack, and Sònia Muñoz. Washington, D.C.: International Monetary Fund.

Walker-Crawford, David Noah. 2021. "Climate Change in Court: Making Neighbourly Relations in a Warming World." PhD diss, University of Manchester.

Climate Change in the Southern Cone from 1950 to the Present

Anthropogenic Dynamics and their Impacts in the South American Gran Chaco

Valeria Hernández and Carolina Vera

> Shut down a coal plant, and you can slow global warming for a day; shut down the relations that made the coal plant, and you can stop it for good. (Moore 2015)

This chapter examines anthropogenic climate change in the Southern Cone during the period known as the Great Acceleration (approximately 1950 to the present), with a particular focus on the South American Gran Chaco (SGCh). The SGCh is located within the "Southeastern South America" (SES) region, one of seven areas identified by the Intergovernmental Panel on Climate Change (IPCC) for the analysis of regional climate change diversity. The SES includes eastern Argentina, southern Brazil, and Uruguay (Arias et al. 2021), and forms part of the broader Southern Cone, which incorporates areas beyond the SGCh. By analyzing the nature-society relationships that have developed in this region during the Great Acceleration, this chapter links human-driven activities and their effects on climate-related processes, as well as the influence of international sustainability agendas (such as the Paris Agreement, Sustainable Development Goals, and Future Earth) implemented through local initiatives. It is important to note that Steffen et al. (2015) critically revised the concept of the "Great Acceleration" to more accurately distinguish the contributions of individual regions to the various indicators underlying the notion of an "acceleration" in changes to the Earth system around 1950. The authors also highlight a shift in trend, noting that their analysis of key indicators from 2000–2010 suggests, "the future trajectory of the Anthropocene may well be determined by what development pathways urbanization takes in the coming decades, particularly in Asia and Africa" (Steffen et al. 2015: 91).

The chapter is structured into three sections. The first section outlines the current status of climate change in the SGCh, highlighting the principal risks and expected impacts on both populations and ecosystems. The second section examines key land use change processes associated with the expansion of the commodity frontier within the broader context of global climate change, as well as the evolving relationships between nature and society that these transformations have triggered. According to Le Polain et al. (2018: 2), the concept of the "commodity frontier" pertains to "areas where the production of agricultural commodities (e.g., beef, soy, or palm oil) by large-scale farms expands over other land uses, the development of which is shaped by the greater ability of these large-scale actors to influence and capture agricultural rents." This section examines the involvement of various territorial actors, including non-governmental entities, in regional climate change initiatives and development policies. It reviews narratives and methods used to address climate and environmental issues. The chapter concludes by considering the relationship between the scenario described in the SGCh and how this case's findings may inform discussions on the challenges contemporary societies encounter regarding planetary boundaries.

Description of Anthropogenic Climate Change in the South American Gran Chaco

The SGCh is a plain of approximately 1.1 million km^2, originating in the Tertiary Period, extending from 67° 50' W to 57° 52' W and from 16° 55' S (tropical region) to 33° 52' S (temperate region) (Metz and Wessling 2006). Archaeological studies have detected the presence of hunter-gatherers and fishermen around 3,000 BC. Occupied by various waves of populations from the South American rainforest and the Andean region, ethnic diversity progressively expanded. The social, political, and economic changes experienced by native groups as a result of the Spanish conquest and subsequent territorial colonization during the formation of nation-states in the nineteenth century were significant, involving population loss and forced labor for some Indigenous communities. In the nineteenth and twentieth centuries, the SGCh region saw immigration from Europe, Asia, Africa, and other neighboring countries. Currently, this area has a population of nearly nine million people: 93.42 percent reside in Argentina, 4.33 percent in Bolivia, and 2.25 percent in Paraguay (Castro Arze et al. 2021). Native peoples make up 8 percent of the population and are classified into six ethnic groups (different tribes sharing the same language) according to analyses of semantic fields (Tomasini and Braunstein 2006): Zamuco, Mataco-Maka, Guaycuú, Maskoy, Tupí-Guaraní, and Lule-Vilela.

From a morpho-geological perspective, the SGCh encompasses a broad range of environments, including grasslands, wetlands, savannas, marshes, salt flats, mountains, and rivers. Notably, the region is situated atop two significant aquifers: the Yrenda Toba Tarijeño and the Guaraní, the latter recognized as the world's second most important groundwater aquifer. In addition, the area contains the largest expanse of forest on the continent after the Amazon and features a low population density, averaging between ten and twenty-two inhabitants per square kilometer, with a maximum of forty and a minimum of one inhabitant per square kilometer (Castro Arze et al. 2021). Recent records indicate the presence of over 3,400 plant species, approximately 500 bird species, 150 mammal species, 120 reptile species, and nearly 100 amphibian species within the SGCh (Castro Arze et al. 2021). These characteristics collectively position the SGCh as a region of considerable global geopolitical importance and underscore its role as a priority territory for biodiversity conservation at the planetary level (The Nature Conservancy 2005).

At the beginning of the twentieth century, after the definitive consolidation of nation-states in the region, the SGCh came under the control of four countries as indicated in Table 1 (although due to the small proportion of territory it has in this region, most of the bibliography and information sources do not involve discussions of Brazil) (Castro Arze et al. 2021).

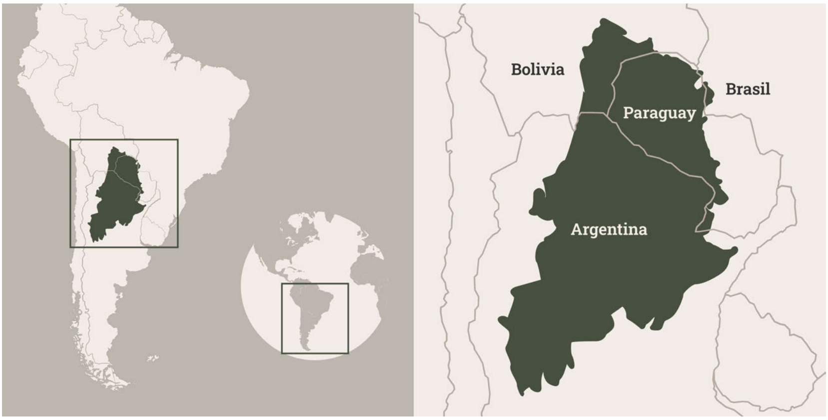
Table 1: Percentage of SGCh Surface Area by Country

Country	**% of SGCh Surface**
Argentina	62
Paraguay	25
Bolivia	12
Brazil***	1

Source: Castro Arze et al. (2021).

In terms of climate, the IPCC highlights the continuous increase in mean temperature since the mid-twentieth century in the SES, accompanied also by a significant increase in the frequency and intensity of heat waves and a decrease in the frequency and intensity of cold waves and frost. Most of the SES has also experienced an increase in annual rainfall, largely attributed to the increase in summer rain, as well as an increase in the intensity and frequency of extreme rain events. It is worth mentioning that currently natural climate variability can either reinforce or, on the contrary, moderate these regional climate changes that are at least in part attributed to human influence on the global climate (Arias et al. 2021; Seneviratne et al. 2021).

Figure 1: Map of South America Highlighting South American Gran Chaco, by Country



Source: Map extracted from redeschaco.org

In the future, if global warming continues to increase, the magnitude of these changes over the SES region will intensify and the contribution of anthropogenic climate change is likely to outweigh natural climate variability. Regarding droughts, whether meteorological (associated with rainfall deficits) or agro-ecological (associated with deficits in soil water content), Seneviratne et al. (2021) conclude that the changes experienced have not been statistically significant and that there is still great uncertainty about the dominant direction of future change. A recent study concludes that it is not possible to rule out future scenarios of precipitation deficit since human activities are altering physical processes within the climate system that could result in either a wetter future or a drier future for the area (Mindlin et al. 2023). Recent drought conditions from 2019 to 2022 could be an example of the tug of war between two climate states – humid and dry – both influenced by human activities. Conversely, substantial evidence indicates a decrease in hydrological droughts (characterized by flow deficits) from the mid-twentieth century to the present, though there remains considerable uncertainty regarding the persistence of this trend. There is moderate confidence that, should global warming intensify, the region will see both increased average river levels and more frequent flooding in the future. However, van Garderen and Mindlin (2022), in a recent study assessing the regional drought of 2011–2012, identified anthropogenic factors as contributors to the surface drying observed during this event.

In sum, the SES has experienced and will most likely continue to experience alternating extreme wet and dry events with consequent adverse impacts on socio-environmental dynamics (Reboratti 2008). A study carried out by UNEP (2013) indicates an increase in pressure on water resources (including "virtual water," that is, the total amount of water required to obtain a product) due to a “combination of changes in climate and increased demand for production in response to population growth and development plans” (UNEP 2013: 110). These changes will have a high impact on the region’s agricultural production, as was seen in the past with droughts and floods. As indicated by the UNEP study, “Argentina lost 2.8 percent of its GDP during the 2008 drought. On the other hand, in four events recorded in Paraguay (two of drought in the years 2004/5 and 2007/8, and two of excess rainfall in the years 2000/01 and 2011/12), it lost around 1,250 million dollars in the sector” (UNEP 2013: 149). Furthermore, Castellanos et al. (2022) assessed the SGCh and identified significant vulnerabilities within its terrestrial and freshwater ecosystems, food systems, urban areas, and infrastructure. The population living in poverty and their sources of livelihood also experience pronounced vulnerability. Notably, there is limited scholarly literature addressing climate change and its local impacts on the SGCh region. In 2013, UNEP published the *Estudio de Vulnerabilidad e Impacto del Cambio Climático en el Gran Chaco Americano* (Vulnerability and Impact Study of Climate Change in the American Gran Chaco), in partnership with universities from Argentina, Bolivia, and Paraguay. Additionally, Scribano et al. (2017) demonstrated that the intrinsic adaptive capacities (human, social, economic, infrastructure, institutional, etc.) vary considerably across the SGCh, with higher levels observed in the Argentine Chaco and lower levels in the Paraguayan counterpart.

In relation to the greenhouse gas emissions made by countries with territories in the SGCh, Table 2 shows total and sectoral emissions for each country, as well as the percentages that represent both total emissions and total emissions by country.

Table 2 indicates that emissions from the combined agro-livestock and land-use change sectors are higher than those from the energy sector in Brazil, Bolivia, and Paraguay, constituting 62.85 percent, 80.62 percent, and 81.14 percent of their total emissions, respectively. In Argentina, this sum accounts for 42.54 percent of total national emissions, which is lower than the share attributable to the energy sector. For all four countries, the percentage of emissions from agro-livestock and land-use change significantly exceeds the global average of approximately 15 percent reported by Climate Watch. Therefore, these countries have a comparatively high proportion of emissions related to these two sectors, which is further evidence of the environmental consequences of such human activities.

Table 2: Characterization of the total and sectoral emissions generated in 2020 by each of the countries with territory in the SGCh

Country /Emissions (MTCO2e and %)	**Global Rank as CO2 Emitter**	**Totals**	**Energy**	**Agri-cultural Activities**	**Land Use Change and Forestry**	**Industrial Processes**	**Waste**
Brazil***	7	1,470 (3.09%)	440.02 (29.94%)	518.86 (35.3%)	404.94 (27.55%)	34.28 (2.33%)	71.56 (4.87%)
Argentina	23	394.76 (0.83%)	175.77 (44.53%)	134.6 (34.1%)	33.33 (8.44%)	28.78 (7.29%)	22.28 (5.64 %)
Bolivia	48	131.43 (0.28%)	20.71 (15.75%)	29.74 (22.62%)	76.23 (58%)	1.66 (1.26%)	3.10 (2.36%)
Paraguay	58	97.29 (0.2%)	7.99 (8.21%)	32.77 (33.68%)	46.51 (47.46%)	2.12 (2.18%)	7.92 (8.14%)

Source: Climate Watch (n.d.)

Baumann et al. (2017) report that land use changes in SGCh since the late twentieth century have led to significant carbon emissions, primarily resulting from the conversion of forests to grazing land (68 percent) for livestock. The environmental impact of grazing is influenced by the technology employed in its practice. Additionally, Ferraina et al. (2022) examined how large-scale mechanized grazing operations and traditional peasant and indigenous grazing practices affect woodland structures. The results show that mechanized grazing reduces the volume and vertical complexity of woodlands with yields greater than 3 m. This is relevant in the Chaco context where the practice of roller chopping, which is an important stress factor in the structure of forests, is widely used. On the other hand, they found no difference in the structure of the woodlands between the grazing areas of small farmers and preserved forests, indicating that these types of productive systems maintain a metabolism similar to their environment. The change in land use is also due to the advance of agricultural activity, implying high rates of deforestation (Zak et al. 2008; Gómez Lende 2018). Between 1985 and 2013, almost 40 percent of forests in the Chaco were replaced by cropland (Baumann et al. 2017) and between 2013–2017, the annual average of forests transformed into productive land was almost half a million hectares (Castro Arze et al. 2021).

Soil salinization represents a significant adverse effect resulting from substantial changes in land use driven by commodity agriculture within the region. In the plains of the Argentine Espinal and Dry Chaco, the expansion of agriculture to replace natural forests, shrubs, and pastures has led to water surpluses. This has resulted in the emergence of "neo-wetlands," which are characterized by elevated water table levels, waterlogging, and increased soil salinity (Díaz, Jobbágy, and Marchesini 2022). Similar patterns of land use transformation are observed in various ecosystems across the Southern Cone that face pressure from the advancing commodity frontier (Le Polain et al. 2018), whether for crops or livestock production. These include the Paranaense Forest, the Pantanal, the Iberá Wetlands, the Pampean Pasture, and the Paraná Delta. The relationship between agricultural and livestock systems involves shifts in land use to accommodate changing production needs (Pengue 2009; Baumann et al. 2016; Fehlenberg et al. 2017). Cattle herds are relocated to the SGCh region after being moved from areas considered more suitable for agriculture in various countries, often due to these lands being converted for soybean cultivation. In some instances, producers initially introduce livestock to the area and subsequently transition to soybean farming. Baumann et al. (2016) report that approximately 40 percent of grazing land present in 1985 has since been transformed into farmland. The replacement of native vegetation with agricultural crops such as soybeans, cotton, peanuts, corn, sunflower, wheat, sorghum, and beans, as well as the expansion of livestock activities, corresponded with a continued increase in deforestation rates beyond the 1980s and 1990s (Oren and Zavala 2016). Based on a study of the challenges the climate issue poses for South American countries, Bidegain et al. warn:

> The current process of expansion and intensification of production increases the socio-ecological system's vulnerability, since it does not incorporate the main characteristics of current climate variability. If these current characteristics continue, the capacity to adapt will surely be even more limited in the new scenarios of climate variability. (Bidegain et al. 2019: 113)

In short, deforestation has been identified as the primary land use change in the SGCh during the period known as the Great Acceleration. The expansion of the agricultural frontier is the main economic activity affecting forests (Gasparri and Grau 2009; Gasparri et al. 2013; Piquer-Rodríguez M. et al. 2018). Both deforestation and agricultural expansion are significant contributors to greenhouse gas emissions in the SGCh region (Baumann et al. 2017). A key question concerns the type of society-nature relationship that underpins the production of agricultural commodities in the SGCh. Addressing this issue requires a thorough examination of the prevailing production model and its socio-environmental impacts, alongside an analysis of the regulatory framework governing agricultural activities and the range of stakeholders involved.

Global Demand and Local Impacts: The Limits of the SGCh and Market Devices

Features of the Commodity Frontier's Advance in the South American Gran Chaco

Since the late twentieth century, agricultural production in South America has grown in response to global market trends, notably marked by the expansion of the commodity frontier in the SGCh region (Paolasso et al. 2012; Le Polain et al. 2018). Advances in seed genetics, such as resistance to glyphosate, drought tolerance, and built-in pesticides, along with direct seeding techniques, have turned previously unsuitable land into arable fields (Hernández 2007; 2009). SGCh lands experienced this shift when transgenic soybeans replaced regional crops at the end of the twentieth century. Entrepreneurs also adopted new technologies, including communication and information systems, enabling them to efficiently manage larger-scale agribusiness operations (hereafter AM, Gras and Hernández 2009; 2013; 2014; 2016). Advancements in sensor technology integrated into agricultural machinery, along with specialized management software for agribusinesses, have facilitated significant improvements in supply calculation (resulting in cost savings), data generation on key variables (such as soil moisture and organic matter composition), and real-time analysis for the development of efficient strategies, among other benefits (Phélinas and Hernández 2024). These innovations have enabled substantial cost reductions by eliminating certain tasks – such as stubble removal and soil breakage by using direct seeding planters – consolidating multiple operations within a single-time frame (including planting, spraying, and fertilizing), and automating or digitizing processes throughout production. Furthermore, sensors on tillage equipment routinely collect diverse data sets to monitor crops, supporting ongoing comparative analyses across growing seasons.

The dynamics of AM expansion in the SGCh involved internal migration within countries from agricultural zones to new border areas, as well as cross-border movements where successful businesses from one country sought to operate in "cheap" lands of neighboring countries. The growth of the commodity frontier involved not only land acquisitions by these entrepreneurs but also the leasing of hundreds of thousands of hectares, resulting in changes in land management and notable effects on social structures (Borras et al. 2012; Murmis and Murmis 2012; Gras and Cáceres 2017; Gras and Zorzolli 2019; Venencia et al. 2022). In the Bolivian Chaco, Brazilian and Argentinian companies arrived in the 1990s to cultivate soybeans and in the 2000s to develop livestock farms; ten years later, they had come to control approximately one million hectares (Urioste 2012). Since the 2000s, the Paraguayan Chaco has seen the arrival of enterprises from neighboring countries whose incentive was, first, the cattle breeding (Mereles and Rodas 2009) and then the cultivation of transgenic soybeans (Ávila and García 2019; CEPAL 2014). In the Argentine Chaco, on the other hand, starting in the late 1990s and early 2000s, there was a migration of national companies from the Pampas region who, after the boom in the land market, sought to expand the scale or improve the financial equation by leasing or buying land in the northeast and northwest of the country (Zarrilli 2008; Pertile and Torre Geralgia 2009; Morello et al. 2013).

The cross-border activities of agricultural entrepreneurs in the region, coupled with the growing involvement of foreign investors in these ventures, have sparked discussions regarding foreign ownership of land in countries with high agricultural potential. The extent of internationalization is influenced by each country's regulatory framework (such as the presence or absence of agrarian reforms and laws restricting foreign ownership), the existence of both legal and illegal practices – including instances of direct violence – in the real estate market, and the ability of local and global organizations to resist such processes, among other factors. For instance, Urioste (2012) notes that, despite a 2009 prohibition on "double endowment, purchase, sale, exchange, and donation of land previously provided free of charge by the state," significant portions of land sales to foreigners continue to circumvent these legal restrictions:

> In practice, this provision no longer has an effect, because the vast majority have sold the lands or have "fabricated" the documents to prove that they have transferred them. Thus, the "new owners" who now sell them on the land market claim that they have bought them and are therefore free to sell them to whoever they want and at the price that suits them best. (Urioste 2012: 25)

Furthermore, since the late twentieth century, the growing interest of investment funds in agricultural commodities as financial assets has contributed not only to increased volatility in the grain market (Masters 2008), but also to significant effects on the land market. This trend has facilitated the financial valuation of land and encouraged its use as a capital refuge for acquisitions (Urioste 2012; Gras and Cáceres 2017; McKay 2017; Henderson et al. 2021). The adoption of these financial practices in the Chaco region has been driven by both global stakeholders and national agribusiness entrepreneurs (Ceddia et al. 2022; see also: Urioste 2012; McKay 2018).

According to the report by Mitchell et al. (2022) published on Planet Tracker – defining itself on its website as "a non-profit financial think tank that aligns capital markets with planetary boundaries" – about the action of financial agents in the Argentine and Paraguayan Chaco, there were twelve companies linked to deforestation in 2022 that "account for more than 88 percent of soy exports from the Argentinian Gran Chaco and more than 99 percent of the exports from the Paraguayan Gran Chaco" (18), financed by around twenty agents (banks and investors). According to a survey of economic and financial stakeholders and an examination of sustainability and "zero deforestation" agreements among them, the report states that legal measures protecting the Chaco forests in Argentina and Paraguay are insufficient. The companies, financial institutions, and investors included in the study have not made commitments to "zero deforestation" in this region. Furthermore, research indicates that deforestation significantly contributes to climate change and results in financial costs, including impacts on capital. For example, if the cost of deforestation, measured by CO_2 emissions, is valued at $91 per ton, the production cost of soybeans in the Gran Chaco region would be three times higher (Mitchell et al., 2022). As outlined in the report: "To illustrate, assuming a 5 percent yield on debt financing and using the price of CO_2 emissions as a proxy for natural capital depletion, USD 52 billion in financing would generate annual revenues of USD 2.6 billion – less than the corresponding carbon cost of USD 2.7 billion, assuming all Gran Chaco deforestation is linked to debt finance" (Mitchell et al. 2022: 5). These data underscore a proportional decline in investor returns. In December 2022, these calculations began to multiply due to the regulatory sanction enforced for anti-deforestation (or "zero deforestation") framework in the European Union, the destination of a significant portion of exported soybeans in the form of flour for animal feed.

The allocation of hundreds of thousands of hectares for commodity production in Argentina, Brazil, Paraguay, and Bolivia is identified as a priority by leading global governance organizations (including the World Bank, FAO, and IICA), transnational corporations, agricultural entrepreneurs, NGOs, foundations, and both national and subnational governments. For example, Colque (2014) points out that "the 1991 World Bank 'Eastern Lowlands' project played a strategic role in expanding soybean production and subsequently consolidating this production model in eastern Bolivia" (Colque 2014: 37; see also: Toftum and Fal 2019; Fal and Allami 2017; Le Polain et al. 2016). Many stakeholders, including those in public-private partnerships, consider SGCh to be an area with significant potential for agricultural production expansion. According to a FAO report projecting the global agri-food system for 2022, it was anticipated that American agricultural countries would provide 93 percent of the world's oilseed supply. The report also projected that global meal output would increase by 25 percent, with two-thirds of the 67 million tonnes increase expected to come from Argentina, Brazil, China, and the United States (OCDE-FAO 2013: 150). The following section will examine the narratives presented by these stakeholders, along with the strategies they have implemented to establish their visions within the territorial dynamics of the SGCh.

Sustainable Development Policies and Public-Private Conglomerates in the SGCh

From the perspective of agribusiness enterprises, the expansion of this model within the SGCh is viewed as a positive development, as it facilitates the integration of rural populations into the productive cycle – populations that might otherwise face marginalization and exclusion from participation in the global economy. Furthermore, converting extensive areas to agricultural use addresses the issue of "idle" land by putting these resources to productive work. The reflection of a senior official of the Institute for Economic Studies of the Argentine Rural Society summarized this vision when explaining the commodity frontier's advance over Santiago del Estero, one of the most deforested provinces in the Argentine Chaco:

> [The advance of soybeans] allows us to incorporate those people [the local population] who were out of the market process. Thanks to the development of this activity, they are part of the global economy, they participate in the world, and with that they participate in its development and they grow. They are part of something; before, they were producing or living for subsistence. […] This [soybean production] has given them the possibility of having a higher income, improving their level of infrastructure. There, throughout that area [the Argentine Chaco], the roads are much better than they were twenty years ago, they have a local economic movement, with businesses […]. They have even been making progress in some value-added integrations, for example, in the transformation of corn to meat [livestock production] that is also operating in that area.

In the vision of entrepreneurship, AM incorporates these territories into modernity, offering a horizon of social belonging to local populations considered hitherto "marginalized." In this perspective, this was a "win-win" model that generates benefits throughout society: creating employment as well as developing "social services" (education, health), as well as rural and agricultural infrastructure (water supply).

Entrepreneurs share their vision regarding the transformation they are leading in these territories and of the impacts on native communities:

> there is a great transformation […]. The people who lived there twenty years ago now live much better, because all this [soybean production] has allowed the incorporation of infrastructure, more resources into the public sector, which has allowed the governments of those provinces to have more resources, and the most important thing, a population that was not part of a scheme of the division of labor in the world before and that, now, is. And that region [the Argentine Chaco] produces around 10 percent of the country's soybean production, and that's a significant percentage of soybean production worldwide. So being part of something, of a scheme, the people who live in that place have another perspective on everything. Previously, when this [soy] did not exist, they were dependent on the economy that could be generated by the province's public sector. It was a very small and closed economy, and with this, they began to be entrepreneurs of their own, they could make decisions to carry out this or that thing […]. They leave behind a pattern of living where they dig a well in the morning only to cover it up at night, for a scheme that serves another, and that makes these people better off because

> they serve a process and a society, they are part of globalization. (Interview, July 4, 2018)

Arguments regarding integration into the global economy and the social trickle-down effects of business activity are similarly present in climate change adaptation and mitigation narratives promoted by international organizations (USAID 2019), as well as in initiatives led by non-governmental actors relevant to the SGCh. In regions where the nation-state's involvement has primarily supported economic activities linked to successive production cycles – such as logging and tanning, sugar cane cultivation, and cotton production – and maintained only a minimal level of social order through security forces and state agencies, civil society organizations have assumed an increasingly significant role. Their contributions now extend beyond the economic sphere to encompass social, cultural, and political domains. ProYungas (Argentina), Nativa (Bolivia), and Moisés Bertoni (Paraguay) are all foundations that have managed to position themselves as territorial references in the SGCh. With an important territorial presence and a high capacity to attract international funding, these organizations have created spaces for coordination with local social movements, subnational states, and bodies of global governance. Over time, they developed partnerships between them, achieving greater power to interject at the regional level and also encouraged the creation of the largest non-governmental "network of networks" of the SGCh: Redes Chaco (2008) (Gogna 2018). In turn, these three entities created the *Iniciativa Chaco Trinacional* (ICT, Trinational Chaco Initiative) in 2013, which they present as

> an institutional work scheme [...] with an impact on a series of cross-border actions related to cross-border land management, local development, the dissemination of experiences and findings from the project, and *the generation of knowledge about deforestation and forest degradation processes*. The articulation of ICT with ZICOSUR [Integration Zone of Middle Western South America] occurs through the participation of its members as permanent consultants to the ZICOSUR' Committee on Environment and Sustainability. (Redes Chaco 2020, our highlight)

The ICT presents arguments from the sustainability agenda, focusing on deforestation and forest degradation, alongside the political intentions of private entities to participate in territorial management processes across three countries. Through its involvement with ZICOSUR, the ICT aims to help shape regional development policy. Among the projects it sponsors, the program for transgenic soybean production stands out as a key initiative, introducing cultivation in five pilot sites within the Gran Chaco biome – three located in Argentina and two in Paraguay – with a minimum coverage of 50,000 hectares. This initiative involves the ProYungas foundation, an actor with a high capacity to attract international funding and lead cross-border initiatives, the investment fund Land Innovation Fund (LIF), the Moisés Bertoni Foundation, and the *Asociación Argentina de Productores de Siembra Directa* (Aapresid, Argentine Association of Direct Sowing Producers), which is one of the main technical-ideological powerhouses of AM in the region (Hernández 2013; Gras and Hernández 2016). In the narrative that describes this initiative, this study has identified the key words that make up the grammar of the global sustainability agenda:

> As part of the actions to be carried out [at the production sites of genetically modified soybeans resistant to glyphosate], *the carbon footprint* of the productive activity will be quantified, the carbon inventory of native vegetation and agricultural soils will be evaluated, projects will be developed to *offset carbon emissions* from the native vegetation area, with international accreditation, and create an *online platform* that guarantees transparency and contributes to dissemination. [...] Adding value to *good practices* will be one of the great challenges to be achieved, seeking to link producers with *international certifiers* that allow them to access *carbon credit markets*. The project aims at *sustainability* in all its axes. Only through alliances between the productive sector and civil society is it possible to produce profitably, while contributing to the conservation of nature in the region where the same producers are inserted. (Proyungas 2022, original emphasis)

Through practices like certification, compensatory tools such as carbon credits, and tracking systems including digital markers and blockchain, AM stakeholders seek to align with social, environmental, and economic sustainability goals without undermining the accumulation model (Gras and Hernández 2016). In response to criticisms from the sustainable development agenda regarding deforestation and glyphosate use, agribusiness and its partners are promoting intensified "responsible" commodity production in the SGCh (USAID 2019). Similar strategies have been observed in other Southern Cone nations (Uruguay, Chile), where climate change, biodiversity, and sustainability narratives support dominant production methods under so-called sustainable intensification (Alvarez et al. 2022; Taks 2019; Santos 2017). A key element emphasized within the alliance for sustainable soybean in the SGCh is the pivotal role of technological innovation in simultaneously achieving economic profitability and advancing climate change adaptation strategies – a role substantiated by numerous studies conducted in Southern Cone countries (Taks 2013; Prager et al. 2020; Phélinas and Hernández 2024). Among the leading technological initiatives is Visión Sectorial del Gran Chaco (ViSEC, Sectorial Vision of the Gran Chaco), a collaborative effort involving transnational and local companies, NGOs, and academia, which aligns with the goals of sustainable soy production.

The Voices of Discord: Extractivism, Environmental Crisis, and Local Communities

The commodity frontier's expansion, driven by the AM, possesses a dynamism that seems to have not yet reached its maximum expression. Critical voices have pointed to its "extractivist" nature (Gudynas 2009; Acosta 2009; Svampa 2007; Ortega 2013) based on the extraction of "raw materials in large volumes destined for export, controlled by an oligopolistic market that appropriates the surplus value of labor and nature, without creating intersectoral links or added value" (McKay 2018: 220 [our translation]). The "win-win" vision projected by agribusiness entrepreneurs has been questioned based on the consequences that the accumulation model brings. One aspect involves mapping land conflicts based on major transactions in the SGCh; for example, in the Chaco Salteño region, a paradigmatic territory of the advance of the commodities frontier, 52 percent of Indigenous communities and 72 percent of criollo families are identified as being within a high or very high potential conflict range (Venencia et al. 2022). In Bolivia, Colque (2014) notes that public policies have not sufficiently addressed the expansion of agribusiness into forested and peasant-owned areas. Another aspect concerns deforestation driven by the development of infrastructure to support commodity commercialization – such as bi-oceanic routes, waterway initiatives, and port construction in protected wetlands – which has resulted in local communities being concentrated in increasingly fragmented territories (Irala 2017; Castro Arze et al. 2021; Oren and Zavala 2016). If current patterns of land use change persist, projections indicate that within the next ten to twenty-five years, 50 percent of bird species and 30 percent of mammal species may face extinction as a result of forest fragmentation and the reduction of forested areas (Semper-Pascual et al. 2021; Castro Arze et al. 2021). Furthermore, the interaction between agribusiness and its surrounding environment is expected to increase greenhouse gas emissions through the loss of natural carbon sinks such as forests and wetlands. This will also elevate risk – understood as the intersection of climate threats with vulnerability and exposure among people, livelihoods, ecosystems, and species – in conjunction with the adverse impacts of deforestation and unsustainable agricultural practices, which can further degrade soil quality and accelerate soil degradation (Castellanos et al. 2022). These projections indicate an increase in vulnerability among small-scale producers and Indigenous communities. The loss of biodiversity, degradation of shared resources such as water, soil, and air, and the reduction of ecosystem services due to the impacts of agribusiness contribute to heightened food insecurity within these populations.

Several critical analyses have also emphasized the mechanisms that agribusiness has built around good agricultural practices, such as certification protocols, training spaces, communication support, etc. (Fossa Riglos 2017). These material and symbolic devices have been characterized as a "greenwashing" strategy to preserve the accumulation model (Selwyn 2021; Borras et al. 2021). In fact, as Gómez and Kees (2009: 123) warn, "the proposals for certified agriculture, which is only based on a few biophysical indicators, are not enough and, in addition, they can also present a new threat that is now 'certified' with some degree of technical verisimilitude, a spearhead for continuing with an intense process of deforestation [our translation]". Gómez and Kees (2009) also state the need to calculate the "ecological footprint" to include the costs of deforestation within the international price of commodities. Along the same critical lines, the backing that this greening strategy has found in policies implemented with the aim of reducing GHGs through compensation mechanisms for ecosystem destruction has been notable; although in practice, these policies end up safeguarding the dynamics of deforestation and extractive expansion despite the evidence that indicates how they lead to planetary limits (Achurro 2020; Fossa Riglos et al. 2024).

Conclusions

The present chapter has demonstrated that SGCh is a paradigmatic case of the way in which capitalism shapes the relationship between society and nature, "in which the flows of resources, circuits of capital, and the struggles of classes and states form a dialectical whole" (Moore 2015: 181). During the Great Acceleration, this region integrated into national and global economies by developing an accumulation model focused on primary production cycles. Over the past forty years, the expansion and entrenchment of AM in the area have increased the exploitation of "Cheap Natures" that had sustained local communities for generations (Moore 2015). This trend has also intensified worker displacement through task automation and has contributed to the deterioration of common resources, all aimed at maximizing capital returns – ultimately resulting in a higher concentration of production. This further entrenched pre-existing structural inequalities and exacerbated the disparities inherent in the society-nature relationship, following an extractivist logic.

It is important to highlight that the existing regulatory framework – whether due to a lack of rules or their support of capital interests – aligns with the requirements of capital reproduction. Actions taken by governments, NGOs, and private businesses in the SGCh are often described as efforts to make production more environmentally friendly. However, these measures do not challenge the deeper expansion of the commodity frontier. These actors employ strategies aimed at counteracting the negative perception associating transgenic soybeans with deforestation, highlighting "model cases" of sustainable practices while downplaying adverse effects on local territories. These impacts include the concentration of common resources, health concerns for local populations, displacement of peasant communities to areas less suitable for agriculture, relocation of urban neighborhoods to regions vulnerable to hydroclimatic risks or lacking adequate access, watercourse contamination, and loss of biodiversity, among others. Similarly, by concentrating only on good agricultural practices as a response to environmental concerns, they overlook other important issues raised by critics of the MA. These include the social function of land, the need for food sovereignty, the management of communal resources like water and forests through collaboration with peasant and Indigenous organizations, and the creation of socially relevant knowledge, among others.

There remain significant gaps in understanding the capabilities of stakeholders who are aware of the impacts resulting from the expansion of the commodity frontier, particularly regarding their ability to implement measures that might effectively counteract prevailing agribusiness practices. Given the tri-national context of this region, developing regulatory frameworks that foster an environmentally sustainable and socially equitable relationship between society and nature poses a considerable challenge. As referenced in the epigraph at the outset of this chapter, it is insufficient to merely restrict or regulate agribusiness activities; rather, addressing the serious socio-environmental crisis requires transformative changes to the underlying social relations that perpetuate the current logic of accumulation. The social field encompassing peasant, family, and Indigenous agricultural organizations is permeated by discussions that address this concern. Several proposals arising from these debates suggest that countering agribusiness can be achieved through the development of agroecological systems, which stress the importance of establishing a sustainable relationship between society and nature. Further research could focus on this alternative approach to evaluate the potential impact of these transformative strategies within the context of climate change.

Further analysis of the AM, particularly in connection with today's agri-food system, remains essential. As previously discussed, the high deforestation rates seen in SGCh cannot be understood without considering the expansion of the commodity frontier driven by the MA; this process is deeply linked to a global economy with consistently rising demand for animal proteins, especially in regions like the EU and China (Otero 2014). Investigating how food policies in major countries influence agribusiness trends in commodity-producing nations could provide valuable insights into which aspects of current global relationships require change (Gras and Hernández 2021).

Recent research indicates that certain climate change adaptation policies have led to greater involvement of financial actors in the agri-food sector (Clapp and Isakson 2023) and an uptick in land grabbing (Borras et al. 2020), resulting in negative consequences for both the environment and social equality. These trends also apply to the MA's expansion in SGCh. This chapter has highlighted how sustainable development and climate change adaptation programs – funded by multilateral agencies, foundations, and financial groups – often operate alongside civil society organizations. However, these programs are frequently uncoordinated and may not align with national regulations or global sustainability goals (Ramos Berrondo et al. 2020). This misalignment is evident in many initiatives focused on sustainable forest management or agroecological systems aimed at adapting production and livestock practices to climate change (Fossa Riglos et al. 2024). Moore (2015) introduces the concept of the "Capitalocene" as an alternative to the Anthropocene, highlighting that the logic of capitalist accumulation is characterized by an epochal transformation in the scale, speed, and extent of landscape modification to secure "Cheap Nature" and "cheap labor." Considering these dynamics, efforts to counteract these trends must critically examine the market mechanisms that subsume common resources and labor – encompassing bodies, senses, and practices – of marginalized populations, thereby sustaining the global capitalist system. Regional legislation and targeted agreements, such as those pertaining to forests, foreign land ownership, or the establishment of protected areas, alongside measures for climate change mitigation, sustainable development programs, and biodiversity protection, reflect the global agenda within these regions. However, these responses are frequently hampered by their fragmented approaches and, at times, contradictory effects, exemplified by initiatives like the transgenic soybean cultivation program undertaken by NGOs and financial entities in collaboration with local entrepreneurs in the Argentine and Paraguayan Chaco.

As highlighted in critical literature addressing climate change and the socio-environmental crisis (Martínez Alier 2004; Malm and Hornborg 2014; Ulloa 2017; Clapp et al. 2018; Briones et al. 2019; Jappe 2021; Borras et al. 2021), this issue exemplifies contemporary societal challenges by presenting a dual dilemma: production systems are required to internalize the costs associated with waste, including greenhouse gas emissions, and, additionally, such internalization must not be counterbalanced by adopting new strategies for exploiting "Cheap Nature" that are themselves environmentally detrimental (Moore 2015: 268). In response, some analyses foresee the potential for civilizational decline, whereas others advocate for transition policies situated within the current capitalist paradigm, emphasizing ecological reform. Despite their differences, the discussed positions agree that the prevailing society-nature relationship fostered by capitalism requires transformation. This distinguishes them from groups that deny climate change and attribute it to an ideology purportedly constructed by a "global communist order" (Miguel 2022). Within those advocating change, debate centers on the role of science and technology: is technological innovation sufficient to sustain humanity, or does the current situation necessitate a profound civilizational shift? The case of SGCh illustrates how relationships between society and nature, driven by the logic of accumulation, perpetuate unsustainable cycles that disregard planetary boundaries. While scientific evidence continues to accumulate, it appears insufficient to bring about the transformative and emancipatory changes needed to address the complex, multidimensional crises we face today and to dismantle entrenched coalitions of denial. Thus, questions persist regarding the appropriate pathways for change and the political actors who will lead these efforts.

References

Achucarro, Guillermo. 2020. *Política climática en Paraguay. Una lectura anti-extractivista*. Asunción: Base Investigación Sociales.

Acosta, Alberto. 2009. *La maldición de la abundancia*. Quito: Ediciones Abya-Yala.

Alvarez, Ricardo et al. 2022. "¿Es sustentable la salmonicultura en Chile? Enmarcando narrativas en disputa sobre la actividad salmonera en la Patagonia." *Desenvolvimento e Meio Ambiente* 59: 23–45.

Arias, Paola, Nicolas Bellouin, Erika Coppola, et al. 2021. "Technical Summary." In *Climate Change 2021: The Physical Science Basis*, Intergovernmental Panel on Climate Change [IPCC], 33–144. Geneva: IPCC.

Ávila, Claudia, and Lis García. 2019. *Atlas del agronegocio en Paraguay*. Asunción: Base Investigación Sociales.

Ayuso, Silvia. 2022. "Europa aprueba una ley pionera en la lucha contra la deforestación mundial." *El País*, December 6. https://elpais.com/clima-y-medio-ambiente/2022-12-06/europa-aprueba-una-ley-pionera-en-la-lucha-contra-la-deforestacion-mundial.html%20https:/ec.europa.eu/commission/presscorner/detail/es/qanda_21_5919.

Baumann, Matthias, María Piquer-Rodríguez, Verena Fehlenberg, et al. 2016. "Land-Use Competition in the South American Chaco." In *Land Use Competition. Human-Environment Interactions*, ed. Jörg Niewöhner, Antje Bruns, Patrick Hostert, et al., 115–229. Cham: Springer.

Baumann, Matthias, Ignacio Gasparri, María Piquer-Rodríguez, et al. 2017. "Carbon emissions from agricultural expansion and intensification in the Gran Chaco." *Global Change Biology* 23: 1902–1916.

Borras Jr., Saturnino, Ian Scoones, Amita Baviskar, et al. 2021. "Climate change and agrarian struggles: an invitation to contribute to a *JPS* Forum." *The Journal of Peasant Studies* 49, no. 1: 1–28.

Borras Jr., Saturnino, Jennifer C. Franco, Sergio Gómez, et al. 2012. "Land grabbing in Latin America and the Caribbean." *The Journal of Peasant Studies* 39, no. 3–4: 845–872.

Borras Jr., Saturnino, Jennifer C. Franco, and Zau Nam. 2020. "Climate change and land: insights from Myanmar." *World Development* 129: 1–11.

Briones, Claudia, José Luis Lanata, and Adrían Monjeau. 2019. "El futuro del Antropoceno." *Utopía y Praxis Latinoamericana* 24, no. 84: 19–31.

Castellanos, Edwin, Maria Fernanda Lemos, Laura Astigarraga, et al. 2022. "Central and South America." In *Climate Change 2022: Impacts, Adaptation and Vulnerability*, Intergovernmental Panel on Climate Change [IPCC], 1689–1816. Geneva: IPCC.

Castro Arze, Miguel, Liliana Paniagua, Verena Friesen, et al. 2021. *Análisis y recomendaciones para un abordaje transfronterizo y trinacional del gran chaco americano*. Buenos Aires: Naciones Unidas Argentina.

Ceddia, Graziano, Rodrigo Montani, and Walter Mioni. 2022. "The dialectics of capital: learning from Gran Chaco." *Sustainability Science* 17: 2347–2362.

CEPAL. 2014. *La economía del cambio climático en el Paraguay* (LC/W.617). Santiago de Chile: CEPAL.

Clapp, Jennifer, and S. Ryan Isakson. 2023. "Private finance for food system climate adaptation: opportunity or contradiction?." *Current Opinion in Environmental Sustainability* 61: 1–7.

Clapp, Jessica, Peter Newell, and Zoe W. Brent. 2018. "The Global Political Economy of Climate Change, Agriculture and Food Systems." *Journal of Peasant Studies* 45, no. 1: 80–88.

Climate Watch. n. d. "Climate Watch Data." https://www.climatewatchdata.org/.

Colque, Gonzalo. 2014. *Expansión de la frontera agrícola: luchas por el control y apropiación de la tierra en el oriente boliviano*. La Paz: TIERRA.

Díaz, Yesica R., Esteban G. Jobbágy, and Victoria A. Marchesini. 2022. "Neo-humedales en las llanuras agrícolas del Chaco Seco-Espinal argentino: ¿Cómo son, dónde se originan y qué hacer con ellos?." *Ecología Austral* 32, no. 3: 821–834.

Fal, Juan, and Cecilia Allami. 2017. "Agroindustrias, biotecnología y desarrollo: reflexiones acerca del discurso y praxis del Banco Mundial en Argentina (1997–2010)." *Ensayos de Economía* 27, no. 50: 127–149.

Fehlenberg, Verena, Matthias Baumann, Nestor Ignacio Gasparri, et al. 2017. "The role of soybean production as an underlying driver of deforestation in the South American Chaco." *Global Environmental Change* 45: 24–34.

Ferraina, Antonella, Germán Baldi, Diego de Abelleyra, et al. 2022. "An insight into the patterns and controls of the structure of South American Chaco woodlands." *Land Degradation and Development* 33, no. 5: 723–738.

Fossa Riglos, Florencia M. 2017. "Certificaciones sustentables en el agronegocio." Paper presented at *Seminario CESIA*, Universidad Nacional de San Martin, Buenos Aires, September 23.

Fossa, Riglos, Florencia M., Paula Carolina Serpe, Spinoso Nahuel, et al. 2024. "Sustainability as a social encounter – Dialogues, practices and heterogenous knowledge around the native forest in the Gran Chaco wetlands." In *Environmental and Ecological Sustainability through Indigenous Traditions*, ed. Binay Pattnaik, 313–334. Cham: Springer.

Gasparri, Nestor Ignacio, Héctor Ricardo Grau, and Jorgelina Gutierrez Angonese. 2013. "Linkages between soybean and neotropical deforestation: Coupling and transient decoupling dynamics in a multidecadal analysis." *Global Environmental Change* 23: 1605–1614.

Gasparri, Nestor Ignacio, and Héctor Ricardo Grau. 2009. "Deforestation and fragmentation of Chaco dry forest in NW Argentina (1972–2007)." *Forest Ecology and Management* 258, no. 6: 913–921.

Gogna, Federico. 2018. "Institucionalización regional del Gran Chaco Sudamericano en el siglo XXI." *Revista del Cisen Tramas/Maepova* 6, no. 2: 93–105.

Gómez, Carlos A., and Sebastián Kees. 2009. "Comportamiento de heliófitas y sombrívoras en el desarrollo sucesional del bosque del chaco húmedo." In *El Chaco sin bosques: la Pampa o el desierto del futuro*, ed. Jorge H. Morello and Andrea F. Rodríguez, 93–110. Buenos Aires: Orientación Gráfica Editora.

Gómez Lende, Sebastián. 2018. "Destrucción de bosques nativos y deforestación ilegal: el caso argentino (1998–2016)." *Papeles de Geografía* 64: 154–180.

Gras, Carla, and Daniel Cáceres. 2017. "El acaparamiento de tierras como proceso dinámico. Las estrategias de los actores en contextos de estancamiento económico." *Población y Sociedad* 24, no. 2: 163–194.

Gras, Carla, and Valeria Hernández, ed. 2009. *La Argentina Rural. De la agricultura familiar a los agronegocios*. Buenos Aires: Biblos.

———. 2013. *El agro como negocio: Producción, Sociedad y Territorios en la Globalización*. Buenos Aires: Biblos.

———. 2014. "Agribusiness and large-scale farming: capitalist globalization in argentine agriculture." *Canadian Journal of Development Studies* 35, no. 3: 339–357.

———. 2016. *Radiografía del nuevo campo argentino. Del terrateniente al empresario transnacional*. Buenos Aires: Siglo XXI.

———. 2021. "Global agri-food chains in times of COVID-19: The state, agribusiness, and agroecology in Argentina." *Journal of Agrarian Change* 21, no. 3: 629–637.

Gras, Carla, and Facundo Zorzoli. 2019. "Ciclos de acaparamiento de tierra y procesos de diferenciación agraria en el noroeste de Argentina." *Trabajo y Sociedad* 33: 1–23.

Gudynas, Eduardo. 2009. "Diez tesis urgentes sobre el nuevo extractivismo." In *Extractivismo, Política y Sociedad*, ed. Jürgen Schuldt, Alberto Acosta, Alberto Barandiarán, et al., 187–225. Quito: CAAP/CLAES.

Henderson, James, Javier Godar, Gabriel Ponzoni Frey, et al. 2021. "The Paraguayan Chaco at a crossroads: drivers of an emerging soybean frontier." *Regional Environmental Change* 21: 1–14.

Hernández, Valeria. 2007. "El fenómeno económico y cultural del boom de la soja y el empresariado innovador." *Desarrollo Económico. Revista de Ciencias Sociales* 47, no. 187: 331–365.

———. 2009. "La ruralidad globalizada y el paradigma de los agronegocios en las pampas gringas." In *El agro como negocio: Producción, Sociedad y Territorios en la Globalización*, ed. Carla Gras and Valeria Hernández, 39–64. Buenos Aires: Biblos.

———. 2013. "Genealogía de una elite rural: elucidación antropológica de una práctica de poder." *Mundo Agrario* 13, no. 26: 1–39.

Irala, Abel. 2017. "Agronegocios e infraestructura Inversiones, rutas, deudas y granos." Special report N°13, Base Investigación Sociales, Asunción: Base Investigación Sociales.

Jappe, Anselm. 2021. *Sous le soleil noir du capital*. Albi: Editions Crise & Critique.

Le Polain de Waroux, Yann, Rachael D. Garrett, Robert Heilmayr, et al. 2016. "Land-use policies and corporate investments in agriculture in the Gran Chaco and Chiquitano." *Proceedings of the National Academy of Sciences* 113, no. 15: 4021–4026.

Le Polain de Waroux, Yann, Matthias Baumann, Nestor Ignacio Gasparri, et al. 2018. "Rents, Actors, and the Expansion of Commodity Frontiers in the Gran Chaco." *Annals of the American Association of Geographers* 108, no. 1: 204–225.

Malm, Andreas, and Alf Hornborg. 2014. "The Geology of Mankind? A Critique of the Anthropocene Narrative." *The Anthropocene Review* 1, no. 1: 62–69.

Martínez Alier, Joan. 2004. *El ecologismo de los pobres. Conflictos ambientales y lenguajes de valoración*. Barcelona: Icaria Editorial.

Masters, Michael W. 2008. "Testimony before the CHSGA." *US Senate*. http://hsgac.senate.gov/public/_files/052008Masters.pdf.

McKay, Ben M. 2017. "Agrarian Extractivism in Bolivia." *World Development* 97: 199–211.

———. 2018. *Extractivismo agrario: dinámicas de poder, acumulación y exclusión en Bolivia*. La Paz: TIERRA.

Mereles, María Fátima, and Óscar Rodas. 2009. "El proceso de fragmentación y reducción de hábitat en el Chaco paraguayo y sus efectos sobre la biodiversidad." In *El Chaco sin bosques: la Pampa o el desierto del futuro*, ed. Jorge H. Morello and Andrea F. Rodríguez, 271–290. Buenos Aires: Orientación Gráfica Editora.

Metz, Rosmarie, and Georg Wessling, eds. 2006. *Atlas del Gran Chaco Sudamericano*. Buenos Aires: Sociedad Alemana de Cooperación Técnica.

Miguel, Jean Carlo. 2022. "A 'meada' do negacionismo climático e o impedimento da governamentalização ambiental no Brasil." *Revista Sociedade e Estado* 37, no. 1: 293–315.

Mindlin, Julia, Carolina S. Vera, Theodore G. Shepherd, et al. 2023. "Plausible Drying and Wetting Scenarios for Summer in Southeastern South America." *Journal of Climate* 36, no. 22: 7973–7991.

Mitchell, Ewan, Peter Elwin, and Mario Rautner. 2022. "Gran Chaco: the Deforestation Dozen, Planet Tracker." *Planet Tracker*. https://planet-tracker.org/wp-content/uploads/2022/03/Gran-Chaco-LD-report.pdf.

Moore, Jason W. 2015. *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. London: Verso.

Morello, Jorge, Walter Pengue, and Andrea Rodriguez. 2013. “Un siglo de cambios de diseño del paisaje: El Chaco Argentino.” *Medio Ambiente y Urbanización* 79, no. 1: 25–64.

Murmis, Miguel, and Maria R. Murmis. 2012. “Land Concentration and Foreign Land Ownership in Argentina in the Context of Global Land Grabbing.” *Canadian Journal of Development Studies* 33, no. 4: 409–508.

OCDE-FAO. 2013. *Perspectivas agrícolas 2013–2022*. Texcoco: Universidad Autónoma Chapingo.

Oren, David, and Shirley Zavala. 2016. *Evaluación ecorregional del Gran Chaco Americano*. Buenos Aires: Fundación Vida Silvestre.

Ortega, Guillermo. 2013. *Extractivismo en el Chaco paraguayo. Un estudio exploratorio*. Asunción: Base Investigación Sociales.

Otero, Gerardo. 2014. “El régimen alimentario neoliberal, agricultura moderna y biotecnología.” In *La dieta neoliberal: Globalización y biotecnología en las Américas*, ed. Gerardo Otero, 17–40. Mexico City: Miguel Ángel Porrúa Editor.

Paolasso Pablo, Julieta Krapovickas, and Nestor Ignacio Gasparri. 2012. “Deforestación, expansión agropecuaria y dinámicas demográficas en el Chaco seco argentina durante la década de los noventa.” *Latin American Research Review* 47, no. 1: 35–63.

Pengue, Walter. 2009. “El desarrollo rural sostenible y los procesos de agriculturiación, anaderización y pampeanización en la llanura chaco-pampeana.” In *El Chaco sin bosques: la Pampa o el desierto del futuro*, ed. Jorge H. Morello and Andrea F. Rodríguez, 111–174. Buenos Aires: Orientación Gráfica Editora.

Pertile, Viviana C., and Alejandra H. Torre Geralgia. 2009. “Cambios productivos en el sector agrícola de la provincia del Chaco.” In *El Chaco sin bosques: la Pampa o el desierto del futuro*, ed. Jorge H. Morello and Andrea F. Rodríguez, 175–196. Buenos Aires: Orientación Gráfica Editora.

Phélinas, Pascale, and Valeria Hernández. 2024. “Desafíos socio-ambientales: el caso de la soja transgénica en Argentina.” In *Agriculturas plurales en territorios singulares*, ed. Christophe Albaladejo, Gastón Godoy, María Amalia Lorda, et al. Buenos Aires: EDULP.

Piquer-Rodríguez, Maria, Van Butsicb, Philipp Gärtnerc, et al. 2018. “Drivers of agricultural land-use change in the Argentine Pampas and Chaco regions.” *Applied Geography* 91: 111–122.

PNUMA. 2013. “Estudio de Vulnerabilidad e Impacto del Cambio Climático en el Gran Chaco Americano.” PNUMA.

Prager, Steven, Ana Rios, Benjamin Schiek, et al. 2020. *Climate change vulnerability and economic impacts in the agricultural sector in Latin America and the Caribbean*. Cali: Interamerican Development Bank.

Proyungas. 2022. “Más de 50.000 ha del Gran Chaco serán protagonistas de las buenas prácticas agrícolas y la conservación de bosques.” June 8. https://proyun gas.org.ar/mas-de-50-000-ha-del-gran-chaco-seran-protagonistas-de-las-buenas-practicas-agricolas-y-la-conservacion-de-bosques/.

Ramos Berrondo, Jimena, Matías Berger, and Ariel García. 2020. "Instrumentalización de proyectos de desarrollo rural: Experiencias en el nordeste argentino a principios del siglo XXI." *Revista Estado y Políticas Públicas* 8, no. 14: 253–276.

Reboratti, Carlos. 2008. "La expansión de la soja en el norte de la argentina: impactos ambientales y sociales." *CONICET*. https://observatoriogeograficoamericalatina.org.mx/egal12/Procesosambientales/Impactoambiental/16.pdf.

Redes Chaco. 2020. "Cooperación en el Gran Chaco Americano Mapa de Contrapartes." https://visorgranchaco.org/wp-content/uploads/2020/06/MapaContrapartesGranChaco.pdf.

———. n.d. "Mapa-Verde_Redes-Chaco." https://redeschaco.org/en/territory/.

Selwyn, Benjamin. 2021. "A green new deal for agriculture: for, within, or against capitalism?." *The Journal of Peasant Studies* 48, no. 4: 778–806.

Semper-Pascual, Asunción, Cole Burton, Matthias Baumann, et al. 2021. "How do habitat amount and habitat fragmentation drive time-delayed responses of biodiversity to land-use change?." *Proceedings of the Royal Society B: Biological Sciences* 288: 1–10.

Seneviratne, Sonia I., Xuebin Zhang, Muhammad Adnan, et al. 2021. "Weather and Climate Extreme Events in a Changing Climate." In *Climate Change 2021: The Physical Science Basis,* Intergovernmental Panel on Climate Change [IPCC], 1513–1766. Geneva: IPCC.

Steffen, Will, Wendy Broadgate, Lisa Deutsch, et al. 2015. "The trajectory of the Anthropocene: The Great Acceleration." *The Anthropocene Review* 2, no. 1: 81–98.

Svampa, Maristella. 2007. "Consenso de los Commodities, Giro Ecoterritorial y Pensamiento crítico en América Latina." *OSAL* 13, no. 32: 15–38.

Taks, Javier. 2013. "Variabilidad climática y eventos extremos críticos para la producción del sector ganadero, agricultura de granos y horti-frutícola." In *Clima de cambios*. Vol. 1; *Nuevos desafíos de adaptación en Uruguay*, ed. Mario Bidegain, Carolina Crisci del Puerto, Inda Laura, et al., 33–39. Montevideo: FAO-MGAP.

Taks, Javier. 2019. "Transformaciones de la narrativa del cambio climático global en Uruguay." *Sociologias* 21, no. 51: 102–123.

The Nature Conservancy [TNC]. 2005. *Evaluación Ecorregional del Gran Chaco Americano*. Buenos Aires. Fundación Vida Silvestre Argentina.

Toftum, Nicole, and Juan Fal. 2019. "El Banco Mundial en la Argentina: Consolidación de la plataforma agroexportadora." *De Raíz Diversa* 6, no. 11: 151–166.

Tomasini, Alfredo, and José Braunstein. 2006. "Geografía y Sociedades Tradicionales Del Gran Chaco." *Folia Histórica del Nordeste* 16: 173–185.

Ulloa, Astrid. 2017. "Dinámicas ambientales y extractivas en el siglo XXI: ¿es la época del Antropoceno o del Capitaloceno en Latinoamérica?." *Desacatos* 54: 58–73.

Urioste, Miguel. 2012. *Concentración y extranjerización de la tierra en Bolivia*. La Paz: TIERRA.

USAID. 2019. *Evaluación de medio término del desempeño del proyecto Alianza para el Desarrollo Sostenible*. Asunción: USAID-Paraguay.

Van Garderen, Linda, and Julia Mindlin. 2022. "A storyline attribution of the 2011/2012 drought in Southeastern South America." *Weather* 77, no. 6: 212–218.

Venencia, Cristian Darío, José Luis Agüero, Griselda Salas Barboza, et al. 2022. "Competencia y potenciales conflictos por el uso del suelo vinculados a las grandes transacciones de tierras en el Chaco salteño." In *Impactos del Acaparamiento de Tierras en América Latina y el Caribe*, ed. Martín Pablo Simón, 68–79. Buenos Aires: Fundapaz.

Zak, Marcelo R., Marcelo Cabido, Daniel Cáceres, et al. 2008. "What drives accelerated land cover change in central Argentina? Synergistic consequences of climatic, socioeconomic, and technological factors." *Environmental Management* 42: 181–189.

Zarrilli, Adrián. 2008. "Bosques y agricultura: una mirada a los límites históricos de sustentabilidad de los bosques argentinos en un contexto de la explotación capitalista en el siglo XX." *Revista Luna Azúl* 26: 87–106.

Climate Change in the Andes from 1950 to the Present

Ecosystem Transformations and their Repercussions

Katherinne Mora Pacheco and Fernando Bravo Alarcón

Paul Crutzen and Eugene Stoermer's coining of the *Anthropocene* in the year 2000 gave life to an evocative debate that has brought about not only a revision of the concept's theoretical relevance and explanatory capacity but also a series of alternative proposals (Capitalocene, Eurocene, Chthulucene, Soyacene, etc.) (Haraway 2015; Svampa 2019b: 38; Ulloa 2017: 67) that intend to explain the impact of anthropocentric activities on climate, ecosystems, habitats, biological corridors, and human settlements in more detail. In the case of the Andean region, this has become more urgent by virtue of its peculiar climatic, hydrological, orographic, and biological conditions that make it a space especially sensitive to the impacts derived from anthropogenic transformations.

As Trischler highlights (2017: 45), even before the Anthropocene discourse began, Christian Pfister, an economic and environmental historian, had already classified the 1950s as a major turning point, calling it the "1950s syndrome." If North America and Europe were reaching their high standards of development in those years, the Andean countries, as will be seen, in parallel though unequally among themselves, would have been experiencing only hesitant policies of industrialization, population growth, overflowing urbanization, internal migrations, increased energy consumption, and loss of biodiversity (García Acosta 2017: 9), among other forms of social change that some theorists would later seek to fit in with the processes of transition from traditional to modern societies (Germani 1971).

Although the Andean region has experienced uneven industrialization compared to other regions, including Latin America as a whole, it has nonetheless made significant contributions to the development of the Anthropocene from a climatic perspective, as the focus of the current volume suggests. While it might be thought that climate change is only the responsibility of highly industrialized countries due to their consumption of fossil fuels and the consequent greenhouse gas (GHG) emissions, there are other ways to contribute to global environmental change. By way of example, in the second half of the twentieth century and so far in the twenty-first century, actions such as targeted colonization to allow for agricultural land in forest areas – especially to occupy a place in the global market for raw materials and tropical food or to expand crop for narcotics production – have resulted in deforestation, that is, in a lower capacity for carbon capture. The construction of hydraulic infrastructure, mainly reservoirs for energy production, has modified river basins and microclimates, resulting in impacts in the face of climatic extremes.

In this chapter, some of these aspects will be discussed. From the spatial point of view, as in the previous chapters on the region, the focus will be on the countries that run through the Andes Mountains and that, due to their proximity to the equator, are considered tropical. When defining the time period, the Great Acceleration – a reference point marking a shift in the Anthropocene – will be included; however, the unique characteristics and different dynamics of the region will also be taken into account. Thus, thinking in the long-term, this chapter dialogues with processes that began in the nineteenth century with the expansion of the agricultural frontier and the domestication of water and accounts for the temporal differences in state efforts towards industrialization – much earlier for Colombia in the 1930s and later in Ecuador and Bolivia in the 1960s – or the unequal opportunities for fossil fuel extraction and export.

The first section will reflect on the contributions of the tropical Andes to current anthropogenic climate change from GHG emissions, which have only begun to be reported regularly since the Paris Agreement in 2015. Although in global terms the contribution might seem insignificant, attention must be drawn to these activities that generate the highest emissions and the way in which, beyond percentages, they converge to shape the Anthropocene, exacerbating or altering the occurrence of climate variability phenomena and increasing vulnerability to hydrometeorological phenomena. In this sense, the second part of the chapter is retrospective and analyzes transformations that, regardless of whether the emissions occur in the Andes or to what extent, since the mid-twentieth century, have contributed to the social construction of vulnerability and the generation of disasters in the period under consideration. Here, the aim of this chapter is not to make a social history of disasters or to delve into the consequences for female, Afro-descendant, and Indigenous populations, but to instead delve into the decisions that are made from above and the political-administrative centers, where the ecosystem and social contexts are unknown and whose decisions, in the end, have deepened the vulnerability of those who really inhabit the territories.

Contributions of the Andean Region to Anthropogenic Climate Change

The Anthropocene in the Andean region cannot be understood without acknowledging a turning point in its industrialization processes. After an era of insertion into the world market through agriculture, forestry, and mining exports, spanning from the mid-nineteenth century to the Great Depression, the Andean countries began to think about the logic of industrialization. In the region, a policy of import substitution was promoted to achieve a desired industrialization. Faced with the lack of markets for its primary products due to the global economic crisis and, later, the war, this route was taken by Colombia in the 1930s, at which time subsidies were mainly oriented to the non-traditional manufacturing and agricultural sectors. During the 1960s and 1970s, Colombia experienced industrial growth through a second phase of import substitution, which focused on the production of durable consumer goods, intermediate goods, and capital goods. This second cycle, driven by the preponderance of developmentalist discourses and ECLAC's proposals, among other factors, later included Venezuela and Peru at the end of the 1950s and Ecuador and Bolivia in the 1960s. However, this development did not mean the abandonment of the primary sector and the extractive economy. On the contrary, Colombia continued to depend on the export of coffee, flowers, and bananas, Ecuador on bananas, and Peru on fishing and mining products. Venezuela turned to oil extraction, especially after the 1973 supply crisis of OPEC countries, while Bolivia maintained mining, especially tin, while the industries of substitution at the time were focused on creating as much added value as possible (Ground 1988; Puma 2015; Creamer 2021).

This background allows us to understand why the contribution of Latin America, and the Andes in particular, in GHG emissions is insignificant (Galindo et al. 2015: 17; Grupo Banco Mundial 2022: 3). In this regard, it is worth noting that while this chapter covers a more extensive period, the tracking of GHG emissions is limited to the last two decades. This is due to the fact that the Intergovernmental Panel on Climate Change (IPCC) guidelines for national greenhouse gas inventories date back to 2006; furthermore, it was only following the 2015 Paris Agreement that signatory countries committed to the formal measurement and reduction of their emissions.

In the Andean countries, the productive apparatus, especially in the secondary sector of the economy, has never been large enough to become a prolific emitter of GHGs. Table 1 illustrates the minimal contribution of these countries to the global CO_2 emissions, accounting for merely 2.86 percent of the total emissions from all Andean countries, and only 1.93 percent when considering solely the tropical Andes, which is the primary focus of this chapter (GHG emissions in Latin American countries are estimated at 8 to 10 percent of the global total).

Table 1: CO_2 emissions of Andean countries, percentage of the global total (2021)

Country	**Percentage**
Argentina	0.83
Bolivia	0.28
Chile	0.10
Colombia	0.57
Ecuador	0.20
Peru	0.38
Venezuela	0.50
Total	2.86

Source: ClimateWatchData (n.d. a)

Table 2: Distribution of GHG Emissions in Latin America and the Caribbean (2018)

Activity	**Percentage**
Agriculture	26
Land-use Changes and Forestry	21
Electricity and Heating	13
Transport	15
Manufacturing and Construction	6
Combustion of Other Fuels	3
Industrial Processes	4
Waste	6
Fugitive Emissions	3
Buildings	3

Source: Data taken from World Bank Group (Grupo Banco Mundial 2022: 3).

Now, do low GHG emissions mean that the region is not a contributor to global environmental change and exempt it from its contribution to the Anthropocene? On the contrary, as several studies have shown in pre-industrial societies dependent on agricultural activities, they required arable land and thus resorted to slashing and/or burning to do so. With this, carbon emissions increased while the decline of forests also meant a drop in the capacity to capture it (Ruddiman 2003; Ruddiman 2005). Similarly, at present, although industry is not the main economic engine in Latin

America, the still important primary sector is an emitter of GHGs, as can be seen in Table 2.

According ClimateWatchData (n.d. b) for 2021, the main producer of emissions in Colombia was energy at 34.86 percent, followed by land use change and forestry at 29.38 percent, and agriculture at 24.46 percent. In the case of Peru, land use change and forestry are its main sources of emissions at 48.35 percent, followed by energy at 27.11 percent. As for Bolivia, almost 57 percent of emissions were caused by land-use change and forestry, i.e., deforestation, followed by 22 percent for agriculture and 17.5 percent for energy. Ecuador, on the other hand, has a somewhat different pattern; the main emitting sector is energy at 44.52 percent, followed by land use change and forestry at 26.56 percent, and agriculture at 12.91 percent. The case of Venezuela is atypical in the region due to its dependence on oil extraction for more than half a century. According to ClimateWatchData (n.d. a), by 2021, 44.5 percent was coming from energy. Other sources indicate that for 2022, 64.24 percent of its total emissions came from the energy sector, which includes oil extraction, flaring, and gas venting, although the national inventory has not been updated since 2020 and there is a lack of access to reliable information. It has also been seen that, since 2019, emissions from this sector may have fallen due to its inability to produce electricity and ration it at the national level, rather than from any environmental policy. The second sector in emissions is agriculture with 13 percent, mainly due to methane emissions from livestock that is concentrated in the Orinoco plains (Academia de Ciencias Físicas, Matemáticas y Naturales 2022; Vásquez Heredia 2024).

In general, it can be said, then, that the predominant GHG-emitting activities in the Andean region are concentrated in land use change and forestry, and agricultural activities. Deforestation, which in turn is responsible for lower global GHG sequestration, is driven by a lack of agrarian reforms that have prevented the closure of the agricultural frontier, illegal mining and logging, drug trafficking, the expansion of monocultures, cattle ranching, and agribusiness, among other factors. This panorama can be examined through a line of critical interpretation that observes that the relationship of Latin American societies with their ecosystems has materialized with the extraction of resources and their irrational use. The literature that has critically studied these processes (Alayza and Gudynas 2012; Gudynas 2009; Gudynas 2010; Gudynas 2018; Svampa 2018; Svampa 2019a; Svampa 2019b) has coined a concept whose trajectory and dissemination have had some political and academic success: extractivism. Gudynas defines it as "a type of appropriation of natural resources in large volumes and/or high intensity, where half or more are exported as raw materials, without industrial or limited processing" (2018: 62). In addition to the damage to ecosystems and the processes associated with climate change, extractivism is described as leading to the "environmental and territorial grabbing and dispossession that they cause, as well as their cultural and social implications, and the increase of socio-environmental inequalities" (Ulloa 2017: 59).

For climatic and geographical reasons, the Andean countries do not have the capacity to replicate the experience of their neighbors and large soybean producers: Brazil, Paraguay and Uruguay. However, in those countries there are already systems of agricultural exploitation where monocultures, industrialized agriculture, and agribusiness have been gaining importance in the heat of a commodities consensus, which has contributed to the fact that, precisely, land-use change and forestry are the activities that emit the most GHGs in these same countries. As Gudynas (2009) points out, since 2000, when neoliberal policies promoting the territorialization of extractive economies in a differentiated way were consolidated, Andean countries have promoted a series of extractivist projects in mining and gas and, to a lesser extent, agribusiness and monocultures (Devia and Piñeros 2021: 41). Thus, the image of the Andes as a region that supplies raw materials on a global scale continues today as powerful as it has been since the times of gold, silver, guano, saltpeter, sugar cane, or bananas.

In Bolivia, this extractivist approach is evident as it aims to increase state revenue collection and implement redistributive policies. However, there is significant tolerance for environmental impacts, occasionally disregarding the pro-environmental narratives previously promoted. Alongside its narratives and rhetoric in favor of the rights of nature (see Ministry of Environment and Water 2021: 3, where the current climate crisis is attributed to the anthropocentric model and the global capitalist system) and "*Buen Vivir*" (see Larrea 2017), its concrete actions have been to practically replicate the old extractivist approach, that is, it spreads a supposedly "anti-imperialist," nationalist rhetoric with certain tones of environmentalism and socio-environmental justice – defined as a form of environmentalism rooted in "a notion of inequity in the relationship between society and the environment, and a critique of the economic model that discriminates against or penalizes certain social groups" (Bebbington 2009: 121) – but acts based on a need to maximize income and ensure "development." As Morfa-Fernández (2020: 194) argues, the Bolivian State – under the MAS governments (MAS stands for *Movimiento al Socialismo*, Movement for Socialism) – authorized the increase in areas concessioned to hydrocarbon exploration; then it bet on iron mining and the industrialization of lithium; but it also favored the construction of hydroelectric plants and the expansion of the agricultural frontier with coca leaf and soybean crops. According to McKay and Colque (2002), agribusiness and monocultures have also experienced a great boost coinciding with the arrival of the MAS to the government, with its leader and founder Evo Morales in 2006. Under his administration, far from his commitments to nationalism and promises of redistributive agrarian reform, agribusiness and the food industry have expanded their activities. These same authors ratify that the MAS administration accentuated the presence of this agrarian extractivism in that country by "(i) significant volumes of extracted materials, mainly for export, with little or no processing; (ii) concentration of the value chain and sectoral disarticulation; (iii) high intensity of environmental degradation; and (iv) deterioration of job opportunities and working conditions in areas of exploitation" (McKay and Colque 2022: 96).

In Bolivia, soybeans represent the agribusiness model, whereas in Ecuador, this model is represented by ethanol, a compound produced from the fermentation of sugars derived from sugarcane monocultures. Like in Bolivia, its promotion was prevalent during the center-left governments of the Alianza PAIS movement (2006–2021), reflecting a historical pattern of agrarian extractivism (Landivar 2022). Ecuador presents another case of an Andean country fully involved with agrarian extractivism, but where sugarcane production, together with oil palm and bananas, occupy the largest area of land in the country (Landivar 2022). Since Rafael Correa's government (2007–2017), the country has tried to reconcile aspects of environmentalism with its use of oil: the reason why the country has the highest emissions related to the energy in the region, at 51 percent of its total, after Venezuela. In the words of Bravo (2015: 90), "in Ecuador, in addition to trying to legitimize neo-extractivism through the implementation of social plans, it is politically legitimized by the policy of changing the productive matrix so as not to have limitations toward achieving Buen Vivir."

As far as Peru is concerned, things have not been so different. With center-right presidents such as Alejandro Toledo (2001–2006), Alan García (2006–2011), Pedro Pablo Kuczynski (2016–2018), as well as with converted presidents such as Ollanta Humala (2011–2016) – who initially had a center-left agenda and attempted to reconcile a pro-extractivism position regarding forests and ecosystems, but failed (Lanegra 2015) – the neo-extractivist framework, stripped of its progressive elements, has remained stable over the recent decades, despite facing strong opposition from jurisdictions and populations located within the areas of influence of mining or oil deposits due to polluting impacts. Recently, agricultural enterprises have expanded, mainly in the Amazonian regions of the country, where oil palm and cocoa monoculture are practiced. A study covering the expansion of this activity between 2000 and 2016 published strong findings on the risks generated in terms of water consumption, loss of soil fertility, effects on the human and territorial rights of local populations, the permissiveness of Peruvian legislation, the weakness of environmental institutions and, above all, deforestation as a result of land-use change, with collateral costs such as the loss of carbon sequestration capacity. Between 2000 and 2016, the establishment of oil palm plantations resulted in the loss of approximately 2,859,535 metric tons of carbon in the four primary departments where oil palm cultivation occurs in Peru (Escobedo 2021: 91).

In Colombia, issues related to land access have arisen due to the armed conflict. This situation has been exploited by certain companies and individuals who acquired land at significantly reduced prices as a result of the forced displacement of small landowners. According to Moreno (2022), the context of forced displacement and armed conflict in various regions of the country created favorable conditions for the consolidation and expansion of monocultures such as oil palm. In the regions studied, including the departments of Bolívar, Norte de Santander, and the Bajo Atrato and Orinoquia regions, three elements have been identified that contribute to the expansion of oil palm cultivation: violence, which can lead to land dispossession and land grabbing; state policies focused on development, coupled with a lack of effective responses to this dispossession; and the advancement of agribusiness into peasant economies (Moreno 2022: 73). Although the country does not primarily focus on mining compared to other Andean nations, foreign direct investment in mining and hydrocarbon megaprojects increased from 21 to 85 percent in the first decade of the twenty-first century. Additionally, between 2010 and 2014, foreign investment in agribusiness, agriculture, forestry, and fishery projects grew by 241 percent (Arias 2017: 32–33).

Due to its climatic, topographical, and hydrological conditions, electricity production in Colombia does not rely on fossil fuels, unlike several neighboring countries. Despite the prevalence of hydroelectric generation, emissions from the energy sector have not decreased. Although not exceeding 50 percent as seen in Ecuador and Venezuela, this sector has recently been responsible for the highest emissions in the country. Second, the extraction of hydrocarbons has also increased in recent decades. Last but not least, hydropower does not have net-zero emissions. In addition to the well-known effects that dam construction has on ecosystems (e.g., the radical alteration of watersheds, microclimates, or the habitats of hydrobiological species) or on human settlements (e.g., the flooding of arable land and residential areas that might encompass entire villages), the accumulation of organic matter in dammed water and subsequent eutrophication processes generate GHGs, especially methane; the effects of these in warmer regions near the equator are yet to be studied in detail (Demarty and Bastien 2011; Guerín and Abril 2008; Loaiza 2016; Palau and Prieto 2009). As will be seen in the next section, this type of hydraulic infrastructure has additionally been related directly to a capacity to respond to droughts and floods, not only in the course of the diverted rivers but also in their basins (Mora Pacheco 2023).

In summary, although on a broader scale no Andean country contributes more than 1 percent to global GHG emissions, this should not be presumed to be the result of a productive transformation towards clean energy, forest recovery, or the fight against desertification. Rather, it has been due to a lack of technical capacity and resources and a historical dependence on the primary sector and extractivist dynamics that continue to be privileged even into the twenty-first century. If the focus is shifted to indicators such as per capita emissions, measured in metric tons of CO_2 per person, the numbers become more alarming, as can be seen in Table 3, even when compared to countries that are industrialized or among the highest emitters of GHGs.

Table 3: Comparison of per Capita Emissions (Tons of CO2 per Person) in 2021

Country	Emissions
United States	15.96
Bolivia	11.26
China	8.71
Japan	8.42
Venezuela	8.36
Germany	8.29
Italy	5.71
Peru	5.45
Ecuador	5.34
Colombia	5.31
France	4.67
India	2.29

Source: Prepared by the authors based on ClimateWatchData (n.d. a). The Andean countries are highlighted.

Given this situation, which requires further research, the role of Latin America, particularly the Andean region, needs to be understood beyond merely being a victim of GHG emissions. The region must acknowledge its responsibility in addressing anthropogenic climate change and contributing to the construction of the Anthropocene. This is necessary not only due to the degradation of its forests and soils, which once acted as carbon sinks, but also because of its own emissions. Now, even without taking into account shared responsibilities in transforming the atmosphere, biosphere, and hydrosphere we share at a global level, the repercussions of this climate change as an expression of the Anthropocene are undeniable in the region over the last seventy years. How have they been expressed? And what conditions have contributed to the social construction of vulnerability?

The Vulnerability of Andean Societies to Climate Change

The tropical Andes offer a favorable context for the emergence of multiple natural phenomena. The region is part of the Ring of Fire and a point of contact between four tectonic plates (Nazca, South American, Cocos, and the Caribbean), characteristics that explain its intense seismic and volcanic activity. As these are areas close to or crossed by the equator, insolation is direct and permanent all year round and the dry and rainy seasons, which we know as intra-annual climate variability, depend on the oscillation of the Intertropical Convergence Zone (ITCZ). Its proximity to the Pacific Ocean means that the region is the first to experience the impact of the El Niño/Southern Oscillation (ENSO), which functions as an aperiodic driver of interannual climate variability. The differential volumes of rainfall throughout the year or from one year to the next, combined with mountainous characteristics, numerous and steep slopes, sedimentary sections, and soil types, create the possibility for mass wasting in drier conditions or alluvial rivers or avalanches in wetter conditions. Droughts often lead to wildfires or insect infestations, such as locusts, especially in the inter-Andean valleys and lowlands of the Pacific, Caribbean, Orinoquia, and Amazon regions. The way in which this intra-annual and internalized climate variability has been altered or exacerbated by climate change is still a matter of research, although it is intuited that ocean warming may have had an impact on the behavior of ocean currents and winds. However, beyond this discussion and whether it is climate variability or change or their conjugation, the failure in the response to hydrometeorological pressures is clear, which seem to also be occurring with greater strength, frequency, and damage.

While conditions may differ between countries in the region and within each territory (Table 4), data from ClimateWatchData indicate that floods have the highest average annual percentage of occurrence. As a result, they are a significant concern for the inhabitants of the region. When cross-referencing this information with the database maintained by Desinventar (a conceptual and methodological tool that provides an open-source database, developed by the Network for Social Studies on Disaster Prevention in Latin America, with the support of the OSSO Corporation and the United Nations Office for Disaster Risk Reduction), for instance, in the case of Colombia between 1912 and 2020 – although more data is available from 1970 onwards – flooding has the highest number of recorded incidents with 17,096 entries, followed by landslides with 10,532 entries. These events are associated with an excess of rainfall. In third place, there is another meteorological phenomenon known as "strong winds" with 5,644 entries within the specified period. Beyond the number of entries, other data highlight the impact of these phenomena on human populations and their activities. For example, while volcanic eruptions have caused the greatest loss of human life, landslides are responsible for at least 7,385 deaths during the same period. Floods remain the primary cause of lost cultivated hectares, with a cumulative total of 2,249,213 hectares affected. Similarly, meteorological phenomena are responsible for significant cattle losses, with drought resulting in 2,541,476 heads lost, and floods accounting for an additional 77,057 heads (Desinventar, n.d. a).

Table 4: Average Annual Percentage of Occurrence of Natural Phenomena by Country, Calculated in 2021

Phenomenon	Venezuela	Colombia	Ecuador	Peru	Bolivia
Flood	56.36	43.89	32	30.9	47.78
Earthquake	14.55	13.89	19	25.84	3.33
Epidemic	12.73	2.78	13	7.87	13.33
Alluvium river or landslide	7.27	23.33	15	17.98	8.89
Mass wasting (in dry conditions)	s.d	1.67	1	1.12	s.d
Storm	7.27	5	s.d	2.25	2.22
Drought	1.82	1.11	4	4.49	14.44
Extreme temperature	s.d	s.d	s.d	6.74	5.56
Volcanic activity	s.d	6.11	13	1.69	s.d
Forest fire	s.d	1.67	3	0.56	4.44
Insect infestation	s.d	0.56	s.d	0.56	s.d

Source: Prepared by the authors based on ClimateWatchData (n.d.), information by country.

For Ecuador, data covering the period from 1970 to 2007 shows a recurrence of the above pattern. Floods are the most frequently recorded events, with 1,122 entries, followed by landslides with 662 entries. Landslides rank second in terms of loss of human life, following traffic accidents (categorized under natural phenomena) with 1,265 deaths. Regarding damage to cultivated land, more than one million hectares were affected by eruptions, with floods accounting for 428,876 hectares and droughts for 227,181 hectares. Livestock losses due to eruptions amount to nearly 3 million heads, while floods and droughts have caused the loss of 9,060 and 1,400 heads of livestock, respectively (Desinventar, n.d. b).

In Peru, where rainfall is generally lower than in its northern neighbors, excess water is frequently documented. For instance, among various recorded phenomena from 1970 to 2015, the most common were floods (3,697), rains (2,399), and alluvial rivers (2,069), even surpassing earthquakes (1,401) and epidemics (1,539). The highest number of deaths were attributed to floods (21,023), followed by earthquakes (15,105). Regarding livestock losses, droughts caused the most significant losses (6,660,341), followed by frosts (376,786), floods (335,517), and snowstorms (219,109), all classified as meteorological events (Desinventar n.d. c).

As emphasized in the previous chapters on the tropical Andes in this volume, the loss of human life and damage to activities such as agriculture or livestock, often referred to as disasters, should not be classified as "natural" as they are socially and historically constructed (Maskrey 1993). In other words, the impact of natural phenomena on human settlements and activities typically depends on the actions and omissions of humans themselves. For instance, surges and floods are part of the natural dynamics of these bodies of water. They are necessary for the regeneration of their own course, the cleaning of their sediments, the restoration of soil fertility, and connection to the wetlands, among other aspects. This overflow becomes a disaster when humans establish structures at ground level, use impermeable materials for paving, favor permanent or long-cycle crops with low water tolerance, deepen channels by extracting sand and boulders, and alter basins through dam construction on riverbanks and floodplains. The magnitude of this disaster is also linked to the inadequate capacity to anticipate and respond to such events, which includes implementing early warning systems, resettling populations, timely evacuations, and the provision of non-perishable food, water, and medicines, among other measures.

From the latter half of the twentieth century to the present, numerous incidents in the Andean region have arisen from human decisions, contributing significantly to the Anthropocene epoch that we are continually shaping. The purpose of this chapter is not to delve into each of these disasters but to show some exemplary cases that have to do with droughts, abundant rains, and floods, especially during the atypical conditions of El Niño and La Niña (see Table 5). As summarized previously, this period is particularly interesting because of the level of intervention in watersheds, soils, forests, and ecosystems as a whole as a result of the developmentalist policies that have prevailed approximately since the 1940s despite the diversity of political spectrums in different periods and countries.

Many flood-related disasters in the region are associated with the construction of canals, drainage systems, and damming projects designed for commercial agriculture, power generation, and water supply to large cities. Due to its hydrographic and climatic conditions, the Colombian territory is a striking case at the regional level. As detailed in the chapter covering the nineteenth and early twentieth centuries, since the 1910s, initiatives have been undertaken in the *Sabana de Bogotá*, the location of the country's capital, Bogotá, to provide water and electricity to its increasing population. Infrastructure projects such as *El Alicahín* and *La Regadera* quickly fell short of meeting the demands of an expanding city. During the same period, initiatives were undertaken in the central regions of the country to reclaim land from swamps and lagoons, such as Fúquene, for commercial agricultural use. The drive for constructing hydraulic infrastructure, especially in densely populated areas with abundant water resources like the *Sabana de Bogotá*, the inter-Andean valley of the Cauca River, and the Caribbean plains (including the flood zones of the Sinú, San Jorge, Cauca, and Magdalena rivers), gained momentum post-World War II. This effort was supported by loans and development plans from the World Bank (Camargo 2020).

Table 5: Occurrence of Strong to Extreme ENSO in the Second Half of the Twentieth Century

Year	**El Niño**	**La Niña**
1953		E
1955		S
1956		VS
1957	S	
1964	S	
1965	S	
1971		VS
1974		E
1975		S
1982	E	
1983	E	
1987	VS	
1989		VS
1990		VS
1991	VS	
1992	VS	
1995		S
1998		E
2000		S
2002	E	

Source: Gergis y Fowler (2009: 367)

Throughout the second half of the twentieth century, the Colombian state itself explicitly promoted the work of entities whose main function was to alter the watersheds through drainage, channeling, and damming. In the 1950s, under the dictatorship of Gustavo Rojas Pinilla, the Corporación Autónoma Regional del Valle del Cauca (CVC) was created, which for the next thirty years was in charge of leading the canal and dam projects in the Aguablanca, La Unión-Roldanillo, Juanchito, Buga, Cartago, and Timba, as well as for the Salvajina dam. These projects were undertaken in conjunction with the private construction of canals, urban expansion, and the development of roads to enhance connectivity between rivers, lagoons, and swamps—bodies of water that also functioned as flood regulators (Perafán Cabrera, Peña Salamanca, and Buitrago Bermúdez 2018). In the plains of the Caribbean, the agrarian reform of 1961 led to the occupation of beaches and flood zones, both by landowners and peasants in search of plots. By that time, and with the influx of external loans for productive projects, the flood-prone areas had been transformed from fishing spots or pastures into housing and commercial crops, which were more susceptible to floods (Camargo 2020).

Between 1967 and 1993 (the year it was replaced by the Institute of Hydrology, Meteorology and Environmental Studies, or IDEAM), the Colombian Institute of Hydrology, Meteorology, and Land Improvement (HIMAT, by its Spanish acronym) was tasked with maintaining national meteorological records while simultaneously "improving land" – as its euphemistic name suggests. In practice, this meant reclaiming agricultural zones at the expense of floodplains and marshes. In urban areas, there were numerous instances of social housing projects promoted by the Territorial Credit Institute (which operated between 1939 and 1991) that were constructed within flood-prone zones.

In all these cases directed by national and local governments – compounded by spontaneous irrigation works or self-built housing – the areas occupied by crops and dwellings have collapsed repeatedly. This occurs particularly whenever La Niña impacts Colombian territory through increased precipitation, leading to crop and topsoil loss, livestock drowning, road blockages, housing destruction, the spread of diseases, and, in many instances, fatalities. As established in previous research, over the last seven decades, the country's worst disasters – in terms of simultaneity, material loss, and recovery costs – occurred during the La Niña events of 1971, 1974, and 2010–2011. Nevertheless, governments continue to propose further hydraulic infrastructure, and it is the affected population itself that pressures for these types of solutions (Mora Pacheco 2023).

In contrast, faced with droughts during El Niño, hydraulic infrastructure policy for decades focused especially on the construction of reservoirs for the generation of hydroelectric power, which affected watersheds, as well as flooded populations and arable land. However, such policies have not been able to respond to human needs either. This was demonstrated in one of the most deeply remembered cases, the energy crisis of 1992, which occurred due to the lowering of reservoirs during a very strong El Niño, requiring the rationing of electricity to a minimum of eight hours a day. It is still remembered today as "*El Apagón*" (the blackout). In addition to attributing the crisis to climate variability, political-administrative and technical decisions also played a significant role in limiting responsiveness. In subsequent years, the event was leveraged to advocate for the construction of additional hydroelectric infrastructure or to transfer parts of the existing infrastructure to private ownership (Patiño Sánchez 2022). In April 2024, again during an El Niño, Colombia suspended energy supplies to Ecuador, a country that had to enter a period of energy rationing because its own reservoirs had dried up. From April 2024 to April 2025, Bogotá completed twelve months of water rationing by sector. Each sector had to be prepared to be without a water supply once every nine days for twenty-four hours. Without considering the industrial, agricultural, and urban demand that reduces water sources, there are proposals being made to start new projects for reservoir construction or groundwater extraction.

The discourses concerning the abundance or scarcity of water, which influence decisions to construct additional reservoirs, have been prevalent in the region and have intensified over the past three decades. This trend is particularly evident in the zones of ecosystem connectivity between the Andes and the Amazon within the territories of Ecuador, Peru, and Bolivia, including the Marañón, Ucayali, and Napo river basins. The topography and high rainfall of these areas have made them attractive for numerous projects, which, from their very planning, result in radical modifications like the fragmentation of rivers, the alteration of the dynamics of sediment dragging and deposit, the modification of the seasons and volumes of overflows, deforestation due to the construction of access roads and transmission lines, the flooding of areas with large volumes of biomass that decomposes, increased GHG emissions, and an impact on the settlements and living conditions of Indigenous communities (Finer and Jenkins 2012). In the highlands, instances like the Amaluza Dam in Ecuador are instructive. This dam experienced a decrease in storage and energy generation capacity due to deforestation in the upper basin of the Paute River, which led to sediment accumulation (Larrea Maldonado 2006).

In addition to issues associated with hydraulic infrastructure, other conditions in the Andean countries have limited their capacity to respond effectively to climate variability and change, leading to disasters and conflicts. Factors such as land concentration, growing urban populations, and dependence on agro-exports and mining have influenced food production and the ability to manage crises. Furthermore, until the late twentieth century, risk management and responses to declarations of disaster were frequently handled by entities such as the Catholic Church, the Red Cross, public charities, or even winners of beauty pageants (Mora Pacheco 2023). Consequently, it is not surprising that significant crises occurred at specific points, such as those during La Niña in 1971, 1974, and 2010–2011, or El Niño in 1991–1992 in Colombia, as well as in other Andean regions mentioned below.

In the period between 1983 and 2002, of the seven million people affected by droughts in the Andean Community (CAN, for its initials in Spanish) (not including Venezuela), half were concentrated in Bolivia and Peru. One of the most impactful droughts occurred during the El Niño event of 1982–1983. Colombia experienced a significant reduction in the flow of the Atrato and San Juan rivers, which traverse the biogeographic Chocó region – one of the rainiest areas globally, receiving over 9000 mm of annual precipitation. However, the largest losses – more than 50 percent – were related to water and electricity services. The main impacts related to the agricultural sector, that is, to the food supply itself, in the context of CAN, occurred with low yields or loss of sheep, crops, or camelids in the Peruvian-Bolivian highlands. In Peru, the economic losses from the phenomenon represented 7 percent of GDP in 1983, which was higher than the 5 percent experienced during the ENSO of the late 1990s. However, when expressed in millions of dollars, the difference is minimal, with an estimated loss of $3,283 million in 1983 compared to $3,500 million in 1998. In Bolivia, estimated losses in 1983 amounted to $1,372 million, compared to $527 million in 1998 (*Secretaría General de la Comunidad Andina* 2009). Javier Puente examines the effects of the 1982–1983 drought on agrarian conflicts in Peru, the Shining Path's increase in violence, and the state's counterinsurgency actions, which included executions, massacres, and murders of peasants between 1981 and 1986 (Puente 2018; Puente 2021).

For Ecuador, on the other hand, the greatest effects occurred at the end of the 1990s. The weak El Niño of 1997 and the extreme La Niña of 1998 affected around 34,000 people, causing an economic crisis exacerbated by the Southeast Asian financial collapse and unfavorable oil prices for exporting countries. The economic losses during the late 1990s were significantly higher than those caused by the 1983 El Niño. In 1983, the losses amounted to $1,051 million, whereas by 1998, this figure had risen to $2,882 million (Larrea Maldonado 2006; Secretaría General de la Comunidad Andina 2009). In Venezuela, the 1997–1998 ENSO event was particularly severe due to the drought, which adversely affected the supply of drinking water and hydroelectric power as a result of reduced reservoir levels. Conversely, available records indicate that the 1982–1983 ENSO did not have a similar impact, coinciding with a period of oil prosperity in the country (Altez, Urbani, and Suárez 2016).

Regardless of the numerical differences, in all instances and across the entire Andean region, the recurring impacts associated with strong, very strong, or extreme ENSO events have highlighted the historical construction of vulnerability and the ineffectiveness, if not the absence, of risk management. As demonstrated in the previous section, irrespective of political affiliations, the solutions remain unchanged and continue to focus on the production and export of agricultural and mining products, the construction of infrastructure, and short-term technological fixes.

Conclusions

It is well-documented that the countries of the Andean region are not significant emitters of greenhouse gases (GHGs). This can be attributed in part to their import substitution policies, which have either failed or only been effective in the short term, as well as their emphasis on extractive or agricultural activities without value addition. Consequently, their emissions are comparatively lower than those of countries such as the United States, China, or India. Regardless of the contribution in tons or percentages, it is evident that some damage is occurring. Firstly, in the context of global environmental change, every contribution matters. Secondly, within the Anthropocene and at a regional level, an alteration has taken place in ecosystems that appears to be irreversible.

Fossil fuels have been a relevant export line for most Andean countries. The ostensibly cleaner option of generating energy from reservoirs and hydroelectric dams has caused various environmental impacts, such as altering microclimates, reducing river overflows vital for soil fertility, diminishing hydrobiological species critical to fisheries, flooding forests and human settlements, producing methane emissions, and ultimately failing to meet the energy demands of expanding urban centers, especially during ENSO events due to changes in rainfall volumes. The agricultural frontier and monoculture expansion have accelerated deforestation in these Andean and Amazonian countries, reducing their carbon capture capacity. As observed in previous periods in the same region, rather than merely being a victim of the Anthropocene, this area has played a role in its development, resulting in boomerang effects that have impacted its own population.

References

Academia de Ciencias Físicas, Matemáticas y Naturales. 2022. *Aportes para la actualización de la Contribución Nacionalmente Determinada (NDC) de Venezuela para el período 2020–2030*. Caracas: Academia de Ciencias Físicas, Matemáticas y Naturales.

Alayza, Alejandra, and Eduardo Gudynas, ed. 2012. *Transiciones y alternativas al extractivismo en la región andina. Una mirada desde Bolivia, Ecuador y Perú*. Lima: CEPES.

Altez, Rogelio, Franco Urbani, and Gerardo Suárez. 2016. *Atlas Nacional de Exposición ante Amenazas Naturales y Tecnológicas*. Caracas: Ministerio del Poder Popular para Relaciones Interiores, Justicia y Paz/Viceministerio de Gestión de Riesgo y Protección Civil/PNUD/Total Oil and Gas Venezuela/Terracon Ingeniería.

Arias, Carolina. 2017. "Neoextractivismo en América Latina y Colombia: una reflexión desde la ecología política." *Revista Controversia* 208: 16–53.

Bebbington, Anthony, ed. 2007. *Minería, movimientos sociales y respuestas campesinas. Una ecología política de transformaciones territoriales*. Lima: Instituto de Estudios Peruanos-CEPES.

Bravo, Andrea. 2015. "Oportunidad política y coaliciones: Yasuní Itt y el neoextractivismo en Ecuador." Master's thesis, Pontificia Universidad Católica del Ecuador.

Camargo, Alejandro. 2020. "Aguas indomables: Vulnerabilidad y transformaciones hidrosociales en el sur del departamento del Atlántico." In *Fragmentos de historia ambiental colombiana*, ed. Claudia Leal, 145–168. Bogotá: Universidad de los Andes.

Climate Watch. n.d. a. "Countries." https://www.climatewatchdata.org/countries.

———. n.d. b. “Bolivia.” https://www.climatewatchdata.org/countries/BOL?end_year=2021&start_year=1990.

Creamer, Claudio. 2021. “Historia de la industria en Ecuador: 1920–2020.” *Boletín de la Academia Nacional de Historia* 99, no. 205: 245–283.

Demarty, Maud, and Julie Bastien. 2011. “GHG emissions from hydroelectric reservoirs in tropical and equatorial regions: Review of 20 years of CH4 emission measurements.” *Energy policy* 39, no. 7: 4197–4206.

Desinventar. n.d. a. “Colombia.” https://db.desinventar.org/DesInventar/profiletab.jsp?countrycode=col&continue=y.

———. n.d. b. “Ecuador.” https://db.desinventar.org/DesInventar/profiletab.jsp?countrycode=ecu&continue=y.

———. n.d. c. “Perú.” https://db.desinventar.org/DesInventar/profiletab.jsp?countrycode=per&continue=y.

Devia, Claudia, and Robinzon Piñeros. 2021. “Dinámica territorial del extractivismo agrícola y petrolero a comienzos del siglo XXI en el departamento del Meta, Colombia.” *Perspectiva Geográfica* 26, no. 1: 37–62.

Escobedo, Annie. 2021. *Agronegocios y crisis climática en el Perú. Monocultivos, deforestación y emisiones de carbono en la Amazonía peruana*. Lima: OXFAM.

Finer, Matt, and Clinton Jenkins. 2012. “Proliferation of Hydroelectric Dams in the Andean Amazon and Implications for Andes-Amazon Connectivity.” *PLOS ONE* 7, no. 4: 1–9.

Galindo, Luis, Jose Luis Samaniego, José Eduardo Alatorre, et al. 2015. *Ocho tesis sobre el cambio climático y el desarrollo sostenible en América Latina*. Santiago de Chile: CEPAL.

García Acosta, Virginia. 2017. “La incursión del Antropoceno en el sur del planeta.” *Desacatos* 54: 8–15.

Gergis, Jöelle L., and Anthony Fowler. 2009. “A history of ENSO events since A.D. 1525: Implications for future climate change.” *Climatic Change* 92: 343–387.

Germani, Gino. 1971. *Política y sociedad en una época de transición: de la sociedad tradicional a la sociedad de masas*. Buenos Aires: Eudeba.

Ground, Richard Lynn. 1988. “La génesis de la sustitución de importaciones en América Latina.” *Revista de la Cepal* 36: 181–207.

Grupo Banco Mundial. 2022. *Hoja de ruta para la acción climática en América Latina y el Caribe 2021–2025*. Washington, D.C.: Banco Mundial.

Gudynas, Eduardo. 2009. “Diez tesis urgentes sobre el nuevo extractivismo.” In *Extractivismo, Política y Sociedad*, Jürgen Schuldt, Alberto Acosta, Alberto Barandiarán, et al., 187–225. Quito: CAAP/CLAES.

———. 2010. “Agropecuaria y nuevo extractivismo bajo los gobiernos progresistas de América del Sur.” *Territorios* 5: 37–54.

———. 2018. “Extractivismos: el concepto, sus expresiones y sus múltiples violencias.” *Papeles de Relaciones Ecosociales y Cambio Global* 143: 61–70.

Guerín, Frédéric, Gwenaël Abril, Alain Tremblay, et al. 2008. "Nitrous oxide emissions from tropical hydroelectric reservoirs." *Geophysical Research Letters* 35, no. 6: 2–7.

Haraway, Donna. 2015. "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin." *Environmental Humanities* 6, no. 1: 159–165.

Larrea Maldonado, Carlos. 2006. *Hacia una historia ecológica del Ecuador. Propuestas para el debate*. Quito: Ecociencia/Universidad Andina Simón Bolívar/Corporación Editora Nacional.

Landivar, Natalia. 2022. "Agrarian extractivism and land struggles in Guayas province, Ecuador: A Feminist Political Ecology analysis." PhD diss., University of Manitoba.

Lanegra, Iván. 2015. "Humala: el neoextractivista que no fue." *Ojo Público*, June 11. https://ojo-publico.com/67/humala-el-neoextractivista-que-no-fue.

Loaiza, Sandra. 2016. "Cuantificación de gases de efecto invernadero generados en represa y embalses tropicales: Caso Calima – Valle del Cauca." Master's thesis, Universidad Nacional de Colombia sede Palmira.

Maskrey, Andrew, ed. 1993. *Los desastres no son naturales*. Bogotá: Red de Estudios Sociales en Prevención de Desastres en América Latina.

McKay, Ben, and Gonzalo Colque. 2022. "Dinámicas extractivas en el sector agrario de Bolivia." In *Extractivismo agrario en América Latina*, ed. Ben McKay, Alberto Alonso-Fradejas, and Arturo Ezquerro-Cañete, 91–123. Buenos Aires: CLACSO.

Ministerio de Medio Ambiente y Agua. 2021. *Contribución Nacionalmente Determinada (CND) del Estado plurinacional de Bolivia*. La Paz.

Mora Pacheco, Katherinne. 2023. "'Con el agua al cuello': Una historia de batallas perdidas contra el agua y desastres por inundaciones en Colombia, 1950–2011." *Agua y Territorio* 22: 77–92.

Moreno, Laura. 2022. "Palma de aceite: balance sobre los fenómenos de despojo y concentración de tierras ligados a su expansión en Colombia." Master's thesis, Universidad del Rosario.

Morfa-Fernández, Geidy. 2020. "Un plurinacionalismo contado desde el neoextractivismo en tierras bajas bolivianas." *Ciencia Política* 15, no. 29: 181–223.

Palau, Antoni, and Clemente Prieto. 2009. "Hidroelectricidad, embalses y cambio climático." *Ingeniería del Agua* 16, no. 4: 311–324.

Patiño Sánchez, Camila. 2022. "El gran apagón: Tecno-políticas, hidroeléctricas y crisis en el sector eléctrico colombiano." In *La urbanización de las aguas en Colombia*, ed. Alejandro Camargo, Denisse Roca-Servat, and Kathryn Furlong, 57–86. Medellín: Universidad Pontificia Bolivariana.

Perafán Cabrera, Aceneth, Enrique Javier Peña Salamanca, and Oscar Buitrago Bermúdez. 2018. *Humedales vallecaucanos. Escenario natural de cambios históricos de ocupación y transformación*. Cali: Universidad del Valle.

Puente, Javier. 2018. "Una guerra de ocupación: La territorialización del conflicto armado interno en Perú, 1981–1986." *Folia Histórica del Nordeste* 32: 175–197.

———. 2021. "The Enduring Climate of Conflict: Drought, Impoverishment and the Long Aftermath of Civil War in Peru." *Global Environment* 14, no. 1: 146–179.

Puma, Carlos. 2015. *El modelo de Industrialización por Sustitución de Importaciones. Caso Complejo Metalúrgico de Karachipampa*. La Paz: Universidad Andina Simón Bolívar.

Ruddiman, William F. 2003. "The Anthropogenic Greenhouse Era began thousands of years ago." *Climatic Change* 61: 261–293.

———. 2005. *Plows, plagues, and petroleum. How humans took control of climate*. Princeton: Princeton University Press.

Secretaría General de la Comunidad Andina. 2009. *Atlas de las dinámicas del territorio andino: Población y bienes expuestos a amenazas naturales*. Cali: Corporación OSSO.

Svampa, Maristella. 2018. *Debates latinoamericanos: indianismo, desarrollo, dependencia, populismo*. Buenos Aires: Edhasa.

———. 2019a. *Las fronteras del neoextractivismo en América Latina*. Bielefeld: Bielefeld University Press.

———. 2019b. "El Antropoceno como diagnóstico y paradigma. Lecturas globales desde el Sur." *Utopía y Praxis Latinoamericana*,24, no. 84: 33–53.

Trischler, Helmuth. 2017. "El Antropoceno, ¿un concepto geológico o cultural, o ambos?." *Desacatos* 54: 40–57.

Ulloa, Astrid. 2017. "Dinámicas ambientales y extractivas en el siglo XXI: ¿es la época del Antropoceno o del Capitaloceno en Latinoamérica?." *Desacatos. Revista de Ciencias Sociales* 54: 58–73.

Vásquez Heredia, Omar. 2024. *Crisis climática y Derechos Humanos en Venezuela. Una aproximación al debate entre justicia climática y seguridad*. Bogotá: Friedrich Ebert Stiftung.

Climate Change in the Amazon from 1950 to the Present

The Region as a Global Arena in the Great Acceleration

Danielle Heberle Viegas, André Secchieri Bailão, Henrique Gasperin, André Da Silva, and Patrick Roberts

From "the Lungs of the Earth" to a Net Carbon Source, the Amazon and the Great Acceleration

In 2024, the Articulation of Indigenous Peoples of Brazil (APIB) called on the Brazilian government to let them co-chair the 30th Conference of the Parties (COP-30), which took place in Belém do Pará in November 2025. APIB has consistently advocated for Indigenous peoples to have a stronger political voice both nationally and internationally. Alongside other Indigenous organizations, they have criticized the approval of new oil and gas projects in the Amazon (APIB 2024). In their manifesto, *We are the answer*, they emphasize that "the wealth of our ancestral knowledge and experiences offers the world a chance at a different future" (APIB 2024).

The APIB manifesto and the convening of a COP within a tropical economic periphery provide an instructive starting point for analyzing significant contradictions that characterize the current status of the world's largest and most biodiverse tropical rainforest as a focal point for global climate policy (Fatheuer 2019). With the worldwide effects of climate change becoming increasingly pronounced – particularly concerning biogeochemical cycles, precipitation patterns, and temperature variation – the arena for geopolitical decision-making extends well beyond the confines of the rainforest, which spans nine South American nations and territories (Brazil, Peru, Colombia, Venezuela, Ecuador, Bolivia, Guyana, Suriname, and French Guiana) and covers approximately 8 million km^2 (RAISG 2020). During the 1980s, international development institutions increasingly characterized tropical forests as biomes that were both susceptible to rapid anthropogenic degradation and essential for sustaining global ecological stability amid climate change (Le Preste 1989). These efforts coincided with a waning post-World War II consensus regarding development as an inevitable result of economic growth (Hirschman 1981). As a consequence, the Amazon region emerged as a prominent symbol of the rising ecological movement gaining momentum on a global scale. While major international development institutions, such as the World Bank, adapted their funding policies in response to environmental risks associated with projects (Wade 2011), multilateral frameworks, such as the United Nations Framework Convention on Climate Change, were created. The 1992 Rio Earth Summit consolidated concerns over the planetary environment as a central topic in global diplomacy and international relations. This context favored the formation of transnational networks connecting those living in the Amazon basin with global NGOs, international development platforms, academic networks and legal experts (Conklin and Graham 1995).

In the twenty-first century, calls for Amazonian protection have become ever more urgent. During the 2022 United Nations Climate Change Conference (COP-27) in Sharm El Sheikh, Egypt, newly elected left-wing Brazilian president Luiz Inácio Lula da Silva stated that "there is no climate security for the world without a protected Amazon," tying Amazon protection with planetary survival. At the 2019 G7 Summit, French President Emmanuel Macron declared that "our house is burning," urging leaders of the world's largest economies to make addressing the Amazon fires a top priority. He also warned that he would withdraw his backing for the Mercosur-EU free trade deal if then Brazilian president Jair Bolsonaro of the extreme right failed to act on the crisis. The importance of the Amazon's fate had become a central issue on the global political stage. Even earlier, in 2007, Amazonian concerns were spotlighted during the massive Live Earth Concert. Reaching an estimated audience of two billion worldwide, Ecuadorian lawyer Pablo Fajardo publicly condemned Chevron-Texaco for oil pollution, joined by Sting and Trudie Styler at a Live Earth press event in New York (Santana 2007).

While global debates and discussions took place, disputes over land rights and resource exploitation intensified, highlighting tensions between global capitalism and the social and ecological resilience of the rainforest. A deeply troubling aspect of these conflicts has been the increase in violence against environmental defenders and activists in the Amazon (Global Witness 2024). This includes the assassinations of Chico Mendes in 1988 and Dorothy Stang in 2005, the killings of Guajajara indigenous protectors from 2019 to 2022, and the murder of journalist Dom Phillips and activist Bruno Pereira in 2022.

The recognition of the Amazon as a pivotal arena for global climate discourse has coincided with a notable rise in extreme climate events in the region since the early twenty-first century, underscoring the rainforest's importance as a fundamental component of the Earth system. Research involving land cover and climate modeling suggests that the Amazon biome is approaching a tipping point and may be "on the verge of ecological collapse," with the possibility of transitioning to a stable savannah-like state (Pereira and Viola 2022: 2). Between 1990 and 2007, the carbon uptake of the rainforest accounted for approximately one quarter of the remaining planetary carbon sink (Brienen et al. 2015). However, ongoing climate pressures in tropical regions – such as increased drought frequency and rising temperatures – have been identified as significant risks to the Amazon's role as a carbon sink. These factors, together with deforestation driven by fire, may cause the region to become a net carbon source in the coming years (Nobre 2014; Brienen et al. 2015). Notable events impacting the region include the exceptional rainfall experienced in Guyana in 2005, the severe flooding in Colombia in 2010, and the widespread human-induced forest fires in Brazil during August 2019, frequently referred to as Fire Day. In August 2024, massive arson efforts aimed at clearing land for cattle ranching once again swept through millions of hectares across Amazonian countries like Brazil, Bolivia, and Peru. These fires were compounded by severe and persistent droughts in the region, which have occurred repeatedly in recent years – specifically in 2005, 2010, 2015/16, and 2023–24 – and have further accelerated forest dieback. The flames destroyed millions of hectares, causing major loss of biodiversity, forcing wildlife from their habitats, and emitting large quantities of carbon into the atmosphere, thereby intensifying global climate change (Martins 2024).

These events highlight the diverse and significant climate change drivers that influenced the Great Acceleration (McNeil and Engelke 2014) in the Amazon, which has increasingly served as a focus for resource extraction supporting the global expansion of capitalist economies. Through the implementation of centralized and rational bureaucratic strategies, Amazonian nations facilitated the influx of global capital by providing fiscal incentives, developing large-scale infrastructure, and ensuring energy availability. These measures contributed to the conversion of forested regions and local societies into contemporary, monetized, property-based economic and social systems (Hecht et al. 2021: 7). Economic activities, particularly mining and agroindustry, received significant encouragement due to their ability to attract international investment and facilitate the development of urban settlements. The urban networks that evolved in response to these economies contrast markedly with pre-colonial and non-capitalist urban models, including the Indigenous *Garden Cities* found in the Amazon (Neves et al. 2021; Rostain et al. 2024). Unlike the urban landscapes characteristic of the twentieth century, these configurations are notably integrated within their respective local and regional ecosystems (Roberts et al. 2024).

The Amazon holds importance not only as a biome and a region rich in socio-biodiversity, but also as a site of global cultural relevance, historically shaped by prevalent narratives surrounding the neotropic wilderness. While terms such as "lungs of the world" are frequently used in media and advocacy, this characterization is an oversimplification, as the Amazon does not generate a net production of oxygen (Zimmer 2019). Nevertheless, such references remain common in discussions advocating for rainforest preservation. Traditionally, pristine nature has been viewed as integral to the identity of the Amazon; however, Western perspectives partially shifted during the twentieth century. Developmental initiatives throughout that period often positioned the rainforest within broader colonization and integration agendas, exemplified by efforts such as the Roncador-Xingu Expedition (1941) and Operação Amazônia (1966). These initiatives significantly contributed to the expansion of the capitalist frontier in the forest and the creation of new extractivist hubs. However, whenever projects faced difficulties or failed, the idea of the *Green Hell* – a concept coined in the early twentieth century – was revived. This term reflected the view that the Amazon was a wild and inhospitable environment, where attempts at colonization and exploitation were doomed to failure due to the region's harsh conditions.

This chapter addresses the complexities associated with the Amazon's role as a pivotal arena for global climate politics and Earth system science. Drawing upon research on the Anthropocene – an epoch characterized by significant planetary alterations and the emergence of international narratives and institutional mechanisms dedicated to environmental preservation (Radkau 2014) – the discussion highlights the intricate balance between economic development, social equity, and conservation within a globalized context impacted by climate change, as articulated by Brondizio et al. (2013: 10). In the past seventy years, the Amazon has undergone substantial socio-environmental transformations, positioning the region as a major site for the evolution of policies, development paradigms, democratization efforts, multicultural initiatives, political ideologies, and environmental strategies (Brondizio et al. 2013: 10). Therefore, the Amazon serves as an exemplary case for broader considerations related to the Anthropocene.

The text is divided as follows: the first section synthesizes the main climate drivers that have been affecting the Amazon over the last seven decades. We point out the intersection between climate change, land use, and biodiversity loss concerning deforestation and extractivism in the Amazon, exploring how Amazon development unfolded in different Amazonian countries. Secondly, we historicize the formation and consolidation of ecological and climate sciences about the Amazon from the second half of the twentieth century to the twenty first century. Amidst deep socio-environmental transformations, a series of transnational research projects advanced scientific understandings of the Amazon as an interconnected biogeophysical system. We also discuss the blossoming of climatic and ecological sciences in and about the rainforest, which contributed to evidence-based criticisms of global development. In our final remarks, we present an agenda based on the planetary importance of the Amazon in the face of the climate crisis, highlighting the importance of traditional knowledge and lived experiences as development alternatives for the region.

Deforestation and Extractivism: Key Elements of Climate Change

In 2024, global temperatures increased by 1.5°C relative to pre-industrial levels (WMO 2024), presenting significant challenges to existing climate models. Evidence indicates that practices such as swidden cultivation, indigenous forest management, and urban settlements predate the era commonly referred to as the Great Acceleration (Zuccarelli Freire et al., 2024). Nonetheless, it is the scale, methodologies, market-driven purposes, and, notably, the impacts associated with extractive agricultural and urban systems originating from the colonial and industrial periods that have profoundly transformed Amazonian ecosystems. The colonial emphasis on implementing new extractive land uses, along with the exploitation of Indigenous labor, individuals, and resources within broader capital flows, has prompted some scholars to advocate for the term Capitalocene rather than Anthropocene to characterize the origins of global human-Earth system impacts as early as the fifteenth century (e.g., Lewis and Maslin 2015). This terminology also serves to underscore how concepts of climatic difference and perceived superiority informed racist imperial ideologies (Mahony and Endfield 2018: 2).

Globally, fossil fuel combustion for energy generation is recognized as the principal contributor to greenhouse gas (GHG) emissions in the twenty-first century, representing a significant trend within the Great Acceleration of human impacts on the Earth System (Steffen et al. 2015). In contrast, within the Amazon region, deforestation constitutes the primary source of GHG emissions. The PRODES program defines deforestation as "the conversion by suppression of areas of primary forest physiognomy by anthropogenic actions" (Souza et al. 2019: 4). The consequences of this process include modifications to weather patterns, disruption of ecosystems, changes in precipitation and hydrological cycles, increased incidence of tropical diseases, and displacement of human populations.

In Brazil, which contains approximately 60 percent of the Amazon rainforest, deforestation rates are systematically monitored by the National Institute for Space Research (INPE). According to INPE's data, the initial stages of Amazonian deforestation during the 1950s through the 1970s were primarily driven by agricultural expansion, though on a smaller scale than in subsequent decades. The 1980s witnessed a significant intensification of deforestation, with the annual rate peaking at around 13,000 km² in 1988. Although Brazil introduced various control measures throughout the 1990s and 2000s, deforestation remained substantial, reaching roughly 27,000 km² in 2004 and generating considerable international concern. In the following decade, enhanced anti-deforestation efforts – including the establishment of conservation units and stronger enforcement – resulted in a marked decline in rates, from 27,000 km² in 2004 to approximately 7,000 km² by 2012. Nonetheless, the period from 2012 to 2020 saw an uptick in deforestation, culminating in figures of about 10,000 km² in 2019 and 11,088 km² in 2020, the highest levels since 2008. Most recently, INPE reported a 30 percent reduction in deforestation, representing the most substantial decrease observed in the past fifteen years.

Deforestation in the Amazon is primarily driven by logging and intentional burning, activities that facilitate the conversion of forest land into pastures for livestock or areas designated for plantations and grazing. These practices frequently involve the clearing or burning of extensive forest sections, resulting in the release of carbon stored in vegetation, as well as potent greenhouse gases such as methane and nitrogen oxides (Steffen et al. 2015). The majority of deforested areas are subsequently utilized as pasture for cattle ranching or for soy cultivation, both of which further contribute to emissions – particularly due to methane generated by livestock. A notable example is the Volkswagen Farm, officially known as Companhia Vale do Rio Cristalino (CVRC), a cattle operation covering over 100,000 hectares in southeastern Amazonia, within the state of Pará, established in 1974 under Volkswagen's direction. The German multinational corporation led the project, which attracted investment from additional companies, supported by substantial incentives from the Brazilian federal government as part of Operation Amazon (1966). The primary objective of the farm was to produce beef for export, to be processed at regional slaughterhouses constructed expressly for this purpose, in addition to generating timber and cellulose (Acker 2018). Infrastructure such as roads and airstrips was developed to facilitate these operations, resulting in the deforestation of thousands of hectares. Promotional materials highlighted anticipated employee benefits and the implementation of advanced agricultural techniques to enhance production.

Within a decade, global environmental and labor scandals – amplified by the scientific community and the media – dismantled the project's idealistic image. The Volkswagen Farm (Companhia Vale do Rio Cristalino) became an iconic case study, intersecting Latin American themes of dictatorship and developmentalism with global phenomena like the Cold War and the nascent environmental movement. This period, characteristic of the Great Acceleration, culminated in ecological and humanitarian crises: a massive fire visible from space in 1976 and damning 1983 reports of debt slavery among subcontracted laborers (Acker 2018). Ultimately, the farm's history is a vital component of the regional Anthropocene, challenging the notion that modernization in Brazil was confined solely to its major urban centers. Antoine Acker (2018) suggests that VW's project in the Amazon is better understood as part of Brazil's broader developmentalist political culture throughout the twentieth century, rather than just a product of the military dictatorship. This view highlights the Volkswagen Farm as an important example for studying climate change, since deforestation for cattle ranching in the Amazon continued even after the dictatorship and after the farm closed. The VW cattle ranch, despite being part of global discussions on ecology, was ultimately sold in 1987.

Agrarian colonization remains a significant force in Brazil, with the influential agribusiness sector playing a leading role over the past thirty years. Logging roads, mainly constructed to extract mahogany, often come before and run alongside highways, opening up new opportunities for converting timber profits into soybean farms and cattle ranches. Removing timber makes forests more prone to fires, starting a damaging cycle: understory fires lead to tree loss, which creates more fuel, causing repeated fires and eventually resulting in forest destruction (Fearnside 2016).

Prior to the development of the agribusiness sector, Brazil's authoritarian and developmentalist policies for the Amazon region were already promoting agrarian colonization, inviting settlers from the southern regions. Initiatives such as the Polonoroeste project (1981) and various institutions – including the Superintendência do Desenvolvimento da Amazônia (SUDAM), the Amazonian Bank (BASA), and the National Institute for Colonization and Agrarian Reform (INCRA) – were established to facilitate state-directed agrarian colonization (Pereira 2017).

In this context, fire serves as a significant factor associated with the expansion of inland motorway infrastructure. Following the decline of developmentalist policies in the late 1980s, fire incidence in the Amazon increased, primarily driven by external demand for agricultural commodities such as soybeans along major federal highways BR-163 (Cuiabá-Santarém) and BR-364 (Cuiabá-Porto Velho). The development of this infrastructure, coupled with rapid growth in agricultural production, contributed to the formation of an "arc of deforestation," characterized by the combined use of heavy machinery and widespread application of fire (Relly and De Majo 2022). Over the past two decades, annual burning and forest fires have impacted an area nearly equivalent to the size of Uruguay (Pereira and Viola 2022: 3). Bolivia and Brazil are among the countries most affected by this phenomenon. In addition to cattle ranching, Amazonian deforestation has largely resulted from the expansion of diverse agricultural activities, including cultivation of palm oil (notably in Peru and Ecuador), coca (in Colombia), and especially soybeans (in Brazil and Bolivia). The increase in soybean cultivation, particularly in Brazilian states such as Mato Grosso and Pará, has contributed to the conversion of extensive rainforest areas into agricultural land, with environmental consequences also affecting the Cerrado biome. Despite the implementation of the 2006 Soy Moratorium – which was designed to prevent the purchase of soy produced on illegally deforested land – deforestation persists in certain regions. This ongoing loss is primarily attributed to agricultural expansion in less monitored areas and the rising global demand for soy, particularly from China (Relly and De Majo 2022).

In addition to the well-documented climate change effects associated with deforestation, extractivism has also been connected to extreme climate events and disasters that adversely affect both the environment and local communities (Fearnside 2017). Within the Amazon, predominant forms of extractivism include logging, mining for bauxite, iron, gold, copper, and tin, as well as oil and gas extraction. Extractivism is characterized by the large-scale removal of natural resources primarily for export, with limited local processing or value addition. This economic model, which has underpinned Latin America's role in the global economy since the colonial period, has seen significant acceleration in peripheral regions such as the Amazon. Export-led industries have been targeted by progressive-leaning Latin American governments in the early twenty-first century, as these administrations have aimed to finance national redistribution policies through revenues derived from such sectors. The connection between the expansion of commodity frontiers and strategies for popular legitimation reflects the phenomenon Gudynas (2009) describes as neoextractivism, with the Amazon serving as a significant setting for these processes of resource appropriation and commodification.

A related concept is extractive urban planning, which refers to the systematic organization of space, the intricate structuring of labor relations, and the strategic development of territorial infrastructure influenced by extractivism (Correa 2016). This planning methodology structures urban environments to primarily serve resource extraction interests, frequently placing industrial and economic objectives above environmental and social concerns. Within this framework, labor systems are progressively adapted to support extractive industries, and infrastructure – including roads, ports, and power lines – is designed chiefly to enable the transport and processing of natural resources. Consequently, extractivist principles become embedded within both urban and regional settings.

By the late 1960s, regional development strategies were centered on the creation of "development poles" – urban nuclei designed to irradiate modernist progress across the Amazonian interior (Campaña 2023). This paradigm relied on massive capital injections to finance critical infrastructure, including ports, highways, and pipelines (Harvey 2001). These cities were – and remain – intrinsically linked to global extractive industries and national developmentalist goals. By facilitating the expansion of the capitalist frontier, these urban centers effectively integrated the Amazon's resources into the global market, solidifying the region's role within the international economic order.

These activities, driven by global demand for commodities such as minerals and oil, facilitate the transformation of extensive forested regions into urban and industrial zones. This process has resulted in the development of roads, both above and below ground infrastructures, and established new urban networks within the forest. A prominent example of extractive urban planning in the Amazon is the history of Nueva Loja – also known as Lago Agrio – which exemplifies unsustainable development trends. As the most populous municipality in the Ecuadorian Amazon, Nueva Loja derives its name from Sour Lake, Texas, the origin of Texaco, a major oil company. The area, which is the ancestral land of numerous Indigenous communities, underwent significant changes following the discovery of oil by the Texaco-

Gulf consortium in 1967. This event marked a pivotal shift in the social, political, and environmental landscape of the Ecuadorian Amazon, initiating transformative operations that have had lasting impacts.

Following the discovery of substantial oil reserves, the Ecuadorian government expanded its colonization policies to address national land pressures and mandated that oil companies construct roads linking the Amazon region with the Andes. This approach facilitated the emergence of rapidly growing settlements around oil extraction sites – such as Lago Agrio – which became emblematic of the nation's oil boom and related development strategies in the Amazon. Although infrastructural and colonization initiatives intensified after Texaco's discoveries, conceptualizing the Amazon as a "resource environment" predated both Texaco's operations and the transformation of Lago Agrio into a key oil frontier (Feichtner 2023: 54). As internal migration brought more settlers to the Amazon alongside expanding oil infrastructure, tension and conflict with Indigenous communities escalated, resulting in significant displacement. The proliferation of roads connected various oil fields to the extensive Oleoducto Transecuatoriano (SOTE) pipeline, which, at over 500 km in length, linked Lago Agrio to Esmeraldas on the coast. By 1972, this pipeline was transporting approximately 220,000 barrels of crude oil daily, with the majority destined for international export.

Texaco's operations were consistent with colonization policies aimed at converting undeveloped land into agricultural estates, contributing to substantial population growth in the Amazon from 46,000 in 1950 to 264,000 by 1982. This expansion accelerated deforestation, as settlers cleared at least half of forested areas to secure land titles. Government incentives promoting large-scale palm oil and cattle production further intensified both deforestation and the development of monoculture estates. Texaco's waste management practices were inadequate for the region's humid and rainy climate, relying on outdated methods that resulted in frequent spills from ineffective waste pits, leading to pollution of rivers, soil, and waterbeds. Approximately 18 billion gallons of toxic "produced water" – a byproduct of oil extraction containing drilling fluids, hydrocarbon residues, naturally occurring hazardous substances, and various chemical additives used to facilitate extraction – were released into local water sources. This contamination adversely affected aquatic ecosystems and trophic chains. Furthermore, gas flaring, oil spills from compromised pipelines, and the dispersal of waste on unpaved roads contributed to additional pollution. The environmental impacts resulting from Texaco's operations persisted long after the company's departure from Ecuador in 1992, causing continued ecological degradation and presenting ongoing risks, including contributions to climate change.

A significant example of extractivism in the Amazon pertains to aluminum production throughout Brazil, Guyana, Suriname, and Venezuela. Since the early twentieth century, the Amazon has served as an important source of bauxite, and from the 1960s onward, the development of the aluminum industry prompted the initiation of large hydroelectric projects in the region (Lobach 2024). Although the global aluminum sector is currently progressing toward sustainability, sites in the Amazon continue to carry the legacy of environmental degradation caused by earlier practices. In Guyana, for instance, the government fostered a conducive environment for industry growth by establishing partnerships with international corporations such as the Aluminum Company of America and Reynolds Aluminum Company. Major investments from these companies have supported bauxite mining, refining, and the development of transport infrastructure like railways and ports to help export bauxite. These activities have caused deforestation, harmed land quality, and polluted rivers and local ecosystems. In certain regions, local communities have faced displacement and lost their livelihoods, with indigenous peoples experiencing particularly significant effects (Lobach 2024).

A significant case in the mining sector is the renowned Serra do Carajás, located in the southeastern Brazilian Amazon. This region has been pivotal for large-scale industrial development due to its abundant mineral resources, especially iron ore. Discovered in the 1960s and developed as a major mining center in the 1970s, the Carajás Mining Complex ranks among the largest iron ore mines globally. The project was launched by the Brazilian government in partnership with Companhia Vale do Rio Doce (CVRD), now known as Vale. The complex's expansion has included extensive infrastructure development – such as roads, railways, and power lines – to support the efficient transportation of extracted minerals. Nonetheless, the rapid expansion of industrial activity has resulted in extensive deforestation throughout the adjacent rainforest. This process releases substantial quantities of stored carbon from both vegetation and soil into the atmosphere. The conversion of land for mining operations and associated infrastructure has not only eliminated considerable forested areas but also fragmented ecosystems, reducing their capacity to absorb carbon dioxide and increasing the region's vulnerability to climate change (Fearnside 2015).

The history of Serra dos Carajás has been characterized by ongoing tensions between economic development and environmental conservation. Indigenous groups, including the Xikrin and the Kayapo, as well as local communities, have consistently raised concerns regarding environmental degradation and displacement resulting from mining activities. These stakeholders contend that the expansion of Vale's operations has contributed to the loss of ancestral territories, disruption of traditional lifestyles, and contamination of water resources (Bunker 1985). Throughout the 1980s and 1990s, as Vale expanded its operations, these disputes escalated, resulting in increased violent confrontations and legal proceedings. Vale has been criticized by environmentalists for contributing to deforestation and environmental harm, including the loss of biodiversity and changes to local water cycles (Nepstad et al. 2006). Although Vale has come under pressure in recent years to implement more sustainable methods, significant environmental damage has already occurred in the region. This includes more erratic rainfall, extended periods of drought, and warmer temperatures. Mining operations in Serra dos Carajás highlight how extracting resources from ecologically sensitive places such as the Amazon not only accelerates climate change but also intensifies socio-environmental disputes.

Alongside many other examples, extractivist activities and deforestation have transformed many natural and urban environments into wastelands which now stand as Anthropocene "ghosts" (Tsing 2017), symbolizing the lasting impact of environmental degradation and climate change that continue to haunt the present and future of the Amazon.

Ecology and Climate Research in the Amazon

During the Great Acceleration, significant socio-environmental changes reshaped the Amazon landscape, while scientific knowledge of the region also expanded, highlighting its role as a complex ecological system crucial to the global climate. Initial research primarily focused on cataloguing the Amazon's animals, plants, and terrain (Sá, Sá, and Kury 2024), but often lacked a holistic view of how water, soil, and forests interact ecologically. It was only with the emergence of climate science in the 1970s that the Amazon's climate began to be included within this broader environmental understanding. Ironically, some of these scientific advancements took place within institutions that were initially established to promote Amazon colonization policies focused on exploiting natural resources and supporting extractive urban growth. To clarify this topic, this subchapter will trace the history of climate science in and concerning the Amazon, illustrating how it helped transform the region into a central arena for global climate politics by the late twentieth century – a status reinforced with the decision to host COP 30 there in 2025.

The foundation for a comprehensive understanding of the Amazon began with water studies, led by German limnologist Harald Sioli (1910–2004) in the early 1940s. Sioli identified three main types of Amazonian waters – white, black, and clear – and linked their characteristics to the geology, vegetation, and soils found in each region. His observations about sediment-rich whitewater rivers like the Amazon, as well as nutrient-poor blackwater and clearwater rivers, overturned the belief that the area's biodiversity was mainly due to fertile soils. Instead, he emphasized water as the key ecological connector, tying together landscapes and influencing the Amazon's range of ecosystems. At the Agronomic Institute of the North (IAN) in Brazil, Sioli worked alongside Felisberto Camargo to advance farming techniques tailored to the *várzeas*, the fertile floodplains nourished by whitewater rivers, while also considering the limitations of the more common *terra firme* soils (Sioli 1984; Sá and Silva 2019; Silva 2024).

In 1947, Camargo and Sioli participated in preliminary discussions regarding the establishment of the International Hylean Amazon Institute (IIHA), a UNESCO-led initiative aimed at fostering interdisciplinary research and development in the Amazon region of Brazil. The project was ultimately terminated due to nationalist opposition (Maio and Sá 2000). In response, the Brazilian government founded the National Institute for Amazonian Research (INPA) in 1952 to promote Amazonian development through research in ecology and resource management. Despite operating with limited resources, INPA launched studies encompassing botany, ecology, silviculture, medicinal plants, and plant chemistry. Collaborative efforts with international scientists, including André Aubréville from UNESCO, contributed significantly to the expansion of INPA's ecological research and enhanced understanding of Amazonian vegetation (Panzu 2015; Weigel 2014).

Sioli briefly served as director of INPA's hydrobiology laboratory before returning to West Germany in 1957, where he assumed leadership of the Max Planck Institute for Limnology. At the institute, he continued his research on Amazonian ecology and assembled an interdisciplinary team that maintained strong affiliations with INPA. By 1969, a formal collaborative agreement was established between INPA and the Max Planck Institute for Limnology, thereby advancing studies of Amazonian aquatic ecosystems. Sioli's conceptualization of *landscape ecology* integrated water analysis into broader examinations of soil and vegetation interactions. His observations regarding soil impoverishment prompted further research into nutrient cycling, plant adaptations, symbiotic relationships, and forest structure, aiming to address the paradox of the Amazon's high biodiversity in spite of nutrient-poor soils (Klinge 1983; Herrera et al. 1978; Jordan and Medina 1977; Moran 1982; Silva 2024).

Research conducted by soil specialist Hans Klinge and biologist Ernst Fittkau of the Max Planck Institute for Limnology, alongside INPA botanist William Rodrigues, has significantly contributed to advancements in this field. Complementing soil mapping initiatives supported by UNESCO and FAO, Klinge's work elucidated the heterogeneity of Amazonian soils, although their generally nutrient-poor profile remains a prominent characteristic (Moran 1982; Klinge 1983; Sioli 1984). Subsequent investigations by these researchers corroborated Sioli's earlier observations regarding the relationship between geochemical water diversity and landscape nutrient status. Collectively, Klinge (1983) and Fittkau (1983) posited that the Amazon operates as an effective nutrient-retention system, underpinned by dense root mats, rapid nutrient uptake, and closed nutrient cycling. This closed nutrient cycle maintains the forest's biomass and biodiversity despite the relative paucity of soil nutrients (Herrera et al. 1978; Klinge 1983).

In the 1970s, research carried out at San Carlos de Río Negro in Venezuela helped confirm how the Amazon preserves nutrients and deepened scientific understanding of these ecological systems. This joint effort included organizations such as the Instituto Venezolano de Investigaciones Científicas (IVIC), with ecologists Rafael

Herrera and Ernesto Medina, the University of Georgia, and the Max Planck Institute for Limnology. In 1977, their work was incorporated into UNESCO's Man and the Biosphere (MAB) program, which combined studies of ecosystems with local conservation strategies. The program emphasized notable adaptations like multilayered forests and the interactions between roots and leaf litter (Jordan and Medina 1977; Herrera et al. 1978).

Botanical research has been instrumental in documenting Amazonian biodiversity. The New York Botanical Garden's *Flora Amazonica* initiative, established in 1952, systematically identified and classified the region's plant species through partnerships with INPA and the Museu Paraense Emílio Goeldi. Revitalized in 1977 under Ghillean Prance's direction, the project refined phytogeographic frameworks and delineated seven discrete Amazonian regions. Advances in taxonomy have underscored the ecological complexity of the area, spurring further investigation into the evolutionary and ecological foundations of tropical biodiversity (Prance 1978). Additionally, the significance of Amazonian biota was emphasized in 1966 at the Symposium for Amazonian Biota (Simpósio da Biota Amazônica), convened during the Association for Tropical Biology's conference in Belém, Pará. The symposium's proceedings offer an extensive compilation of scientific knowledge relating to Amazonia, encompassing ecological insights. A comparable event occurred three years later in Florencia, the capital of Caquetá Department in Colombia.

To advance economic development and facilitate comprehensive resource assessment, the Brazilian military government launched the RADAM-Brasil project in 1975. This extensive initiative utilized remote sensing techniques, notably radar imaging, to systematically map soils, vegetation, waterways, minerals, and other natural assets throughout Brazil, with particular emphasis on the Amazon Basin. The RADAM-Brasil program produced a substantial dataset that greatly improved scientific knowledge of Amazonian ecosystems, specifically regarding soil composition, vegetation distribution, and landscape patterns (Cruz and Silva 2022). The project not only informed domestic policies but also inspired similar initiatives abroad, such as Colombia's PRO-RADAM, which sought to apply comparable methodologies to its own territory.

The development of comprehensive datasets has established the Amazon as a valuable site for testing biodiversity theories, including Wilson and MacArthur's island biogeography, which contributed to the SLOSS (Single Large or Several Small Reserves) debate. Accelerated deforestation during Brazil's military government transformed the region into a natural laboratory for examining the impact of forest fragmentation on ecosystems, climate, and biodiversity. The 1965 Forest Code in Brazil permitted the clearance of up to 50 percent of private land, further increasing rates of deforestation and habitat fragmentation. In response, American biologist Thomas Lovejoy initiated the Biological Dynamics of Forest Fragments Project (BDFFP) in 1978 in collaboration with INPA and the World Wildlife Fund

(WWF). This significant project investigated the effects of forest fragmentation on species diversity, ecosystem dynamics, and local microclimates. Currently managed by INPA, the BDFFP continues to inform conservation policies amidst ongoing deforestation (Gama 1997).

The Brazilian military government's rapid development programs caused significant ecological damage, prompting experts to investigate how human activity was altering the Amazon's ecosystem structure and function. For example, INPA's ecology department researched the environmental consequences of quickly converting forests into pastures along the Trans-Amazonian Highway. Since 1978, American ecologist Philip M. Fearnside, who works at INPA, has expanded these studies to assess the human carrying capacity of tropical agroecosystems. Fearnside became a prominent authority on the environmental and climate impacts of major Amazonian projects like roads and dams (Fearnside 1989, 2015), with particular attention to greenhouse gas emissions. Major dams such as Tucuruí, Samuel, Balbina, Santo Antonio, Jirau, and Belo Monte have been widely analyzed for their ecological impact. Many researchers specializing in floodplain areas – such as *varzeas* and *igapos* – focused on how large dams affect aquatic environments and the landscapes where water meets land. While there have been important advances in understanding the interactions between Amazonian water, soil, and forests, the influence of climate remains relatively understudied.

Systematic research into the Amazonian climate commenced in the early 1970s, underscoring the rainforest's significant impact on both regional and global water and carbon cycles. These findings highlighted the Amazon's crucial function within the Earth system and reinforced the imperative to integrate conservation priorities with development initiatives. During this period, Brazilian researcher Eneas Salati (1933–2022), then a professor at the Centro de Energia Nuclear na Agricultura (CENA) at the University of São Paulo in Piracicaba, led a comprehensive scientific study that established an intricate relationship between the rainforest and climate through the hydrological cycle. Trained in nuclear physics and isotopic hydrology in the United States during the "Atoms for Peace" era, Salati received support from Brazil's National Commission of Nuclear Energy (CNEN) and the International Atomic Energy Agency (IAEA). He coordinated a collaborative network of Brazilian and international researchers who conducted isotopic analyses on thousands of samples collected from rivers, precipitation, and water vapor, initially to inform development programs under the military regime (Bailão 2024).

Salati and his team determined that nearly half of Amazonian precipitation is produced by the forest itself through evapotranspiration, challenging the prevailing climatological theory that attributed rainfall primarily to humidity transported inland by equatorial trade winds from the Atlantic Ocean. Utilizing satellite data analyzed by the Brazilian Institute for Space Research (INPE), they further demonstrated that the Amazon exports moisture to distant regions of South America.

Consequently, deforestation could disrupt this delicate forest-climate equilibrium, posing risks to both development projects and the rainforest's long-term viability. Through publications in reputable international journals, Salati and his colleagues disseminated these results and advocated for policies prioritizing sustained forest utilization and protection, representing a significant evolution from their earlier support of developmentalist programs to internationally recognized environmental advocacy (Salati and Vose 1984: 137; Bailão 2024).

In 1979, the World Meteorological Organization (WMO) convened its First World Climate Conference in Geneva, where scientists addressed the issue of rising greenhouse gas (GHG) concentrations in the atmosphere – particularly atmospheric carbon dioxide – and their potential implications for the global climate and human societies (WMO 1979: 743). The outcomes of this conference catalyzed the formation of international research initiatives and ultimately led to the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988. Deforestation was identified as a significant source of carbon emissions in tropical nations, while urban and industrial pollution remained central concerns in developed countries. Since the 1972 UN Conference on the Human Environment in Stockholm, Brazil had maintained that developing countries should not limit their economic growth due to environmental regulations, contending that responsibility for environmental mitigation fell primarily on the Global North (Morgan 2024: 62–64).

During the final years of Brazil's military dictatorship, amidst growing social, environmental, and political movements, Salati assumed the directorship of INPA (1979–81). He increasingly articulated concerns about the ecological risks associated with Amazonian development projects and anthropogenic climate change, both in media forums and scientific literature. Salati's conceptualization of the Amazon as a system in equilibrium – where climate and vegetation influence one another – provided a foundation for subsequent decades of research (Nobre 2014). In the early 1980s, his work brought him into collaboration with leading scientists such as Thomas Lovejoy, Emilio Moran, Paul Crutzen, and James Lovelock; together, they co-organized workshops and edited publications on Amazonian ecology and climate (Moran 1983; Prance and Lovejoy 1985; Dickinson 1987). Notably, Crutzen was among the first to introduce the concept of the Anthropocene, while Lovelock, alongside microbiologist Lynn Margulis, had previously formulated the Gaia hypothesis.

During the 1980s, scientific interest in vegetation-climate interactions, forest fire impacts on the atmosphere, cycles of bioactive elements, and climate change in the Amazon Basin increased. This surge was spurred by advances in Earth System Science at NASA and the International Biosphere-Geosphere Programme. In 1979 and 1980, Crutzen directed a U.S. National Center for Atmospheric Research (NCAR) team that studied biomass burning and trace gas emissions in Central Brazil's savanna and Amazon rainforest, with assistance from the University of Brasília and INPA (Crutzen et al. 1985; Rojas 2016).

Debates about deforestation rates and mapping methods had persisted since the 1970s, relying on tools like aerial surveys, satellite images, and fieldwork such as Philip Fearnside's research at INPA (Angelo and Azevedo 2024). The military regime backed INPE's space initiatives, installing antennas to capture satellite data across South America. In 1985, NASA, INPE, and INPA jointly measured atmospheric composition above the rainforest. Consistent forest monitoring began later in the decade, championed by Alberto Setzer and his colleagues at INPE. By 1988, INPE established PRODES (Program for the Calculation of Deforestation in the Legal Amazon), which used NASA's remote sensing data to track yearly deforestation rates. These PRODES reports fueled sociotechnical debates about data reliability and political consequences, especially in a context dominated by landholding elites (Angelo and Azevedo 2024).

Following two decades of fiscal incentives that encouraged land-use changes, deforestation rates increased significantly, attracting attention from international media and the World Bank and leading to policy reforms. From 1988 to 1992, Brazil adopted a new constitution that incorporated environmental and indigenous protections, while global platforms began addressing climate change and conservation issues. This period saw the formation of the IPCC and the prohibition of chlorofluorocarbons (CFCs). The 1992 Earth Summit in Rio de Janeiro resulted in conventions focused on biodiversity and climate change and fostered commitments among Amazonian countries to consider "conservation as a collective interest" (Josse et al. 2021: 9). As a result, the number of protected areas in the region expanded considerably, surpassing 500 by 2024 and reflecting diverse levels of protection and land use.

Climate modeling has significantly enhanced the scientific understanding of climate systems and facilitated the projection of future scenarios resulting from greenhouse gas emissions (Edwards 2010). General Circulation Models (GCMs), initially developed by institutions in the United States, Western Europe, and Japan, have been instrumental in simulating global climate dynamics. These models serve as key references during IPCC deliberations, providing scenario analyses that inform government strategies for adaptation and mitigation, despite ongoing debates about their underlying assumptions and uncertainties. Since the 1980s, researchers at INPE have actively used, modified, and developed numerical models to improve meteorological and climate forecasting capabilities, establishing Brazil as one of the few countries with sophisticated climate modeling infrastructure (Bailão 2022; Miguel 2017; Miguel, Mahony, and Monteiro 2019). By the late 1980s, Carlos Nobre, a meteorologist at INPE, employed GCMs during his postdoctoral fellowship in the United States to examine the effects of Amazonian deforestation. His simulations forecasted warmer conditions and extended dry seasons – resembling savanna environments in Central Brazil – and identified this transformation process as "savannization" (Nobre, Sellers, and Shukla 1991).

Nobre oversaw INPE's participation in several prominent international research initiatives focused on the Amazon. During the 1990s, he led the Anglo-Brazilian Amazonian Climate Observations Study (ABRACOS), which incorporated micrometeorological measurements, mesoscale observations, and general circulation model (GCM) experiments (Gash and Nobre 1997). In 1998, he served as coordinator for the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), the largest scientific program of its kind in the region, engaging over one thousand researchers and two hundred institutions from Brazil, the United States, and Europe (Lahsen 2009). Supported chiefly by NASA and Brazil's Ministry of Science and Technology, the LBA aimed to produce comprehensive datasets to inform and improve biogeochemical, ecological, and climate modelling efforts (Schor 2008: 82–87).

This research aimed to address the region's deficiency in long-term measurements, observations, and experimental studies of ecological and geophysical processes. The LBA examined the Amazon's significance within both regional and global contexts, specifically assessing the impacts of climate and land use changes on its biological, chemical, and physical functions (Lahsen and Nobre 2007: 63). The project sought to analyze connections between the biosphere and atmosphere by measuring heat flux, moisture balance, and greenhouse gas emissions through remote sensing techniques and a network of observation towers (Schor 2008). The predominance of natural sciences over applied social sciences in the research agenda – largely influenced by NASA's funding priorities – reflects institutional interests in remote sensing and global environmental change (Lahsen and Nobre 2007).

A primary objective of the LBA (Large-Scale Biosphere-Atmosphere Experiment in Amazonia) was to determine whether the Amazon functioned as a carbon sink, source, or remained carbon-neutral – an inquiry that sparked intense scientific and political friction (Lahsen 2009). Greenhouse gas (GHG) concentrations became a geopolitical priority for the United States and the European Union, particularly following the 1997 Kyoto Protocol (Lahsen 2009; Monteiro, Seixas, and Vieira 2014). As industrialized nations faced mandatory emission targets, the Amazon's "ecosystem services" and potential for carbon trading took center stage. However, defining the basin's role was hindered by its immense scale, spatial heterogeneity, and the complex seasonal variations in its soil and vegetation (Lahsen 2009).

By the early 2000s, INPE (National Institute for Space Research) alerted the Brazilian government to surging deforestation, driven by a global commodities boom in soy and beef and exacerbated by lax environmental enforcement. Annual forest loss peaked at over 25,000 km^2 in 2003–04 before targeted interventions under the Lula administration – led by Environment Minister Marina Silva – reversed the trend. This success relied on a multifaceted strategy: enhanced remote sensing, the expansion of protected areas, and stricter agricultural credit policies

(Angelo and Azevedo 2024). However, this data-driven approach faced fierce political resistance from agribusiness interests, who dismissed scientific monitoring as ideologically motivated (Monteiro and Rajão 2017). With land-use changes accounting for 60percent of Brazil's GHG emissions by 2005, curbing deforestation became the nation's primary climate priority. Following a dramatic decline in clearing by 2009, Brazil leveraged its domestic success into a major international commitment, pledging voluntary emission reductions at the COP15 conference in Copenhagen.

Research on Amazonian climate and ecology, such as that pioneered by Salati, initially conceptualized the forest as a pristine environment, largely unaffected by Indigenous populations but significantly altered by subsequent development and colonization. Contemporary scholars, however, have questioned this perspective, emphasizing that biogeochemical cycles are inherently intertwined with human activities – a point illustrated by David Rojas (2016) in his ethnographic work with climate change scientists in Amazonia. Despite these evolving viewpoints, Salati's research agenda has been instrumental in shaping subsequent studies and theories on the Amazon rainforest's ability to influence climate through mechanisms such as moisture recycling, cloud nucleation, biotic pumping, and aerial rivers (see Nobre 2014). Following the initial phase of the LBA and growing global investment in climate change research, further initiatives have emerged. Notable examples include the Green Ocean Amazon (GOAmazon) project, supported by the U.S. Department of Energy, which explores rain formation, cloud nucleation, and the impact of pollution from Manaus on the adjacent rainforest. Additionally, the Amazon Tall Tower Observatory (ATTO) – a 325-meter scientific tower established in 2015 near Manaus by INPA and the Max Planck Institute – serves as a hub for measuring climate variables and investigating both molecular and large-scale atmospheric processes within a forested context.

Peruvian climatologists, such as José Antonio Marengo at INPE and Jhan Carlo Espinoza – formerly of the Instituto Geofísico del Perú and now at France's Institut de Recherche pour le Développement (IRD) – have conducted significant research on climate variability and change in the Amazon. Their findings highlight a rise in extreme weather events over recent decades (Marengo and Espinoza 2015). Marengo, currently the director of Brazil's National Center of Disaster Monitoring and Alerts (CEMADEN), has been using regional models since the early 1990s to study the Amazon. His projections for the next century include up to a 40percent drop in rainfall, greater risks of fires and droughts, and a series of "feedback loops" that could push Amazonian ecosystems – including vegetation, biodiversity, and climate – past critical tipping points, potentially causing irreversible changes (Marengo and Souza Jr. 2018).

Regional initiatives have focused on compiling advanced research concerning the Amazon basin and climate change, often transcending national boundaries. One such effort is the *Atlas de vulnerabilidad hidroclimática de la región Amazónica* (OTCA and CIIFEN 2021), which is supported by the Amazon Cooperation Treaty Organization and the International Research Center on El Niño (CIIFEN) in Guayaquil, Ecuador. This atlas consolidates analyses on the hydro-climatic vulnerabilities faced by Amazonian countries, specifically in relation to increased instances of droughts and floods attributed to climate variability (including El Niño and La Niña events) and global warming, as well as their impacts on local communities and economic activities. The region has witnessed a rising frequency of extreme events, such as the "megadroughts" in 2005, 2010, 2015/16, and 2023/24. The interplay between natural climate variability and human-induced environmental changes remains a subject of ongoing discussion (Marengo et al. 2024).

Another significant regional initiative focused on interdisciplinary research in the Amazon is the Science Panel for the Amazon (SPA), which is structured after the IPCC. The SPA brings together experts from the natural, biological, and social sciences to evaluate current climate change literature and develop policy recommendations. The panel comprises over 200 scientists representing the eight Amazonian countries, French Guiana, and additional international collaborators, all coordinated under the United Nations Sustainable Development Solutions Network (SDSN). The primary objective is to analyze ecological, biogeophysical, and socioeconomic processes and offer guidance on policies promoting conservation and sustainable development. In 2021, Carlos Nobre, in collaboration with 50 other researchers, edited an extensive report featuring thirty four chapters in English, Spanish, and Portuguese, covering topics such as the geological history of the Amazon basin, its climate, ecology, and biogeochemical cycles; the region's Indigenous, colonial, and modern histories; its intertwined cultural, linguistic, and biological diversity; and contemporary socioeconomic drivers, livelihood strategies, and conservation initiatives (Nobre et al. 2021).

The SPA 2021 report identifies the Amazon as a pivotal component of the Earth System, significantly influencing regional and global precipitation, temperature regulation, circular dynamics, and estuarine discharge. Simultaneously, the Amazon is characterized as a complex landscape comprising varied climates, terrestrial and aquatic ecosystems, soils, and urban environments. The region necessitates multifaceted and interdisciplinary research approaches; notably, the SPA 2021 edition incorporated historical, archaeological, and anthropological perspectives, along with the participation of Indigenous coauthors. Indigenous leaders and movements – including Davi Kopenawa and Ailton Krenak – as well as prominent anthropologists and archaeologists such as William Balée, Manuela Carneiro da Cunha, Eduardo Neves, and Charles Clement, have highlighted the significant role of Indigenous peoples in shaping Amazonian forests. Their contributions over millennia include domestication practices, landscape transformations, and the management of both domesticated and wild species (Balée 2013; Clement et al.

2015; Cunha, Magalhães, and Adams 2021–24; Kopenawa and Albert 2013; Krenak 2024; Neves et al. 2021).

Anthropologists Manuela Carneiro da Cunha and Sônia Barbosa Magalhães, together with environmental scientist Cristina Adams, are overseeing an extensive intercultural research initiative examining the contributions of Indigenous and traditional communities to biodiversity. This project is supported by the Brazilian Society for the Progress of Science (SBPC) and Brazilian research agencies (Cunha, Magalhães, and Adams 2021–24). The work comprises multiple chapters authored by numerous contributors, including Indigenous writers, and analyzes the complex relationships among traditional territories, lifestyles, and knowledge systems related to animals, plants, landscapes, water, and climates. Through integrated practices and forms of knowledge, Indigenous and traditional peoples serve not only as stewards of biodiversity but also actively value, cultivate, and conserve a wide range of species and ecosystems (Emperaire 2021). Human well-being in these contexts is intricately connected to forests and other non-human life, as their agroforest systems function without exploitation or control of local flora and fauna, reliance on fertilizers, or adoption of Western production methods that diminish biodiversity (Lima, Oliveira, and Shiratori 2021).

Conclusions: Climate Change Legacies in the Amazon and Beyond

The Great Acceleration, which has dramatically increased the planet's trajectory toward a climate crisis, has produced complex consequences for tropical regions such as the Amazon. On one side, this period ushered in substantial scientific advancements in understanding Amazonian ecology and its interactions with global climate systems, contributing notably to atmospheric sciences, ecological studies, and Earth system modeling. Conversely, Amazonian ecosystems have undergone significant transformation due to local factors – including arson and deforestation – as well as global influences like climate change (Flores et al. 2024). Recent research demonstrates that rainfall across approximately 40 percent of the Amazon has declined to levels that could potentially shift vast areas toward savanna-like conditions (Staal et al. 2020). This juxtaposition underscores the ongoing tension between increased environmental awareness and the persistence – and even intensification – of the driving forces behind ecological degradation. Consequently, an important inquiry arises: How do the case studies analyzed herein inform potential future scenarios for both the Amazon rainforest and the broader planetary context, particularly regarding climate change?

Firstly, the importance of adopting a critical perspective in interdisciplinary research on human-environment interactions during the Anthropocene is emphasized. While quantitative data and models are fundamental for comprehending the scale of climate change, they alone have not resulted in substantial progress toward mitigation. It is essential to integrate these scientific findings with socioeconomic and political frameworks, drawing upon insights from history, economics, environmental science, and policy studies. This comprehensive approach enables a deeper understanding of how anthropogenic activities have altered planetary boundaries and helps inform effective strategies for addressing climate challenges, particularly in relation to policy and governance responses.

A further critical consideration relates to addressing the enduring misconception that climate change is an issue confined to distant, "pristine" forests – a perspective deeply rooted in Western conceptualizations of the separation between nature and culture. Brondizio (2016) has highlighted the notable absence of Amazonian cities in discussions surrounding climate change in the region. Notably, 80 percent of the Amazon's population resides in urban areas, including three metropolitan regions – Manaus and Belém in Brazil, and Santa Cruz de la Sierra in Bolivia – each with populations exceeding two million, as well as Iquitos in Peru and Porto Velho in Brazil, each with more than 450,000 inhabitants. As illustrated in the aforementioned case studies, these urban centers are closely linked to systems of resource extraction and deforestation. Furthermore, evidence from recent extreme weather events indicates that such large urban areas will be among the first to experience significant consequences of climate change. Incidents of flooding, heatwaves, and air pollution – occurring both within and outside the Amazon, such as in Porto Alegre and São Paulo – highlight how climate change affects densely populated environments. These developments challenge outdated dichotomies between *nature* and *urban life*, emphasizing the imperative for comprehensive strategies that integrate environmental, social, and urban planning considerations. Additionally, it is crucial to assess interventions and their impacts across extended historical timelines, encompassing actions both prior to and following the twentieth century. As noted by Roberts et al. (2024), recognizing historical and regional variations over the longue durée can provide valuable long-term perspectives that inform contemporary approaches to urban challenges by drawing on lessons from the past.

Finally, in examining the legacies of climate change, it is evident that the sustainability and ecological justice of the Amazon biome are intrinsically linked to practices incorporating the traditional knowledge of Indigenous communities. The cases discussed facilitate a comparative analysis between contemporary extractive-capitalist urbanism and urban approaches led by Indigenous groups with respect to tropical forests. Current archaeological and historical research increasingly suggests that the ecological characteristics of the Amazon are, at least in part, the result of environmental modifications undertaken by various human societies, including those who developed sophisticated urban settlements (Heckenberger and Goés Neves 2009; Roberts 2021). Over millennia, Indigenous populations have both coexisted with and shaped the Amazon through diverse practices. From the sixteenth century onwards, European colonization marginalized and decimated Indigenous inhabitants, introduced new systems of labor exploitation, initiated cycles of resource extraction, capital movement, and urban logics centered on extractive industries that continue to affect post-colonial Amazonian states and reinforce efforts to access what is perceived as an inexhaustible resource base.

In addition, Indigenous communities play a crucial role in both adapting to and mitigating climatic, economic, and political challenges, a responsibility they have shouldered for over five centuries. Their approach emphasizes living *with* forests, rather than *in spite* of them. Recent developmental initiatives have targeted Indigenous lands and local ecosystems with proposed infrastructure such as roads, expansion of pastures, mining activities, and oil and gas extraction, frequently resulting in violence and land appropriation (Merino 2024). The protection of Indigenous sovereignty and reciprocal ecological practices is essential for mitigating deforestation, addressing climate change, and preserving biodiversity (Barreto Filho et al. 2021; Cunha, Magalhães, and Adams 2021–24). While non-Indigenous researchers often highlight the necessity of forest conservation and the reduction of carbon and greenhouse gas emissions to prevent catastrophic environmental feedback loops and tipping points in the Amazon (Nobre 2014), Indigenous leaders have increasingly drawn international attention by sharing their ancestral knowledge of the complex relationship between forests and climate – referred to by Yanomami shaman Davi Kopenawa as the 'forest-world' (Kopenawa and Albert 2013). Indigenous and traditional peoples play a recognized and quantifiable role in forest protection, with their territories serving as effective barriers against deforestation. To preserve the Amazon's ecological and cultural diversity, it is therefore critical to maintain, protect, and formally recognize these territories, as well as to include Indigenous and traditional communities in scientific and political discourse (Josse et al. 2021). Scholars such as Davi Kopenawa highlight that meaningful understanding of the Amazon emerges through relationships rather than material possessions. Their approach to knowledge prioritizes the maintenance of interconnected systems that support life, rather than the exercise of authority over non-human entities (Kopenawa and Albert 2013; Taddei 2022). These groups advocate for the official recognition of their territories as a climate policy measure (APIB 2024). Moreover, their ways of living and epistemologies contribute valuable concepts and agrobiological practices that foster a more nuanced, historically informed, and socially contextualized comprehension of the Amazon's biological, ecological, and cultural interconnections (Athayde et al. 2021: 25).

References

Acker, Antoine. 2018. *Volkswagen in the Amazon: The Tragedy of Global Development in Modern Brazil*. Cambridge: Cambridge University Press.

Angelo, Claudio, and Tasso Azevedo. 2024. *O silêncio da motosserra: quando o Brasil decidiu salvar a Amazônia*. São Paulo: Companhia das Letras.

Articulation of Indigenous Peoples of Brazil [APIB]. 2024 "We are the answer." https://apiboficial.org/2024/10/26/we-are-the-answer/?lang=en.

Athayde, Simone, Glenn Shepard, Thiago Cardoso, et al. 2021. "Chapter 10: Critical Interconnections between Cultural and Biological Diversity of Amazonian Peoples and Ecosystems." In *Amazon Assessment Report 2021*, ed. Carlos Nobre, A. Encalada, E. Anderson, et al. New York: United Nations Sustainable Development Solutions Network.

Bailão, André Secchieri. 2022. "Imagining Nations and Producing Climate-Change Knowledge in Brazil." In *The Anthropocene of Weather and Climate*, ed. Paul Sillitoe, 271–293. New York: Berghahn.

________. 2024. "Isótopos das águas brasileiras para o desenvolvimento: a hidrologia isotópica, os peritos do Centro de Energia Nuclear na Agricultura e de organizações internacionais no Nordeste e na Amazônia (1968–1978)." *Revista Brasileira de História da Ciência* 17, no. 1: 160–186.

Balée, William. 2013. *Cultural Forests of the Amazon: A Historical Ecology of People and Their Landscape*. Tuscaloosa: University of Alabama Press.

Barreto Filho, Henyo Trindade, Adriana Ramos, et al. 2021. „Chapter 31: Strengthening Governance and Management of Lands and Natural Resources: Protected Areas, Indigenous Lands, and Local Communities' Territories." In *Amazon Assessment Report 2021*, ed. Carlos Nobre, A. Encalada, E. Anderson, et al. New York: United Nations Sustainable Development Solutions Network.

Brienen, Roel, Oliver Phillips, Ted Feldpausch, Emanuel Gloor, et al. 2015. "Long-term decline of the Amazon carbon sink." *Nature* 519, no. 7543: 344–348.

Brondizio, Eduardo, Eduardo Fernandez, and Ziad A. Salem. 2013. "A microcosm of the Anthropocene: Socioecological complexity and social theory in the Amazon. Perspectives." *Journal de la Reseaux Francaise d'Institut d'études avancées* (RFIEA) 10: 10–13.

Brondizio, Eduardo. 2016. "The Elephant in the Room: Amazonian Cities Deserve More Attention in Climate Change and Sustainability Discussions." *ClimaCom* 3, no.5: 15–26.

Bunker, Stephen G. 1985. *Underdeveloping the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern State*. Chicago: University of Chicago Press.

Campaña, Pablo. 2023. "La mirada estatal de la Amazonía: la planificación de la selva en Brasil, Colombia, Ecuador y Perú entre 1968–1978." *Historia Crítica*, 88: 93–115.

Clement, Charles R., William M. Denevan, Michael J. Heckenberger, et al. 2015. "The Domestication of Amazonia Before European Conquest." *Proceedings B. The Royal Society Publishing* 282, no. 1812.

Correa, Felipe. 2016. *Beyond the City: Resource Extraction Urbanism in South America*. Austin: University of Texas Press.

Conklin, Beth, and Laura Graham. 1995. "The Shifting Middle Ground: Amazonian Indians and Eco-Politics." *American Anthropologist* 97, no. 4: 695–710.

Crutzen, Paul, A. Delany, J. Greenberg, et al. 1985. "Observations of Air Composition in Brazil Between the Equator and 20°S During the Dry Season." *Acta Amazonica*, 15, no. 1–2: 77–119.

Cruz, Leandro Gomes Moreira, and Claiton Marcio Da Silva. 2022. "The clouds against progress: technoscience, environment and the U.S./Brazil 'Radar in Amazon Project' (RADAM) (1970–1975)." *Brasiliana: Journal for Brazilian Studies* 10, no. 2: 240–257.

Cunha, Manuela Carneiro, Sônia Barbosa Magalhães, and Cristina Adams, eds. 2021–24. *Povos tradicionais e biodiversidade no Brasil: Contribuições dos povos indígenas, quilombolas e comunidades tradicionais para a biodiversidade, políticas e ameaças*. São Paulo: Sociedade Brasileira para o Progresso da Ciência-SBPC.

Dickinson, Robert E. ed. 1987. *The Geophysiology of Amazonia: Vegetation and Climate Interactions*. New York: John Wiley & Sons; The United Nations University.

Edwards, Paul N. 2010. *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge: The MIT Press.

Emperaire, Laura. 2021. "Seção 7 – Gerar, Cuidar e Manter a Diversidade Biológica." In *Povos tradicionais e biodiversidade no Brasil: Contribuições dos povos indígenas, quilombolas e comunidades tradicionais para a biodiversidade, políticas e ameaças, ed. Manuela Carneiro Cuhna, Sônia Barbosa Magalhães, and Cristina Adams*. São Paulo: Sociedade Brasileira para o Progresso da Ciência-SBPC.

Fatheuer, Thomas. 2019. *Amazonien heute: Eine Region zwischen Entwicklung, Zerstörung und Klimaschutz*. Berlin: Heinrich-Böll-Stiftung.

Fearnside, Philip M. 1989. "Brazil's Balbina Dam: Environment Versus the Legacy of the Pharaohs in Amazonia." *Environmental Management* 13, no. 4: 401–423.

__________.1990. "Environmental Destruction in the Brazilian Amazon." In: *The Future of Amazonia*, ed. David Goodman et al. London: Palgrave Macmillan. https://doi.org/10.1007/978-1-349-21068-8_8.

________. 2015. "Highway Construction as a Force in the Destruction of the Amazon Forest." In *Handbook of Road Ecology*, 414–424. John Wiley & Sons, Ltd.

________. 2016. Tropical Dams: "To Build or Not to Build?" *Science* 351, no. 6272: 456–457.

Feichtner, Maximilian. 2023. *The Metamorphosis of the Amazon*. Cambridge: Cambridge University Press.

Fittkau, Ernst J. 1983. “Grundlagen der Ökologie Amazoniens – Versuch einer Zusammenschau.” *Spixiana, Zeitschrift für Zoologie* 9: 201–218.

Gama, William N.G. 1997. “O PDBFF (INPA/WWF-US/Smithsonian): Uma Base de Pesquisa Científica Norte-Americana na Amazônia Brasileira.” Master’s thesis, NAEA (Núcleo de Altos Estudos Amazônicos)/ Universidade Federal do Pará.

Gash, John, and Carlos Afonso Nobre. 1997. “Climatic Effects of Amazonian Deforestation: Some Results from ABRACOS.” *Bulletin of the American Meteorological Society* 78, no. 5: 823–830.

Global Witness. 2024. “Missing Voices. The violent erasure of land and environmental defenders.” September 2024. https://globalwitness.org/en/campaigns/land-and-environmental-defenders/missing-voices/.

Gudynas, Eduardo. 2009. “Diez tesis urgentes sobre el nuevo extractivismo.” In *Extractivismo, política y sociedad*, ed. Centro Andino de Acción Popular, 187–225. Quito: Centro Andino de Acción Popular.

Harvey, David. 2001. *Spaces of Capital: Towards a Critical Geography*. New York: Routledge.

Hecht, Suzanne, Marianne Schmink, Rebecca Abers, et al. 2021. “Chapter 14: The Amazon in motion: Changing politics, development strategies, peoples, landscapes, and livelihoods.” In *Amazon Assessment Report 2021*, ed. Carlos Nobre, Andrea Encalada, Elizabeth Anderson, et al. New York: United Nations Sustainable Development Solutions Network.

Heckenberger, Michael, and Eduardo Góes Neves. 2009. “Amazonian Archaeology.” *Annual Review Anthropology* 38: 251–266.

Herrera, Rafael, Carl F. Jordan, Hans Klinge, et al. 1978. “Amazon Ecosystems: Their Structure and Functioning with Particular Emphasis on Nutrients.” *Interciência* 3, no. 4: 223–232.

Hirschman, Albert. 1981. *Essays in Trespassing: Economics to Politics and Beyond*. Cambridge: Cambridge University Press.

Jordan, Carl F., and Ernesto Medina. 1977. “Ecosystem Research in the Tropics.” *Annals of the Missouri Botanical Garden* 64, no. 4: 737–745.

Josse, Carmem, Silvia de Melo Futada, Martin von Hildebrand, et al. 2021. “Chapter 16: The State of Conservation Policies, Protected Areas, and Indigenous Territories, From the Past to the Present.” In *Amazon Assessment Report 2021*, ed. Carlos Nobre, Andrea Encalada, Elizabeth Anderson, et al. New York: United Nations Sustainable Development Solutions Network.

Klinge, Hans. 1983. “Forest Structures in Amazonia.” *The Environmentalist* 3, no. 5: 13–23.

Kopenawa, Davi, and Bruce Albert. 2013. *The Falling Sky: Words of a Yanomami Shaman*. Trans. Nicholas Elliott, and Alison Dundy. Cambridge: Belknap Press/Harvard University Press.

Krenak, Ailton. 2024. *Ancestral Future*. Trans. Jamille Pinheiro Dias. London: Polity.

Lahsen, Myanna. 2009. "A Science-Policy Interface in the Global South: The Politics of Carbon Sinks and Science in Brazil." *Climatic Change* 97, no. 3–4: 339–372.

Lahsen, Myanna, and Carlos A Nobre. 2007. "Challenges of Connecting International Science and Local Level Sustainability Efforts: The Case of the Large-Scale Biosphere–Atmosphere Experiment in Amazonia." *Environmental Science & Policy* 10, no. 1: 62–74.

Le Preste, Philippe. 1989. *The World Bank and the Environmental Challenge*. Toronto: Susquehanna University Press.

Lewis, Simon L., and Mark A. Maslin. 2015. "Defining the Anthropocene." *Nature* 519, no. 7542: 171–180.

Lima, Ana Gabriela Morim de, Joana Cabral de Oliveira, and Karen Shiratori. 2021. "Seção 8 – Conhecimentos Associados à Biodiversidade." In *Povos tradicionais e biodiversidade no Brasil: Contribuições dos povos indígenas, quilombolas e comunidades tradicionais para a biodiversidade, políticas e ameaças*, ed. Manuela Carneiro Cuhna, Sônia Barbosa Magalhães, and Cristina Adams. São Paulo: Sociedade Brasileira para o Progresso da Ciência-SBPC.

Lobach, Simon. 2024. "A Socio-Environmental History of the Aluminium Industry in Amazonia." PhD dissertation, Geneva Graduate Institute.

Mahony, Mark, and Geoffrey Endfield. 2018. "Climate and Colonialism." *WIREs Climate Change* 9, no. 2.

Maio, Marcos Chor, and Magali Romero Sá. 2000 "Ciência na periferia: a Unesco, a proposta de criação do Instituto Internacional da Hiléia Amazônica e as origens do Inpa." *História, Ciências, Saúde-Manguinhos* 6: 975–1017.

Marengo, Jose A., and Carlos Souza Jr. 2018. *Climate change: impacts and scenarios for the Amazon*. São Paulo: Alana, APIB, Article 19, Conectas Direitos Humanos, Engajamundo, Greenpeace, SEIEE, PPGCA/USP.

Marengo, Jose A. Ana P. Cunha, Jhan-Carlo Espinoza, et al. 2024. "The Drought of Amazonia in 2023–2024." *American Journal of Climate Change* 13, no. 3: 567–597.

Marengo, Jose A., and Jhan Carlo Espinoza. 2015. "Extreme Seasonal Droughts and Floods in Amazonia Causes, Trends and Impacts." *International Journal of Climatology* 36, no. 3: 1033–1050.

Martins, Rafael Moro. 2024. "Recordes de incêndio na Amazônia são obra de grileiros e pecuaristas, mas poucos são presos." *Sumaúma*, December 4. https://sumauma.com/recordes-de-incendio-na-amazonia-sao-obra-de-grileiros-e-pecuaristas-mas-poucos-sao-presos/.

McNeill, John R., and Peter Engelke. 2014. *The Great Acceleration: An Environmental History of the Anthropocene since 1945*. Cambridge: Belknap Press/Harvard University Press.

Merino, Roger. 2024. "The open veins of the Amazon: rethinking extractivism and infrastructure in extractive frontiers." *The Journal of Peasant Studies* 51, no. 6: 1387–1408.

Miguel, Jean Carlos Hochsprung. 2017. "The Technopolitics of Climate Change: Climate Models, Geopolitics, and Governmentality." *História, Ciências, Saúde – Manguinhos* 24, no. 4: 1–19.

Miguel, Jean Carlos, Martin Mahony, and Marko Synésio Alves Monteiro. 2019. "Infrastructural geopolitics of climate knowledge: the Brazilian Earth System Model and the North-South knowledge divide." *Sociologias* 21, no. 51: 44–74.

Moran, Emilio. F. 1982. "Ecological, Anthropological, and Agronomic Research in the Amazon Basin." *Latin American Research Review* 1, no. 1: 3–41.

________. ed. 1983. *The Dilemma of Amazonian Development*. New York: Routledge.

Monteiro, Marko S., Sonia Regina da Cal Seixas, and Simone Aparecida Vieira. 2014 "The Politics of Amazonian Deforestation: Environmental Policy and Climate Change Knowledge." *WIREs Climate Change* 5, no. 5: 689–701.

Monteiro, Marko S., Raoni Rajão. 2017. "Scientists as Citizens and Knowers in the Detection of Deforestation in the Amazon." *Social Studies of Science* 47, no. 4: 466–484.

Morgan, Ruth A. 2024. *Climate Change and International History Negotiating Science, Global Change, and Environmental Justice*. London: Bloomsbury Academic.

Nepstad, Daniel, Stephan Schwartzman, B. Bamberger, et al. 2006. "Inhibition of Amazon deforestation and fire by parks and indigenous lands." *Conservation Biology* 2, no. 1: 65–73.

Neves, Eduardo, Laura Furquim, Carolina Levis, et al. 2021. "Chapter 8: Peoples of the Amazon before European Colonization." In *Amazon Assessment Report 2021*, ed. Carlos Nobre, A. Encalada, E. Anderson, et al. New York: United Nations Sustainable Development Solutions Network.

Nobre, Antonio. 2014. *The Future Climate of Amazonia. Scientific Assessment Report*. São José dos Campos, SP: ARA, CCST-INPE, INPA.

Nobre, Carlos A., Piers Sellers, and Jagadish Shukla. 1991. "Amazonian Deforestation and Regional Climate Change" *Journal of Climate* 4, no. 10: 957–988.

Nobre, Carlos, A. Encalada, E. Anderson, et al. eds. 2021. *Science Panel for the Amazon. Amazon Assessment Report 2021. Executive Summary*. New York: United Nations Sustainable Development Solutions Network.

Organización del Tratado de Cooperación Amazónica [OTCA], and Centro Internacional para la Investigación del Fenómeno de El Niño [CIIFEN]. 2021. *Atlas de Vulnerabilidad Hidroclimática de la Región Amazónica*. Brasília: OTCA/CIIFEN.

Panzu, Ângela Nascimento dos Santos. 2015. "O Instituto Nacional de Pesquisas da Amazônia – INPA: trajetória institucional por meio de suas práticas científicas, 1954–1975." PhD diss., UFAM, Manaus.

Pereira, Elenita Malta. 2017. "A Década da Destruição da Amazônia: José Lutzenberger e a contrarreforma agrária em Rondônia (Anos 1980)." *Revista de História Unisinos* 21, no. 1: 26–37.

Pereira, Joana Castro, and Eduardo Viola. 2022. *Climate Change and Biodiversity Governance in the Amazon: At the Edge of Ecological Collapse?*. New York: Routledge.

Prance, Ghillean T. 1978. "Origin and Evolution of Amazon Flora." *Interciencia* 3, no. 4: 207–222.

Prance, Ghillean T., and Thomas Lovejoy. eds. 1985. *Key environments. Amazonia*. Oxford: Pergamon Press.

Radkau, Joachim. 2014. *The Age of Ecology: A Global History*. Polity Press.

Rede Amazônica de Informação Socioambiental Georreferenciada [RAISG]. 2020. "Amazonía bajo presión." In *Rede Amazônica de Informação Socioambiental Georreferenciada*. https://www.amazoniasocioambiental.org.

Relly, Eduardo, and Claudio De Majo. 2022. "A soyance of Fire: Knowledge, Science and the igneous Expansion of Soyabean in Tropical/Subtropical South America." In *The Age of the Soybean: An Environmental History of Soy During the Great Acceleration*, ed. Claiton Marcio da Silva and Claudio de Majo, 143–163. White Horse Press.

Roberts, Patrick. 2021. Jungle: *How Tropical Forests Shaped the World – and Us*. Oxford: Oxford University Press.

Roberts, Patrick, Christopher Carleton, Noel Amano, et al. 2024. "Using urban pasts to speak to urban presents in the Anthropocene." *Nature Cities* 1, no. 1: 30–41.

Rojas, David. 2016. "Climate Politics in the Anthropocene and Environmentalism Beyond Nature and Culture in Brazilian Amazonia." *PoLAR: Political and Legal Anthropology Review* 39, no. 1: 16–32.

Rostain, Stéphen, Antoine Dorison, Geoffroy de Saulieu, et al. 2024. "Two thousand years of garden urbanism in the Upper Amazon." *Science* 383, no. 6679: 183–189.

Sá, Dominichi Miranda de, and André Felipe Cândido da Silva. 2019. "Brazilian Amazon, the Breadbasket of the World: Science, Agriculture and Ecology at the Agronomic Institute of the North in the 1940's and 1950's." *Revista de História* (São Paulo) 178: 1–25.

Sá, Magali Romero, Dominichi Miranda de Sá, and Lorelai Kury. 2024. "Science in the History of Amazon Megadiversity." In *Biodiversity. The Anthropocene as Multiple Crisis: Perspectives from Latin America*, ed. Olaf Kaltmeier, Antoine Acker, León Enrique Ávila Romero, and Regina Horta Duarte, 219–241. Bielefeld: Bielefeld University Press.

Salati, Eneas, and Peter B. Vose. 1984. "Amazon Basin: a system in equilibrium." *Science* 225: 129–138.

Santana, Rebecca. 2007. "Ecuadorian lawyer hangs with Sting, highlights oil conflict." *Amazon Watch*, July 7. https://amazonwatch.org/news/2007/0707-ecuadorian-lawyer-hangs-with- sting-highlights-oil-conflict.

Schor, Tatiana 2008. *Ciência e tecnologia. O caso do Experimento de Grande Escala da Biosfera-Atmosfera na Amazônia* (LBA). São Paulo: Annablume; Fapesp; Anppas.

Silva, André Felipe Candido. 2024. "Dos lagos temperados às águas amazônicas: a constituição histórica da limnologia como saber ecológico entre a Alemanha e o Brasil." *Revista Brasileira de História da Ciência* 17, no. 1: 243–275.

Sioli, Harald. 1984. "The Amazon and Its Main Affluents: Hydrography, Morphology of the River Courses, and River Types." In *The Amazon: Limnology and Landscape Ecology of a Mighty Tropical River and Its Basin, ed. Harald Sioli,* 127–165. Dordrecht: Springer Netherlands.

Souza, A. et al. 2019. *Metodologia utilizada nos projetos PRODES e DETER*. São José dos Campos: Instituto Nacional de Pesquisas Espaciais (INPE).

Steffen, Will, Katherine Richardson, Johan Rockström, et al. 2015. "Planetary Boundaries: Guiding Human Development on a Changing Planet." *Science* 347, no. 6223.

Staal, Arie, Ingo Fetzer, Lan Wang-Erlandsson, et al. 2020. "Hysteresis of tropical forests in the 21st century." *Nature Communications* 11, no. 4978.

Taddei, Renzo. 2022. "Kopenawa and the environmental sciences in the Amazon." In *Philosophy on Fieldwork*, ed. Nils Bubandt and Thomas Schwarz Wentzer, 353–372. London: Routledge.

Tsing, Anna L., Heather Swanson, Elaine Gan and Nils Bubandt. 2017. *Arts of Living on a Damaged Planet: Ghosts and Monsters of the Anthropocene*. University of Minnesota Press.

Wade, Robert. 2011. "Boulevard of Broken Dreams: The Inside Story of the World Bank Polonoreste in Brazil's Amazon." Working Paper no. 55, Grantham Research Institute on Climate Change and the Environment, London.

Weigel, Peter. 2014. *A Difícil Gestão Da Pesquisa: Institutos Públicos de Pesquisa ou meros aglomerados de grupos de pesquisa?: O caso do Instituto Nacional de Pesquisas da Amazônia* (INPA). Manaus: EDUA.

World Meteorological Organization [WMO]. 1979. *Proceedings of the World Climate Conference. A conference of experts on climate and mankind*. Geneva: Secretariat of the WMO.

World Meteorological Organization [WMO]. 2024. *State of the Climate 2024 Report*, Geneva. https://library.wmo.int/records/item/69075-state-of-the-climate-2024.

Zimmer, Katarina. 2019. "Why the Amazon doesn't really produce 20% of the world's oxygen." *National Geographic*, August 28. https://www.nationalgeographic.com/environment/article/why-amazon-doesnt-produce-20-percent-worlds-oxygen.

Zuccarelli Freire, Verónica, Michael J. Ziegler, Victor Lery Caetano-Andrade, et al. 2024. "Addressing the Anthropocene from the Global South: Integrating Paleoecology, Archaeology and Traditional Knowledge for COP Engagement." F*rontiers in Earth Science, Geoscience and Society* 12.

Climate Change in Mesoamerica from 1950 to the Present

Indigenous Peoples: Weaving Forests, Confronting the Socio-Environmental and Climate Crisis in the Capitalocene

Elena Lazos Chavero, Alejandro Fujigaki, René Rodríguez Fabilena, and Selmira Flores

The term "Anthropocene" (Crutzen and Stoermer 2000) designates a contemporary geopolitical era in which the future of life on Earth is at considerable risk. Recent discourse has shifted from attributing the socio-environmental crisis solely to general human activity to specifically emphasizing the role of capitalist modes of production. As a result, the concept of the Capitalocene has emerged, linking the current crisis to phenomena such as colonialism, patriarchy, and racial capitalism (Klepp and Chavez 2018; Moore 2020). This development reflects numerous heterogeneous processes characterized by power dynamics and systemic inequalities, where benefits accrue to a limited group while many others bear adverse effects. Climate change is regarded as one manifestation of the Capitalocene, with its impacts being distributed unevenly across different social and spatial contexts.

By situating analyses of catastrophes associated with the Capitalocene within specific local socio-political contexts, it is possible to incorporate alternative epistemological and ontological perspectives (Jasanoff 2010; Klepp and Chávez 2018; Moore 2020) that are often overlooked in traditional approaches to addressing climate change. Mesoamerican peoples exemplify diverse worldviews, bodies of knowledge, and value systems in confronting environmental challenges (Benda Beckmann et al. 2005; Ulloa 2017). Understanding alternative ways of life that respect rather than undermine the fabric of life is essential. Mesoamerican communities have not only developed practices to address climate change but also embed these strategies within complex networks of interaction among various actors and actants, as well as within the power dynamics structuring these relationships (Latour 1996; Ingold 2008; Klepp and Chávez 2018). Nevertheless, the values, knowledge, and strategies offered by these communities have often been marginalized.

Decolonial and counter colonial perspectives facilitate the analysis of power dynamics, interests, stakeholders, and actants within these contexts (Viveiros de

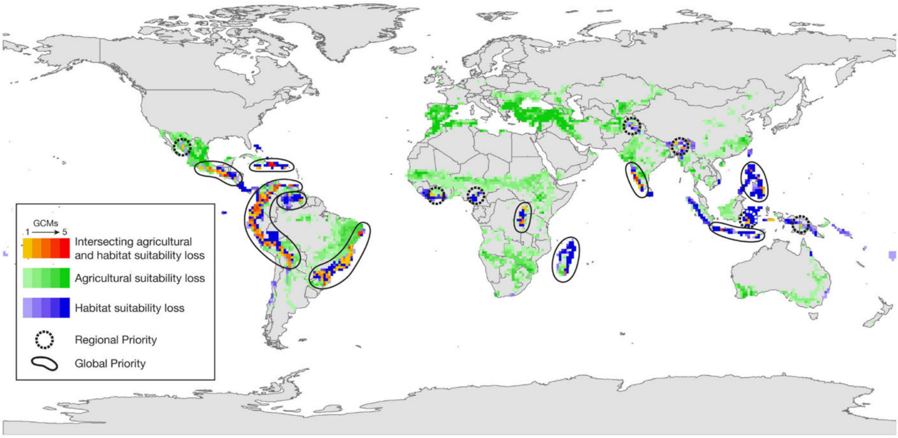
Castro 2010; Quijano 2014; Grosfoguel 2016; Bispo Dos Santos 2023). Comprehensive understanding of such worldviews requires the consideration of cosmopolitics (Stengers 2014), serving as both an approach and analytical tool for examining the intricate relationships and tensions among groups and societies that may differ in ontological, epistemological, and political dimensions.

The peoples presented here are part of Mesoamerica, a region experiencing strong effects from climate change. The Intergovernmental Panel on Climate Change (IPCC) projected that droughts and reduced precipitation would intensify over the twenty-first century (Seneviratne et al. 2012). Southeastern Mexico and the Central American Isthmus, as hotspots for climate change (IPCC 2022: 1698) and as critical points of tropical climate change (De Sherbibin 2014), are subject to extreme geodynamic and hydrometeorological events (Giorgi 2006; Organización Internacional para las Migraciones [OIM] 2021). These countries are among the twenty most affected by extreme events in the last decade (Climate Risk Index 2021 cited in Eckstein, Künzel, and Schäfer 2021). Studies have highlighted projected impacts in Mesoamerica related to food security and biodiversity (Hannah et al. 2013), hydrological services (Imbach et al. 2010), migration (Casillas 2020; De Sherbinin et al. 2021), and national security (Fetzek 2009). Hannah et al. (2013) designate the region as highly sensitive for subsistence farmers and biodiversity (Figure 1), noting potential losses of agro-climatological suitability and habitats by 2050. Northwestern Mexico is identified as an area of major concern due to projected declines in climatic suitability for crops and biodiversity. Communities referenced in this chapter experience notable socio-environmental challenges, including elevated rates of deforestation attributed to external actors, disruptions in agricultural and forestry cycles, and changes impacting their territorial management.

This chapter examines the ways in which various Mesoamerican Indigenous people respond to the challenges of climate change through a holistic worldview by considering the following questions: In what ways do these people construct and deconstruct concepts of "otherness" within the context of neoliberal capitalism that transcends planetary boundaries? How do they engage in dialogue with more-than-human entities to address the climate crisis? Furthermore, how are the challenges imposed on socio-environmental systems by the Capitalocene approached from an Indigenous perspective?

This chapter will start from a dialogic analysis of three original peoples that extend to the north and south of the Mesoamerican territory (Figure 2). The Raramuri, inhabitants of the temperate forests and northern tropical jungle of Mexico, with a temperate and tropical sub-humid climate, transform forests into small agricultural plots at various altitudes within different micro-climatic niches. In southern Mexico, the Maya-Yucatecos, with deciduous forests and a tropical sub-humid climate (Aw), and the Mayangnas, who inhabit evergreen forests in the current Bosawas biosphere reserve in northern Nicaragua with a humid monsoon-like climate, share the Mesoamerican Biological Corridor.

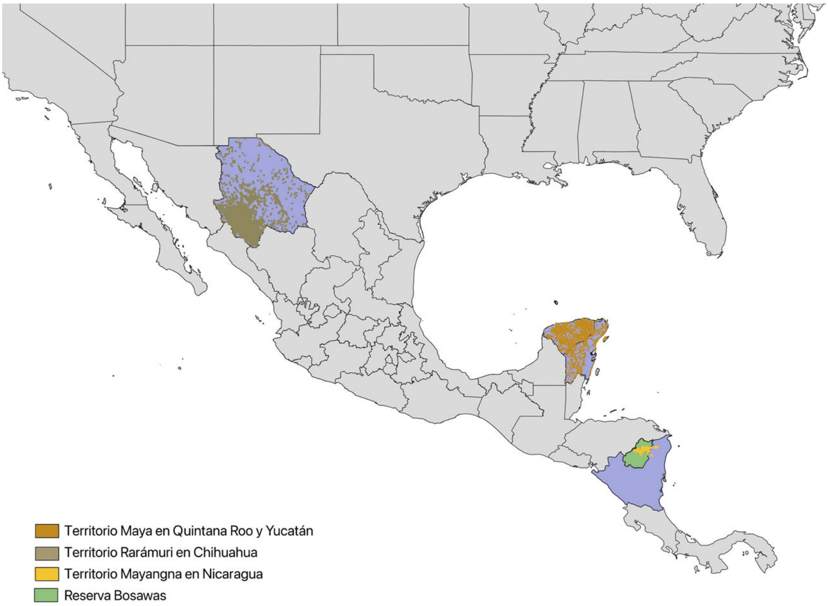
Figure 1: Global and Regional Priorities for the Adaptation of Agriculture and Biodiversity to Climate Change



Source: Hannah et al. (2013).

The territories of these three Indigenous peoples host agroforestry systems that cycle between *milpas* (land dedicated to the cultivation of corn and other crops) and forest in an ecological succession to achieve both subsistence and conservation. This chapter is interested in highlighting the often-silenced voices of these peoples, as they share holistic perspectives in territorial management (climate – water – forests – crops), constituting alternatives based on dialogue and reparations between humans and more-than-humans under the continual recomposition of the fabric of life. This is how they confront climate change – which for them begins with progressive deforestation – and show how their ways of life constitute alternatives to the Capitalocene's transformations. These relationships between climate change, deforestation, and crop loss have been studied in Mexico, Central America, and the Amazon (O'Brien 1998; Werth and Avissar 2002; Pielke et al 2007; Manoharan et al. 2009; Gourdji et al. 2015).

Figure 2: Location of the Raramuri, Maya-Yucateco and Mayangna territories



Source: For Nicaragua (Williamson et al. 2016); For Mexico (Instituto Nacional de los Pueblos Indígenas [INPI], 2010). Design: Jazmín Solís Carpio.

This chapter will focus on the most impactful incidents since the 1950s, in order to understand how these peoples have faced socio-environmental crises and how their ontologies, strategies, and narratives respond to these challenges. Governments considered forests and jungles to be "unproductive" spaces, and companies transformed them into resources or monocultures, thus fracturing natural cycles and commercializing biodiversity.

This commodification has now been extended to the climate through a green economy, in which powerful actors can capture global calls for investment in adaptation and mitigation. These actors frame Indigenous territories as "carbon sinks" (Ulloa 2013) or degraded lands that require climate-friendly investment through conservation schemes or large plantations. Consequently, the state, financial institutions, big international non-governmental organizations, and corporations are able to assert control over territorial resources they have historically managed and safeguarded, often under the framework of climate responsibility (Ulloa 2017). Within the Capitalocene, Indigenous communities face a socio-economic system that generates crises affecting their territories and ways of life, while also facilitating new forms of accumulation that benefit from these crises (Nail 2019).

Global climate policies adopted at the national level do not consider local cultural practices and perspectives or the relationships with more-than-humans proposed by native peoples (Dietz 2013; Ulloa 2017). The lack of recognition of the knowledge, sensibilities, and identities of native peoples has been politically imposed on their territories. The Raramuri, Maya-Yucatec, and Mayangna peoples, however, still struggle and negotiate for their forest, experiencing both wins and losses as they transform these spaces; in confronting climate change, they construct practical, ritual, and discursive alternatives with both humans and more-than-humans that can be ephemeral or long-term. They conceptualize territory, body, and nature as interconnected entities across various cultural dimensions – spatial, physical, symbolic, and practical – within ongoing, diverse assemblages that act, exist, feel, and make decisions regarding their territories. The "feeling of care" (Puig 2011) is operationalized through the transformation of these spaces. Within this framework, critical feminist perspectives on the care of bodies, lives, and territories are essential for highlighting issues that might otherwise remain unacknowledged.

By understanding the multiple relationships woven by these three Mesoamerican peoples, it will be possible to analyze strategies and discursive practices to confront climate change as part of the environmental crisis.

Northern Mesoamerican Peoples: The Raramuri or Tarahumaras

Northern Mexico includes twenty-three Amerindian groups, Afro-descendants, *mestizos*, and Mennonites, as well as several Biocultural Priority Regions (Boege 2008; Luque et al. 2020). The Sierra Tarahumara, one of these regions, has been the most important for capturing and producing drinking water in the northwest of the country (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO] 2014). The area contains high montane temperate forests with a temperate sub-humid climate of up to 3,200 meters above sea level with temperatures of as low as -15°C and deep ravines of tropical rainforest that are warm and subhumid up to 500 meters above sea level with temperatures up to 48°C. The average annual rainfall varies between 500 and 1,000 mm (Instituto Nacional de Estadística, Geografía e Informática [INEGI] 2020; SEMARNAT 2023). Its biodiversity is anthropogenic, a result of both the knowledge and practices of its inhabitants (Tarahumara Sustentable A.C. 2019).

Impacts and Triggers of Climate Change in the Sierra Tarahumara

The effects of climate change on the Sierra Tarahumara vary across different ecological niches and are experienced unequally among its populations. These impacts are shaped by policies, economic development models, and productive activities that have emphasized territorial and sociocultural reorganization. Since 1940, three major strategies – railway expansion, industrial forestry, and Indigenous policy reforms (including agrarian redistribution and national integration) – have collectively reshaped the region, affecting its webs of life.

Urban-rural centers established in forest production areas along railway lines played a key role in these changes. Territorial expansion from 1940 to 1980 resulted in deforestation, desertification, increased water consumption, land use change, and impacts on habitats, including risks to endemic flora and fauna (Luque, Gay, and Ortiz 2020; Grupo Integral de Servicios Ecosistémicos Eyé Kawí A.C. 2014). Ethnobotanical studies have found that between 1885 and 2009, 37 percent of herbal knowledge originating from the Sierra Tarahumara was no longer recorded (Guzmán 2007), coinciding with changes in the role of Indigenous peoples' knowledge.

At the close of the twentieth century and the beginning of the twenty-first, these developments were accompanied by significant extraction and exploitation activities, reminiscent of the impacts of colonization five centuries earlier. These included mining, large-scale state and private projects, tourism infrastructure, and increased cultivation and trafficking of intoxicants (Mancera-Valencia 2004; Sariego 2008; López Bárcenas 2013; Inter-American Commission on Human Rights [IACHR] 2015; Ulloa 2008; Ulloa 2017; Martínez 2019, among others). While these initiatives generated new dynamics, they also contributed to heightened structural violence and inequality, as evidenced by persistent indicators of social disadvantage and extreme poverty (Consejo Nacional de Evaluación de la Política de Desarrollo Social [CONEVAL] 2020; INEGI 2020).

There is no single narrative for understanding the differentiated impacts of climate change. However, the Raramuri people, comprised of 91,544 speakers, (INEGI 2020) assume a self-critical reflection on individual and collective care for the environment. They know the consequences of their decisions to sustain or end the world (Fujigaki 2020), and how other peoples have their own wisdom about managing life and catastrophes (Danoswki and Viveiros de Castro 2014; Vieira, Caballero, and Fujigaki 2022). This is reflected in ethical, ecological, and political commitments and obligations that they transmit to new generations, always with a burden of responsibility, to "take care of the environment together" (*napawika tibupo kawi*).

For most Raramuri, the annual cycle is organized into rainy, winter, and dry seasons. Each season is connected to the agricultural, mobility, and harvesting calendar. Hot and cold temperatures, which have become increasingly extreme due to climate change, are linked to drought, as well as to the absences and delays of rain and snow. Considering that the majority of the inhabitants depend on rainfed agriculture, gathering, and hunting, this situation increases their vulnerability in terms of water, food, and environmental needs. Without snow, the soil cannot be moistened enough to cultivate and eliminate pests, which has provoked the use of toxic agrochemicals. If rain is scarce or delayed, the quantity and quality of the harvest is impaired, while if the rains are torrential or hail arrives, they are lost. The lack of moisture decreases the variety of edible and medicinal roots and wild fruits, as well as of fish and game animals.

Climate change might be the symptom of the disease that the territory and people suffer from. Bodies, social networks, and landscapes are born, grow, weaken, get sick, and die in connection: "everything is related," as says Raramuri leader Luisa Bustillos (Tarahumara Sustentable 2016). The impact on culinary heritage (wild and cultivated) undermines the health of organisms. Territorial deterioration affects bodies, which can be seen in the high rates of malnutrition, the maternal and infant mortality rate, the deaths from curable diseases (such as tuberculosis and gastrointestinal and pulmonary infections), obesity, and diabetes (Cueva, Few, and Mercado 2011; Loera and Martínez 2021).

The mobility of Raramuri individuals and families has been a strategy to counteract the effects of climate change. Historically, they have practiced an extended mode of settlement. The possession and inheritance of land is bilateral and non-transferable between spouses, therefore women and men both have the right to land. In this way, a family can own several houses and ranches located on different ecological floors, moving between them throughout the year. This has made it possible to take advantage of different climates, avoiding extreme temperatures (cold or warm) and diversifying places for cultivation, gathering, hunting, and fishing. Added to this is their mobility outside the Sierra Tarahumara (usually in cities in the state) for employment to obtain money, products, and services. Thus, each Raramuri and their family network develop multilocated organizational strategies (Hoffmann 2018).

Sometimes, these migrations intensify to such an extent that they produce a fragmentation that weakens social networks, since many people do not return to their places of origin (Martínez, Martínez, and Naranjo 2012). This is a concern and a subject of explicit reflection, especially when these mobilities are the product of forced displacement, violence, organized crime, socio-environmental conflicts, and megaprojects. Coupled with the loss of biodiversity, this social fragmentation causes the extinction of both the fabric of life made up of plants, animals, and other beings, and the knowledge that could sustain and recreate biodiversity in the region. Although support networks also languish, they tend toward aid (*kórima*), care (*tibupo*), and collective and multispecies work (*notzama*) (Fujigaki 2020).

Legal and illegal investments have affected the loss of this biodiversity. A large share of developmental and extractivist projects lack the free, prior, and informed consent of the Raramuri. These projects subordinate and violate the Raramuri's rights, since they hide and deny the people's knowledge and ignore their regulatory systems and environmental governance (Almanza and Guerrero 2014; IACHR 2015; Almanza 2016).

Organized crime has intensified, resorting to logging to increase its profits (Gómez and Mayorga 2019; Mayorga 2021; Camou 2021). The state of Chihuahua has the second largest forest area in the country (24,736,398 ha, of which more than 7 million are usable). By October 2022, it had a profit of 5 billion pesos, which represents only 50 percent of annual forest production. Some Raramuri who have fought against illegal indiscriminate logging have been displaced or killed (González et al. 2016; Sánchez 2022).

Links and Responses of Raramuri People to Climate Change

The Raramuri assume responsibility for these problems and propose reflections and strategies to address them, since they have been responsible for the genetic flow of biota from the habitats of the Sierra Tarahumara (Boege 2008: 24). The Raramuri have obligations to everything that exists, since everything is linked by a multispecies and multi-natural kinship that involves harmonious bonds, frictions, and conflicts (Salomón 2000; Wyndham 2009; Martínez 2012; Martínez 2019; Fujigaki 2020).

The Raramuri urge the strengthening of daily and ritual bonds, private and public, through meditations and decisions reflected in acting, speaking, thinking, and dreaming. This Indigenous people prioritizes coexistence and the transmission of transgenerational knowledge about development and the fabric of life (Gardea and Chávez 1998; LaRochelle and Berkes 2009; Alianza Sierra Madre A.C. 2012; Miller and Doolittle 2017). Faced with climate change, the Raramuri are committed to strengthening care (*tibupo*), aid (*kórima*) and collective, mutual, multispecies and multi-natural work (*notzama*). Countering climate change at the local level implies the creation of decent, safe, and well-paid jobs that avoid migration that would lead to the loss of these relationships with the environment.

To combat attacks and socio-environmental injustices, their strategies are transforming. For example, they have modified their forms of social organization, helping to consolidate female political leadership. Women compete for local and regional leadership from the Raramuri forms of government, take advantage of government programs and support, organize with non-governmental organizations (civil, political, religious), or create their own Raramuri directed entities. These women insist that forest management must be responsible, highlighting the need to go beyond a sustainability defined by an area's biological conservation. Knowing and invigorating Raramuri modes of existence are necessities for the environment and the right to differ, as well as a condition for maintaining biocultural diversity in the face of climate change. More than an ethical fashion emergency, this is a cosmopolitical and ecological priority that challenges everyone.

Peoples of the Mesoamerican Southeast: Maya-Yucatecos (MY)

The Fabric of Life Transformed by the Plantationocene

By the conclusion of the colonial era, economic activities in the Yucatán were primarily concentrated in central areas where the majority of *haciendas* had been established. In the eastern part of the region, cattle ranching expanded and chewing gum production intensified, relying heavily on Indigenous labor. The southern region saw the development of tobacco, rice, and sugar plantations (Patch 1979; Farriss 1984; Rejón 1985). By the late nineteenth century, henequen cultivation had become predominant (Bojórquez 1979). The intensive exploitation of land during this period led to the first agroecological crises, lending support to the concept of the Plantationocene (Tsing 2012; Haraway 2015).

The coastal and southern areas of the region were considered "uninhabited." These areas had a sparse population of rebel Mayans who, after resisting subjugation, retreated and managed to reclaim their lands and maintain connections with their surrounding forests (Reed 1971; Farriss 1984; Betancourt, Ruz, and Sierra 1988). Despite the disruption of Indigenous crop rotation practices by Spaniards and Creoles, Mayan communities in the south and east continued to practice cyclical forest and milpa (*kol*) agriculture, maintaining substantial agrobiodiversity through cycles spanning twenty to thirty years. Lands described as "abandoned" by the municipalities were, in reality, integral to Mayan agricultural traditions and ritual practices (Lazos 1992; Ford and Nigh 2015; Levy et al. 2019).

The agrarian reform accelerated by Carrillo Puerto (1918–21) formed the first *ejidos* (government land concession for communal use) during the 1920s (González Navarro 1979: 247). Around 1950, henequen plantations continued in the center and north of the region, already in the hands of collective ejidos; to the east and south, forests interspersed with milpas dominated. After 1960, in the south, development plans transformed milpas into irrigated fruit and vegetable gardens. Commercial production replaced production for the local communities to meet the demands of Mérida and the tourism industry in Quintana Roo. In 1970, the National Clearing Program transformed half of the Yucatan's jungles, considered unproductive, into pasture for cattle and monocultures (Lazos 1992: 186).

How do they Face the Challenges of Climate Change Accelerated by the Capitalocene?

Mayan farmers still cultivate diversified milpas under the *roza-tumba-quema* (slash-and-burn) system to maintain their forests and ensure soil fertility. Forests and milpas inhabit the same unit under rotating cycles of 10 to 15 years in different successive stages (Ilsley 1984). Before the *Ley General del Equilibrio Ecológico y la Protección al*

Ambiente (General Law on Ecological Balance and Environmental Protection) of 1988, hunting and gathering fruits and forest plants were as important as agriculture itself.

On the peninsula, there are no surface water currents. 80 percent of the rain seeps into the ground. In the north, the water tables can be found at ten to fifteen meters, while to the south, they are between sixty and 150 meters deep. In the north and east, cenotes (*ts'onot*), and in the south, *sartenejas* (*pek'*) and *aguadas* (*ts'ats'*) all supplied necessary water. However, with climate change, the latter have dried up.

Milperos (those who cultivate milpas) live under threat of prolonged droughts and hurricanes that cause flooding. In the past, they would predict the behavior of rains through "*cabañuelas*" (*xook k'iin*), a method of observing the sun, clouds, and temperature. Milperos could recognize more than ten types of rain (*chaak* or *haa'*) and winds. Depending on the characteristics of the first rains after the dry season, they would predict their continuation or possible interruptions. The Mayans relate the flowering of jungle trees and the behavior of birds, insects, reptiles, amphibians, and mammals to rain (Lazos 1992; Camacho-Villa et al. 2021). Deforestation caused by livestock and monocultures, however, has undermined this biodiversity and associated knowledge.

To face climate change, milperos have revalued these signs and relate rain to soil for planting. They recognize nine types of soils according to texture, color, depth, quantity and size of stones, type of drainage, relief, relationship with vegetation, and agricultural productivity. With little rain, they choose stony (*tsek'el*) or shallow (*chak-lu'um*) soils for corn and deep soils (*k'ankabal*) for fruit and vegetables (*pach pak'al*). With heavy rains, they will not plant in *ak'al che'* (clay soils without stones) because they will become flooded. They like to cultivate in *yaaxhom* (black soils, rich in organic matter) because of the soil's fertility and its ability to hold water (Lazos 1992).

Milperos selectively and carefully "knock down" the forest, leaving the stumps high enough for vegetation regeneration (Illsley 1984; Ford and Nigh 2015; Levy et al. 2019). They select the most fertile land with mature vegetation to achieve a good harvest (Ruthenberg 1971; Illsley 1984; Ku-Pech et al. 2020). After two years of milpa, the land rests and the vegetation grows. The *hubche'*, a young forest (2–12 years old), goes through several stages until it becomes *k'ax*, a mature forest. Certain trees indicate good soil, so the surveying of the mountain to select the land to cultivate (*ximbal ka'ax*) is essential for a good harvest. Milperos leave communal forest reserves close to the town (*kalaantbi k'aax*) and vegetation along roads (*tolche'*) to regulate the climate (Levy et al. 2019).

This knowledge is key to tackling climate variability. Until 1990, farmers cultivated rich agrobiodiversity (between five and eighteen crops) (Lazos 1999; Terán and Rasmussen 2009; Mateo-Maces et al. 2016; Castillo-López et al. 2021), collecting fruits, leaves, and legumes from the *hubche'* (twenty-nine species, twenty-five of which are eaten) (Lazos 1992). Agrobiodiversity is one way to face climate change, since some crops are more resistant to drought/flooding than others. In addition, farmers establish other production systems: family gardens, vegetables in *kanche'* (tall structures), the *pach pak'al* near the milpas, the *conucos* (vegetable systems) in hollows. In the south, the introduction of irrigation resulted in a boom of fruit and vegetable gardens that, despite the predominance of citrus fruits, are highly diverse (up to thirty species). Hives or trunks are interspersed for native bees. Honey production and domestic animal husbandry ensure the most important protein source.

This high diversity of agricultural and forestry activities in heterogeneous spaces with varied micro-climatic niches makes it possible to face climate variability, particularly drought. If part of the milpa harvest is lost, products from *pach pak'al*, the *kanche'*, or the family gardens can aid in the community's subsistence (Lazos 1994).

However, the lack of agricultural policies for small farmers, the fall in corn prices, the agrarian reform of 1992 – which led to organizational rupture and land privatization – and restrictive environmental legislation on forest use have caused important agroforestry transformations. The surface area and agrobiodiversity of the milpa has been reduced (in some cases from fifteen crops to just three). Most farmers are pursuing irrigation to turn their milpas into fruit and vegetable gardens for the market. With the beginning of privatization in 1992, the lands became divided. Previously, families organized their communal lands through family "*rumbos*" (paths). Vegetation selection is no longer carried out as before, and this increases the risk of a poor harvest due to lack of soil fertility. For this reason, families prefer to cultivate gardens with irrigation, leading them to grow monocultures due to commercial pressure.

Gods and Rituals as Reparations for the Mountain: Symbolic Interactions to Face Climate Change

In the MY worldview, the conception of the mountain and of cosmic time is cyclical. Ritual time is a perpetual repetition. The past is the future and therefore becomes a prophecy (Farriss 1984: 6–8). Agricultural and harvesting activities follow a schedule depending on the season of the year, the climate, and the ritual rhythms. Each cycle lasts between ten and fifteen years to ensure the survival of families under a "collectivity" where humans, more-than-humans, the gods and owners of the mountain, and the cosmos are related through ritually forged reciprocal relationships (Farriss 1984: 6–8; Hanks 1990).

For the milperos, foragers, and tamers of the forest, the jungle is both a benefactor and a hostile one. To start cutting down the vegetation (*tumba*), they ask permission from the owner of the mountain with an offering of *saka'*, a ritual corn drink. If it does not rain, they collectively ask for rain from *Chaak* (the god of rain). At the *Ch'a Chaak* organized by the *H'men* (MY priest) during the *canícula* (August), they call for the rain. Farmers offer their best crops and seeds, ritual drinks (*b'alche* and *saka'*), chickens and pigs, food (*pib*), and candles to the gods of the mountain and to God. Everything is placed on a rectangular altar similar to the universe of the four cardinal points (Villa Rojas 1985; Hanks 1990) under an arch of "cold" plants (i.e., achiote leaves, *Bixa orellana*) to resemble the coldness of the caves where the gods live. Children imitate the songs of frogs to predict the arrival of rain (Lazos and García, in press). The mountain with all its beings is alive. The milpa at the birth of the mountain is a living being, and the milpa when it dies will give it life (García Quintanilla 1986: 19). Even in the irrigated area, orchard farmers offer *Ch'a Chaak* so that the wells do not dry up.

The mountain is like the cosmos, a dynamic and contradictory space. It must be thanked but also feared; it must be transformed but also allowed to grow and regenerate. Gods, mountain spirits, humans, and more-than-humans establish social relationships in continuous transformations (Montolíu 1989: 14; De la Garza 1989: 15–18). This feeling of human dependence vis-à-vis the cosmos and the mountains gives rise to a whole series of ceremonies and rituals.

By establishing reciprocity and collectivities through ceremonies and rituals in each agricultural phase and in each activity, the MYs face climate change through both ritual fulfillment and the agroforestry strategies described. The organization based on cooperation and reciprocity required in ceremonies reinforces the rituality that unites humans, more-than-humans, the beings of the mountain, and the cosmos. This rituality gives meaning to the practices and strategies the MYs use to defend the fabric of Mayan life against the threats of extractivism and transformations under the neoliberal impetus. At the same time, managing forest mosaics that capture large amounts of CO_2 makes it possible to address climate change (Pirard and Karsenty 2009; Wandellini and Fearnside 2015; Altieri and Nicholls 2017). It has become necessary to recreate and restructure alternative ways of life by a Mayan cosmopolitics, where the Maya-Yucatec peoples have the right to build and maintain their own biocultural diversity and processes of caring for life.

Peoples of the Mesoamerican South: The Mayangna in Broadleaf Forests

Cohabiting in Forests: Interwoven Ways of Life and Autonomous Territorial Displacement

The Mayangna, formerly known as Smoos or Sumos, have been living in Nicaragua since before the colonization of the continent in territories of dense broadleaf forests. Eight of the nine Mayangna territories coincide with the area of the Bosawas Biosphere Reserve where their livelihoods interweave perennial and semi-perennial crops (fruit trees, *Musaceae* [bananas and plantains], tubers), short-cycle migratory crops (rice, beans, and corn) without agrochemicals (Cordón and Toledo 2008). Resting soil occurs in cycles of three to fifteen years (Macdonald 1999). Hunting, fishing, occasional artisanal gold mining, and the use of medicinal plants are all woven into the lunar calendars (Conzemius 1932; Levy 1976; Patrón 2017; Robins et al. 2012) and the spiritual dimension. The Mayangnas ask for permission from the spirits that inhabit the forests to respectfully use only what is necessary.

Much of this interwoven organization persists as an appropriate system for the sustainability of life and constitutes a response to current climate change. However, the cyclical management of living spaces has been affected by the systematic deforestation imposed by the Capitalocene through agro-export monoculture, population growth, and the forced displacement of communities by state policies on land appropriation that modify ecosystems and alter the climate (Ocampo 2010; López 2012). This displacement has allowed the state to deny the territorial rights of the Mayangna and to strengthen its colonial vision to govern and legislate without considering ethnic differences or the ecosystemic damage this capitalist, extractivist logic was creating.

In the 1960s, the state sought to reduce the social pressures that land grabbing created in the Pacific region, creating the Instituto Agrario Nacional (IAN) in 1963. To develop agro-export based on the model of coffee and livestock farms, the IAN promoted agrarian colonies in the Mayangna territories. In 1971, Saslaya National Park was established on a sacred Mayangna hill, *Sahlai* (Ryan 1978). In response, the Mayangna mobilized politically against the state, creating their first organizations (Erants and Frank 2001; Von Houwald 2003). Their agendas were interrupted by the civil war of the 1980s when they took refuge in Honduras or became involved in armed conflict in response to policies of exclusion and imposition.

The end of the war in the 1990s brought new pressures on forests considered "unproductive spaces" that should be used for the extraction of wood and gold or that should be transformed into agricultural areas to contribute to the reconstruction of the national economy. New pressures included the creation of development areas, resettlement, the arrival of mining and logging companies, and territorial control by rearmed groups (Kaimowitz 2002; Rueda 2015), resulting in multiple overlaps of ownership and records of legitimacy between different involved parties.

Territorial Overlaps, Deforestation, and New Conflicts Fueling Climate Change

In 1991, the state created Bosawas, the National Natural Resources Reserve to conserve tropical forests and "protect" the cultural heritage of the Mayangna peoples. However, as there was no consultation, Bosawas overlapped with their territories, reducing the control of the Mayangna over their own land (Kaimowitz and Mendoza 2003). In 1997, UNESCO declared Bosawas a Biosphere Reserve in an area of 2,181,500 ha with abundant biodiversity and rainfall ranging from 1,800 mm to 3,200 mm. However, the reserve loses 48,567 ha annually (López 2012) due to expansive livestock farming, which reduced forest cover from 66.8 to 62 percent between 2000 and 2019 (MARENA 2019).

Currently, the Mayangna territories face an advancing agricultural frontier, governmental and commercial control, and political, economic, and climate factors. Recent studies in the region show a close relationship between deforestation, change in microclimates (reduced rainfall), and a stagnation in productive yields of crops such as corn and beans (Gourdji et al. 2015). The agroclimatic forecasts for these and other crops such as coffee show that as temperatures increase and rainfall decreases in the country's lowlands and dry areas more agricultural producers will move into the mountainous and/or humid areas of these territories (Schmidt et al. 2012, Läderach et al. 2017).

Since 2015, the invasion of Indigenous territories has become more violent. In 2018, the Kalmata and Wihilwas communities were disbanded by such conflicts. Between 2015–2022, twenty-nine Mayangna were killed in defense of their territories (The Oakland Institute 2020; Equipo Kiki 2022) and in November 2020, hurricanes Iota and Eta destroyed forests, crops, and houses over a period of fifteen days.

Overlaps in territorial governance, deforestation, and conflict reinforce the detrimental impacts of climate change. Since 2005, the Mayangna have publicly pointed to the loss of water, the extension of the dry period, the high temperatures and consequent low Indigenous agricultural production, as well as the persistent deforestation and invasion of livestock bringing these forests close to extinction.

Regional Mobility, Complaints, Brotherhood, and Reciprocity to Compensate for Damage: Response of the Mayangna

These adverse effects have individually led some Mayangna to accept adaptation projects promoted by the state and NGOs to grow vegetables around the home. Some communities relocate their crops or delay the planting of corn or beans to prevent the high temperatures or excessive rainfall from damaging crops. Others have set up sheds for drying grains.

Collectively, the Mayangna call on the state to implement a territorial "sanitation" that would involve redefining the presence of mestizos in the territory (to reaffirm agreements with "living elders," who embraced Mayangna practices decades ago, but above all, to relocate settlers out of Indigenous territory). They resort to peaceful territorial defense and autonomy, emphasizing the colonists' deforestation as the cause of the breakdown of harmony between the various lives of the territory. They highlight differences between the Indigenous people's agricultural practices and relationship with forest beings and those of the settlers, pointing out that the respectful use of natural assets is the proper way to confront climate change. In everyday practice, keeping their livelihoods interwoven with a sense of gratitude is a practice that promotes "the harmony and tranquility of life" (Sauni As Community Ranger, personal communication, June 2021).

Faced with livestock expansion in the territory, they have proposed some changes. The Awastigni community, for example, proposed transforming pastures, occupied by mestizos, into systems of agroforestry production with lower rents. If pursued in the case of the Mayangna, this could not only maintain their control over the territory but also ensure the recovery of the forest area.

However, proposals like this have not been accepted by all territories nor the communities nor even the migrating mestizos. The Mayangna, who defend forests to confront climate change, have chosen to denounce the parallel structures of power that support the transformation of the territory, irrespective of the decision of the community. Another way to respond would be to patrol the territory for mestizos that deforest to remove them or deliver them to the authorities, framing such deforestation as a crime against the biosphere reserve to capture the interest of state institutions. These complaints are often ignored by the authorities, arguing that they cannot act, since it is the Mayangna themselves who must carry out negotiations (Gonda et al. 2023). In response, a group of community rangers created and circulated two bulletins in 2021, one with the title "They are Killing Us to Defend Our Forests" (Guardabosques Comunitarios Territorio Mayangna Sauni As 2021), which shows the lack of action by the state that publicly approves policies to address climate change but will not stop the direct cause of climate change in its territories.

For the Mayangna, the revitalization of *Biri Biri,* a term that refers to reciprocity and exchange between communities and other populations, has been greatly important. A recent example has been the quest to strengthen their binational networks (Nicaragua and Honduras) with their August 2022 proclamation titled "The Cry of Asang Lawana: Kalwahai, Biribiri, Aslah Lani" (Principles of Brotherhood, Unity, and Reciprocity). In this proclamation, both groups demand the attention of the state and other actors on "the usurpation of communal lands and the lack of compliance with the discourse on mitigation [and] adaptation to climate change" (Proclama 2022). In addition, they demand recognition of the contribution their knowledge has made to environmental justice.

As in other experiences, territorial protection to balance multiple livelihoods also includes forms of tangible and intangible heritage threatened both by climate change and the pressures on the forest (Simpson et al. 2022, Ybarra 2013; Whyte 2017). For Wetterslev (2021), the concern of the Mayangna of Awastingni about deforestation carried out by third parties on the riverbank is not only ecological but spiritual, since this practice bothers the spirits of the waters. People warn about the presence of *was muihni*, the owner of sea and river creatures (Robins et al. 2012), a jealous and capricious spirit, who one should avoid making angry. In the Mayangna worldview, overexploitation of fish can result in diseases caused by their anger. Although Mayangna communities have been influenced by Christian churches in recent decades, ontological syncretism is present in their intercultural model of health, in their histories, and in their governance frameworks.

In this way, sacredness is established in a deliberative and consultative way, politically activating the collective memory of the place. Finally, the interweaving of material and immaterial life in the territory, together with the respect for other groups may have for it, constitutes the Mayangna response to climate change.

Conclusions

> There are deeply human humans who exclude those thousands of quasi-humans who insist on remaining at the edge of the civilized dance, technology, and control over the planet. And dancing a strange choreography, they are removed from the scene by epidemics, poverty, hunger, or directed violence. Why do we insist so much and for so long on participating in this club, which most of the time only limits our capacity for invention, creation, existence, and freedom? (Krenak 2020)

The three Mesoamerican peoples analyzed here have fought and continue to fight for the defense of the fabric of their lives. The diversity in their ways of life has crossed multiple paths that have allowed them to face uncertainties and climate risks. Collectivity, care between humans and more-than-humans and material and ritual exchange with the owners of the forest and rivers (in the Mayangna and Raramuri territories) are the common basis for accessing and transforming these territories into patches of agriculture and forest where they can collect, hunt, fish, and cultivate rich agrobiodiversity in the proper cycle or ecological floor according to the seasonality of the year. The knowledge involved in their worldviews interrelates networks between micro-climatic niches, types of vegetation, soils, crops, wild and semi-domesticated flora and fauna to reproduce their life tissues. The spirits and guardians of the mountain give and receive to reproduce the cycles of life. As Viveiros de Castro (2020) points out, to affirm that another world is possible is to verify that there are alternative societies outside of capitalism. In this sense, we are deeply grateful to the Raramuri, Maya-Yucatec, and Mayangna peoples for sharing their stories, anxieties, experiences, dreams, and hopes for a world where care and respect prevail for biocultural diversities and the entanglements of life between humans, more-than-humans, cosmos, and deities.

Since 1950, the transformations of the Raramuri, Maya-Yucatec and Mayangna peoples' territories have followed other paths. There have been instances of land encroachment that disregard indigenous spiritual values, as well as initiatives and policies involving Indigenous communities in large-scale monoculture commercial agriculture reliant on agrochemicals, which have adversely affected their health and territories. These transformations have resulted in significant changes to crops, increased dependence on seeds, modifications of various production and life cycles, migrations and forced displacements, and incidents of violence. In certain regions, the presence of organized crime has restructured indigenous "otherness" under varying forms of neoliberal capitalism, exerting control over communities and territories. In this sense, these three Indigenous groups have been made dependent and poor (Viveiros de Castro 2020).

Considering potential approaches to addressing these seemingly intractable transformations and conflicts brings attention to the concept of cosmopolitics. Within this framework, diverse perspectives on the cosmos and the existence of various cosmos are discussed (Blaser 2018: 118). We have focused on the possibility and necessity of highlighting the practical consequences "among ontologically, epistemologically, and politically heterogeneous modes of existence" that reflect on and act against climate change, the Anthropocene/Capitalocene (Fujigaki 2020: 5). Latour (2004) points out that humans enter into conflicts along with the non-human "things" that make them act (Blaser 2018: 118).

The Maya-Yucatecos, the Raramuri, and the Mayangna do not refer to different perspectives in the same fabric of life, but to completely different, multiple, and divergent fabrics emerging from the Capitalocene. Therefore, this multiverse of perspectives demands a cosmopolitics, to reevaluate the agency of plural assemblages of humans and more-than-humans. In this sense, these climate crises need to be negotiated in multi-situated arenas (Benda-Beckmann, Benda-Beckmann, and Griffiths 2009). The *Biri Biri* of the Mayangna resonates with other experiences of transnational Indigenous activism that go within and beyond the state-centric paradigm and market-based solutions for the problems they face that include the climate (Suliman et al. 2019; Ulloa 2013).

Throughout their history, the three Mesoamerican peoples have responded to climatic changes by integrating values, practices, and knowledge with human, divine, and more-than-human relationships in daily life and rituals. Conflict is generated when other ways of life are imposed and the essence of the heterogeneous ensembles that they face daily and ritually is exterminated. Their demands and warnings have been uttered and ignored for centuries and go beyond our awareness of climate crises. Why do we not pay attention to them? The three Indigenous peoples have taken care of their cosmos, and the cosmos has taken care of them. They are people who demand respect for their rights in the context of new environmental transformations, always fighting for the defense of their territory, their fabric of life, their cosmos, and their self-determination.

References

Alianza Sierra Madre A. C. 2012. *Serie Cambio Climático y pueblos originarios.* Video. https://youtu.be/PKA3nK_6fAQ?si=OjykQJ4S1wFWNfOA.

Almanza, Horacio, and Guerrero, Rafael. 2014. "Paradojas del turismo: entre la transformación y el despojo. Los casos de Mogotavo y Wetosachi, Chihuahua, México." *Revista de Análisis Turístico* 18: 45–56.

Almanza, Horacio. 2016. "Criminalidad ambiental de Estado en los territorios indígenas del norte de México." In *Ecopolíticas globales. Medio ambiente, bienestar y poder*, ed. Piergiorgio di Giminiani, Ángel Aedo, and Juan Loera González, 193–229. Santiago de Chile: Hueders.

Altieri, Miguel, and Clara I. Nicholls. 2017. "The adaptation and mitigation potential of traditional agriculture in a changing climate." *Climatic Change* 140: 33–45.

Benda-Beckmann, Fran, Keebet Benda-Beckmann, and Anne Griffiths. 2009. Mobile People, Mobile Law: An introduction. In *Mobile People, Mobile Law: Expanding Legal Relations in a Contracting World*, ed. Franz von Benda-Beckmann and Keebet von Benda-Beckmann, 1–26. Farnham: Ashgate.

Betancourt, Antonio, Rodolfo Ruz, and José Luis Sierra, eds. 1988. *Yucatán: textos de su historia.* 3 vols. Mexico City: SEP.

Bishop Dos Santos, Antonio. 2023. *A terra dá, a terra quer*. São Paulo: Ubu Editora/Piseagrama.

Blaser, Mario. 2018. "¿Es otra cosmopolítica posible?." *Anthropologica* 36, no. 41: 117–144.

Boege, Eckart. 2008. *El patrimonio biocultural de los pueblos indígenas de México. Hacia la conservación in situ de la biodiversidad y agrodiversidad en los territorios indígenas*. Mexico City: INAH-CDI.

Bojórquez, Carlos. 1979. "Regionalización de la política agraria de Yucatán en la segunda mitad del siglo XIX." *Revista de la Universidad de Yucatán* 21, no. 123: 32–45.

Camacho, Tania, Tania Eulalia Martínez, Alejandro Ramírez, et al. 2021. "Mayan Traditional Knowledge on Weather Forecasting: Who Contributes to Whom in Coping with Climate Change?." *Frontiers in Sustainable Food Systems* 5: 1–17.

Camou, Teresa. 2021. *Cruz*. Mexico City: FOPROCINE- IMCINE.

Casillas, Rodolfo. 2020. "Migración internacional y cambio climático: conexiones y desconexiones entre México y Centroamérica." *URVIO Revista Latinoamericana de Estudios de Seguridad* 26: 73–92.

Castillo-López, Efraín, Emily Marín, Gorgonio López-Tolentino, et al. 2021. "Perspectivas del sistema milpa en Yucatán." *Bioagrociencias* 14, no. 2: 13–22.

Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL). 2020. "Encuesta Nacional de Ingresos y Gastos de los Hogares." https://www.coneval.org.mx/Medicion/Paginas/Pobreza_grupos_poblacionales_municipal_2010_2020.aspx.

Conzemius, Eduard. 1932. *Ethnographical survey of the Miskito and Sumu Indians of Honduras and Nicaragua*. Washington, D.C.: Government Printing Office.

Cordón, María Rosa, and Víctor Toledo. 2008. "La importancia conservacionista de las comunidades indígenas de la Reserva de Bosawás, Nicaragua: un modelo de flujos." *Revista Iberoamericana de Economía Ecológica* 7, no. 1: 43–60.

———. 2014. "Historia ambiental de las comunidades indígenas de Bosawás, Nicaragua: un análisis metabólico." *Historia agraria: Revista de agricultura e historia rural*, no. 63: 151–182.

Crutzen, Paul y Eugene Stoermer. 2000. "The 'Anthropocene'." *Global Change News Letter* 41: 17–18.

Cueva, Teresa Elizabeth, Roger Few, and Alfonso Mercado. 2011. "Afrontando el Cambio Climático y los riesgos contra la salud: respuestas en la Sierra Tarahumara." *Estudios Demográficos y Urbanos* 26, no. 3: 671–708.

Danowski, Déborah, and Eduardo Viveiros de Castro. 2014. *Há mundo por vir? Ensaio sobre os medos e os fins*. Florianópolis: Desterro,Cultura e barbárie.

De la Garza, Mercedes. 1989. "Los mayas. Antiguas y nuevas palabras sobre el origen." In *Mitos Cosmogónicos del México indígena*, ed. Jesús Monjarás, 15–86. Mexico City: INAH.

De Sherbinin, Alex. 2014. "Climate change hotspots mapping: what have we learned?." *Climatic Change* 123, no. 1: 23–37.

De Sherbinin, Alex, Susana Adamo, Ama Francis, et al. 2021. "Climate Change and its Impact on Urbanization in Mexico and Central America." Mayors Migration Council.

Diet, Kristina. 2013. "Hacia una teoría crítica de vulnerabilidad y adaptación: aportes para una reconceptualización desde la ecología política." In *Culturas, conocimientos, políticas y ciudadanías en torno al Cambio Climático*, ed. Astrid Ulloa and Andrea Prieto-Rozo, 19–46. Bogotá: Universidad Nacional de Colombia/Colciencias.

Escobar, Arturo. 2018. *Designs for the Pluriverse. Radical Interdependence, Autonomy, and the Making of Worlds*. Durham: Duke University Press.

Erants, Martin, and Eloy Frank. 2001. *Oral History of the Mayangna People*. *Historia Oral del Pueblo Mayangna*. Managua: FOREIBCA/IPILC/URACCAN.

Eckstein, David, Vera Künzel, and Laura Schäfer. 2021. *The global climate risk index 2021. Who suffers Most from Extreme Weather Events? Weather-related Loss Events in 2019 and 2000 to 2019.* Bonn: Germanwatch.

Equipo Kiki. 2022. *Desafíos para la gobernanza territorial Mayangna ante el cierre de espacios para la autonomía en Nicaragua*. San Salvador: Heinrich Boll Stiftung.

Farriss, Nancy. 1984. *Maya Society Under Colonial Rule: The Collective Enterprise of Survival.* New Jersey: Princeton University Press.

Fetzek, Shiloh. 2009. "Climate-Related Impacts on National Security in Mexico and Central America." Royal United Services Institute.

Ford, Anabel, and Ronald Nigh. 2015. *The Maya Forest Garden: Eight Millenia of Sustainable Cultivation of the Tropical Woodlands*. Walnut Creek: Left Coast Press.

Fujigaki, Alejandro. 2020. "Caminos Rarámuri para sostener o acabar el mundo. Teoría etnográfica, Cambio Climático y Antropoceno." *Mana* 26, no. 1: 1–35.

García Quintanilla, Alejandra. 1986. *Los tiempos en Yucatán: los hombres, las mujeres y la naturaleza (siglo XIX)*. Mexico City: Claves Latinoamericanas.

Gardea, Juan, and Martín Chávez. 1998. *Kite amachíala kiya nirúami. Nuestros Saberes Antiguos*. Ciudad de México: Gobierno del Estado de Chihuahua.

Giorgi, Fillipo. 2006. "Climate change hot-spots." *Geophysical research letters* 33, no.8: 1–4.

Gómez, Thelma, and Patricia Mayorga. 2019. "Sin territorio no somos nada: defensores de la Sierra Tarahumara luchan contra el despojo." *Tierra de resistentes*. https://contralacorrupcion.mx/tierra-resistentes/mexico/.

Gonda, Noemi, Selmira Flores, Jennifer Casolo, et al. 2023. "Resilience and conflict: rethinking climate resilience through Indigenous territorial struggles." *The Journal of Peasant Studies* 50, no. 6: 1–27.

González, Isela, Ernesto Palencia, Víctor Martinez, et al. 2016. *Report: Territorial rights of the indigenous peoples of the Sierra Tarahumara. The case of the communities of Bacajípare, Bosques de San Elías Repechique, Choréachi (Pino Gordo), Coloradas de la Virgen, El Mochomo, Huitosachi, Mala Noche* and Mogótavo. Mexico City: Alianza Sierra Madre A.C./Tierra Nativa A.C./Consultoría Técnica Comunitaria A.C.

González, Moises. 1979. *Raza y tierra: la Guerra de castas y el henequén*. Mexico City: El Colegio de México.

Gourdji, Sharon, Peter Läderach, Armando Martinez Valle, et al. 2015. "Historical climate trends, deforestation, and maize and bean yields in Nicaragua." *Agricultural and forest Meteorology* 200: 270–281.

Grosfoguel, Ramón. 2016. "Del 'extractivismo económico' al 'extractivismo epistémico' y al 'extractivismo ontológico': una forma destructiva de conocer, ser y estar en el mundo." *Tabula Rasa* 24: 123–143.

Grupo Integral de Servicios Ecosistémicos Eyé Kawí A. C. 2014. "Diagnóstico sobre determinantes de deforestación y degradación forestal en zonas prioritarias en el estado de Chihuahua." United States Agency for International Development (USAID).

Guardabosques Comunitarios Territorio Mayangna Sauni As. 2021. "Boletín Guardabosques Comunitarios Territorio Mayangna Sauni As." https://ondalocalni.com/media/uploads/2021/07/16/boletin-1-guardabosques-junio-2021.pdf.

Guzmán, Fernando. 2007. "To the rescue of medicinal plants." *El Universal*, November 29.

Hanks, William. 1990. *Referential practice. Language and lived space among the* Maya. Chicago: University of Chicago Press.

Hannah, Lee, Makihiko Ikegami, David G. Hole, et al. 2013. "Global climate change adaptation priorities for biodiversity and food security." *PLoS one* 8, no. 8: 1–10.
Haraway, Donna. 2015. "Anthropocene, Capitalocene, Plantationocene, Chtulucene: Making Kin." *Environmental Humanities* 6, no. 1: 159–165.
Hoffmann, Odile. 2018. "Las configuraciones territoriales de movilidad, o el espacio como lenguaje político." In *El territorio como recurso: Movilidad y apropiación del espacio en México y Centroamérica,* ed. Odile Hoffmann and Abelardo Morales, 23–40. San José de Costa Rica: FLACSO.
Instituto Nacional de Estadística, Geografía e Informática (INEGI). 2020. "Censo de Población y Vivienda 2020." https://cuentame.inegi.org.mx/poblacion/lindigena.aspx?tema=P.
Ilsley, Catarina.1984. "Vegetación y Producción de la Milpa bajo Rosa-Tumba-Quema en el Ejido de Yaxcaba, Yucatán, México." Master's thesis, Universidad Michoacana de San Nicolás de Hidalgo.
Ingold, Tim. 2008. "When ANT meets SPIDER: social theory for arthropods." In *Material Agency: Towards a Non-Anthropocentric Approach,* ed. Carl Knappett and Lambros Malafouris, 209–215. Boston: Springer.
Imbach, Pablo, Luis Molina, Bruno Locatelli, et al. 2010. "Vulnerabilidad de los servicios ecosistémicos hidrológicos al cambio climático en Mesoamérica." In *Adaptación al Cambio Climático y servicios ecosistémicos en América-Latina*, ed. Celia Martínez-Alonso, Bruno Locatelli, Raffaele Vignola, et al., 32–43. Turrialba: CATIE.
Inter-American Commission on Human Rights (IACHR). 2015. "Pueblos indígenas, comunidades afrodescendientes y recursos naturales: Protección de derechos humanos en el contexto de actividades de extracción, explotación y desarrollo." IACHR.
Intergovernmental Panel on Climate Change (IPCC). 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.
Jasanoff, Sheila. 2010. "A New Climate for Society." *Theory, Culture & Society* 27, no. 2–3: 233–253.
Kaimowitz, David. 2002. "Resources, Abundance and Competition in the Bosawas Biosphere Reserve, Nicaragua." In *Conserving the peace: Resources, livelihoods and security*, ed. Richard Matthew, Mark Halle, and Jason Switzer, 171–198. Winnipeg: International Institute for Sustainable Development.
Kaimowitz, David, Angélica Faune, and René Mendoza. 2003. "Your Biosphere is my backyard, the store of Bosawas in Nicaragua." *Science for Forest and people* 12, no. 25: 6–15.
Krenak, Ailton. 2020. *Ideias para adiar o fim do mundo*. Rio de Janeiro: Companhia das Letras.

Klepp, Silja, and Libertad Chávez-Rodríguez. 2018. *A Critical Approach to Climate Change Adaptation. Discourses, Policies and Practices*. New York: Routledge.

Ku-Pech, Elia, Javier Mijangos-Cortés, Ruben Andueza-Noh, et al. 2020. "Estrategias de manejo de la milpa maya en Xoy, Peto, Yucatán." *Ecosistemas y Recursos Agropecuarios* 7, no. 1: 1–8.

LaRochelle, Serge, and Fikret Berkes. 2009. "Traditional Ecological Knowledge and Practice for Edible Wild Plants: Biodiversity Use by the Rarámuri, in the Sierra Tarahumara, Mexico." *International Journal of Sustainable Development & World Ecology* 10, no. 4: 361–375.

Läderach, Peter, Julián Ramirez Villegas, Carlos Navarro-Racines, et al. 2017. "Climate change adaptation of coffee production in space and time." *Climatic Change* 141, no. 1: 47–62.

Latour, Bruno. 1996. "On Actor Network Theory: A Few Clarifications." *Soziale Welt* 47, no. 4: 369–381.

———. 2004 "Whose Cosmos, Which Cosmopolitics? Comments on the Peace Terms of Ulrich Beck." *Common knowledge* 10, no. 3: 450–462.

Lazos, Elena. 1992. "Du maïs à l'orange: the transformation of the agrarian structure. Développement et Crise dans une région mexicaine (Oxkutzcab, Yucatan)." PhD diss., École des Hautes Etudes en Sciences Sociales.

———. 1994. "Diversification of agrarian systems and consequences on the Mayan food system in the south of Yucatan." *Journal d'Agronomie Tropicale et Botanique Appliquée* 36, no. 2: 79–109.

———. 1999. "La Milpa en el sur de Yucatán: Ciclos y limitantes." *Estudios de Cultura Maya* 20: 442–477.

Lazos, Elena and Pavel García. In Press. "'Leek leek leek': El aprendizaje de conocimientos agro-ecológicos de los niños-ranas a través del ritual de Cha' Chaak en Yucatán." In *Geometrías variables del parentesco en el trabajo de milpa con niños,* ed. Andrés Medina, et al. Mexico City: IIA-UNAM, Colsan, Colef.

Lévy, Pablo. 1976. Notas Geográficas y Económicas sobre la República de Nicaragua. Managua: Banco de América.

Levy-Tacher, Samuel, Neptalí Ramírez-Marcial, Darío Navarrete, et al. 2019. "Are Mayan community forest reserves effective in fulfilling people's needs and preserving tree species?." Journal of Environmental Management 245: 16–27.

Loera González, Juan F., and Nicolas Martínez Juárez. 2021. "Aproximación a las afectaciones culturales y de salud por Covid-19 en la Sierra Tarahumara." Cuicuilco. Revista de Ciencias Antropológicas 28, no. 81: 1–28.

López, Marcial. 2012. Análisis de las causas de la deforestación y avance de la Frontera Agrícola en las zonas de Amortiguamiento y Zona Núcleo de la Reserva de Biósfera de BOSAWÁS-RAAN. Managua: UNAG-Nicaragua.

López Bárcenas, Francisco. 2013. "¿Qué hacemos con los indios? Pueblos indígenas y desarrollo: entre las políticas gubernamentales y el buen vivir." *Papeles de Población* 19, no. 77: 177–192.

Luque, A. Diana, Carlos Gay, and Benjamín Ortiz Espejel. 2020. *Complejos bioculturales de México: bienestar comunitario en escenarios de Cambio Climático*. Mexico City: Benemérita Universidad Autónoma de Puebla.

Macdonald, Theodore. 1999. "Awas Tingni: Un Estudio Etnográfico de la Comunidad y su Territorio." Weatherhead Center for International Affairs. https://scholar.harvard.edu/files/tmacdon/files/awas_tingni_final_revised.doc.

Mancera-Valencia, Federico. 2004. "Historia Ambiental de la Sierra Tarahumara." In *Chihuahua Hoy 2004: Visiones de su historia, economía, política y cultura*, ed. Víctor Orozco, 173–218. Mexico City: UACJ.

MARENA. 2019. "Presentación: Esfuerzos nacionales para garantizar la protección de la madre tierra." https://www.marena.gob.ni/Enderedd/wp-content/uploads/2019/04/04-presentacion-bosque-bosawas-riosanjuan-VF.pdf.

Martínez, Isabel. 2012. "Tejiendo como caminos la vida social: teoría Rarámuri de la sociedad y la persona." In *Hilando el noreste. Nudos, redes, vestidos, textiles*, ed. Arturo Gutiérrez, 555–562. Mexico City: COLSAN/COLEF.

———. 2019. "El otro del otro. Entre dos narrativas sobre la explotación forestal de la Sierra Tarahumara, Chihuahua, México." *Revista de El Colegio de San Luis* 19: 1–26.

Martinez, Isabel, Jorge Martinez, and Nashielly Naranjo. 2012. "Para seguir siendo lo que se debe ser: parentesco, grupos domésticos y migración entre los Rarámuri." In *Estudios sobre el Parentesco Rarámuri y Ranchero en el Noreste de México*, ed. Maria E. Olavarria and Isabel Martinez, 31–110. Mexico City: Porrúa.

Mateos-Maces, Lourdes, Fernando Castillo-González, José Luis Chávez, et al. 2016. "Manejo y aprovechamiento de la agrobiodiversidad en el sistema milpa del sureste de México." *Acta Agronómica* 65, no. 4: 413–421.

Mayorga, Patricia. 2021. "Chihuahua: cuando los talamontes-sicarios obligan al exilio." *Revista Proceso*, July 2. https://de.everand.com/article/514388936/Chihuahua-Cuando-Los-Talamontes-Sicarios-Obligan-Al-Exilio.

Miller, Andrew M. and Edward Doolittle. 2017. "Raramuri Bird Knowledge and Environmental Change in the Sierra Tarahumara, Chihuahua, Mexico." *Journal of Ethnobiology* 37, no. 4: 663–681.

Montolíu, María. 1989. *Cuando los dioses despertaron, conceptos cosmológicos de los antiguos mayas de Yucatán, estudiados en el Chilam Balam de Chumayel*. Mexico City: IIA/UNAM.

Moore, Jason W. 2020. *El capitalismo en la trama de la vida. Ecología y acumulación de capital*. Madrid: Traficantes de sueños.

Ocampo, Juan Carlos. 2010. *Estrategias de adaptación al medio en comunidades indígenas después del Huracán Félix: los casos de Butku y Awas Tingni*. Managua: Nitlapan/UCA.

Nail, Thomas, 2019. “Forum 1: Migrant Climate in the Kinocene” *Mobilities* 14, no. 3: 375–80.

O’Brien, Karen. 1998. “Scales of Change: The climatic impacts of tropical deforestation.” In *Elements of Change*, ed. Susan Joy Hassol and John Katzenberger, 86–100. Basalt: Aspen Global Change Institute.

Organización Internacional para las Migraciones. 2021. *La movilidad humana derivada de desastres y el cambio climático en Centroamérica*. Geneva: OIM.

Patch, Robert. 1979. “La formación de estancias haciendas en Yucatán colonial.” In *Cuatro ensayos antropológicos*, ed. Salvador Rodriguez, Robert Patch, and Carlos Urzaiz, 5–42. Mérida: Universidad Autónoma de Yucatán.

Patron, Timothy. 2017. “Sauda: Ceremonia-ritual, Identidad y la cosmogonía de la Nación Mayangna.” https://www.el19digital.com/files/notas/source/2020%20(2)/28%20FEBRERO/LIBRO%20SAUDA.pdf.

Pielke, Roger, Christopher Davey, Dev Niyogi, et al. 2007. “Unresolved issues with the assessment of multi-decade global land surface temperature trends.” *Journal of Geophysical Research* 112: 1–26.

Pirard, Romain, and Alain Karsenty. 2009. “Climate Change Mitigation: Should ‘Avoided Deforestation’ Be Rewarded?.” *Journal of Sustainable Forestry* 28: 434–455.

Puig, María. 2011. “Matters of care in technoscience: assembling neglected things.” *Social Studies of Science* 41, no. 85–106.

Proclama. 2022. “Sulani Kaluduhna Tawaka Mayangna de Honduras y Nikarawas. Una iniciativa más, para la visión de Unidad.” Unpublished work.

Quijano, Aníbal. 2014. “Colonialidad del poder, eurocentrismo y América Latina.” In *Cuestiones y horizontes: de la dependencia histórico-estructural a la colonialidad/descolonialidad del poder*, ed. Aníbal Quijano, 285–327. Buenos Aires: CLACSO.

Reed, Nelson. 1971. *La Guerra de castas en Yucatán*. Mexico City: Era.

Rejón, Lourdes. 1985. “La hacienda diversificada del Sur como modelo integrado de producción. El caso de San Juan Bautista Tabi.” Master’s thesis, Universidad Autónoma de Yucatán.

Robins, Taymond, Arlen Ortiz Jacobo, Armando Juwith, ed. 2012. *La naturaleza está poblada de espíritus: cuaderno cultural sumu mayangna*. Managua: UNESCO.

Rueda, Verónica. 2015. “Inserción civil, lucha política y delincuencia en la posguerra: El Frente Norte 3–80 (FN 3–80) en Nicaragua.” *Revista Policía y Seguridad Pública* 5, no. 1: 353–414.

Ruthenberg, Hans. 1971. *Farming systems in the tropics*. Oxford: Clarendon Press.

Ryan, Douglas A. 1978. “Recent development of national parks in Nicaragua.” *Biological Conservation* 13, no. 3: 179–182.

Salomón, Enrique. 2000. “Kincentric ecology: Indigenous perceptions of the human-nature relationship.” *Ecological Applications* 10, no. 5: 1327–1332.

Sánchez, Paloma. 2022. “Pierde Chihuahua 2 mil 500 millones de pesos al año del producto bruto forestal.” *El heraldo de Chihuahua*. October 1. https://www.elhera ldodechihuahua.com.mx/local/pierde-chihuahua-2-mil-500-millones-de-pesos-al-ano-del-producto-bruto-forestal-noticias-de-chihuahua-bosques-flora-fauna-tala-ilegal-6905062.html.

Sariego Rodríguez, Juan Luis. 2008 "La nueva fiebre de los metales en el norte de México: Capitales, territorios y conflictos." In *El norte de México: entre fronteras*, ed. Juan Luis Sariego, 137–172. Mexico City: Instituto Nacional de Antropología e Historia.

Sauni As Community Ranger. 2021. Personal communication. June.

Schmidt Axel, Anton Eitzinger, Kai Sonder, et al. 2012. "Tortillas on the roaster: Central America's maize–bean systems and the changing climate." Technical report. Baltimore (MD): United States.

SEMARNAT. 2023. Atlas Digital Geográfico. https://gisviewer.semarnat.gob.mx/aplicaciones/Atlas2015/atm_PMedia.html.

Seneviratne, Sonia, Neville Nicholls, David Easterling, et al. 2012. "Changes in climate extremes and their impacts on the natural physical environment." In *Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change*, ed. IPCC, 109–230. Cambridge: Cambridge University Press.

Simpson, Nicholas P., Joanne Clarke, Scott Allan Orr, et al. 2022. "Decolonizing climate change–heritage research." *Nature Climate Change* 12, no. 3: 210–213.

Starry Manoharan, Vany, Ron Welch and Robert Lawton. 2009. "Impact of deforestation on regional surface temperatures and moisture in the Maya lowlands of Guatemala." *Geophysical Research Letters* 36, no. 21: 1–5.

Stengers, Isabel. 2014. "La propuesta cosmopolítica." *Revista Pléyade* 14: 17–41.

Suliman, Samid, Carol Farbotko, Hedda Ransan-Cooper, et al. 2019. "Indigenous (im) mobilities in the Anthropocene." *Mobilities* 14, no. 3: 298–318.

Tarahumara sustentable. 2016. "Visión Rarámuri sobre gobernanza ambiental." Video. https://www.youtube.com/watch?v=mIGEkLVnmMU.

———. 2019. "Proyecto Tarahumara Sustentable." http://www.tarahumarasustentable.mx/.

The Oakland Institute. 2020. "Nicaragua's Failed Revolution: The Indigenous Struggle for Sanitation." The Oakland Institute. https://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/nicaraguas-failed-revolution.pdf.

Tsing, Anna. 2012. "Unruly Edges: Mushrooms as Companion Species: For Donna Haraway." *Environmental Humanities* 1, no. 1: 141–154.

Ulloa, Astrid. 2008. "Implicaciones ambientales y culturales del Cambio Climático para los pueblos indígenas." In *Mujeres Indígenas y Cambio Climático perspectivas latinoamericanas*, ed. Astrid, Ulloa, Elsa Escobar, Luz Donato, et al., 15–35. Bogotá: Universidad Nacional de Colombia/UNODC/Fundación natura.

———. 2013. “Controlando la naturaleza: ambientalismo transnacional y negociaciones locales en torno al cambio climático en territorios indígenas en Colombia.” *Iberoamericana* 13, no. 49: 117–133.

———. 2017. “inámicas ambientales y extractivas en el siglo XXI: ¿Es la época del Antropoceno o del Capitaloceno en Latinoamérica?.” *Desacatos* 54: 58–73.

Vieira, Suzanne, Indira Caballero, and Alejandro Fujigaki. 2022. “Antropología da vida diante da catástrofe ambiental.” *Amazônica, Revista de Antropologia* 14, no. 2: 1–13.

Villa Rojas, Alfonso. 1985. “Nociones preliminares sobre cosmogonía.” *Anales de antropología* 22, no. 1: 229–249.

Viveiros de Castro, Eduardo. 2010. *Metafísicas caníbales. Líneas de antropología postestructural*. Trad. Stella Mastrangelo. Madrid: Katz.

———. 2020. “Sobre la noción de etnocidio, con especial atención al caso brasileño.” *Estudios de Historia Moderna y Contemporánea de México* 60: 111–144.

Von Houwald, Götz. 2003. *Mayangna: apuntes sobre la historia de los indígenas sumu en Centroamérica. Contribuciones a la etnología centroamericana.* Managua: Fundación Vida.

Wandelli, Elisa, and Philip Fearnside. 2015. “Secondary vegetation in central Amazonia: Land-use history effects on aboveground biomass.” *Forest Ecology and Management* 347: 140–148.

Werth, David, and Roni Avissar. 2002. “The local and global effects of Amazon deforestation.” *Journal of Geophysical Research* 107: 55–58.

Wetterslev, Julie. 2021. “Entre colonización y reconciliación: la fragmentación de los territorios indígenas en la Costa Caribe Norte de Nicaragua.” In *Pensamiento social danés sobre América Latina*, ed. Anne Marie Edjesgaard Jeppesen, Erick Gonzalo Palomares Rodríguez, and Georg Wink, 131–146. Buenos Aires: CLACSO.

Whyte, Kyle. 2017. “Indigenous climate change studies: Indigenizing futures, decolonizing the Anthropocene.” *English Language Notes* 55, no. 1: 153–162.

Williamson, Marcos, María José Mendoza, Luis Valerio, et al. 2016. “Pueblos originarios y afrodescendientes de Nicaragua – Etnografía, Ecosistemas Naturales y Áreas Protegidas.” URACCAN/UICN. https://www.uraccan.edu.ni/sites/default/files/2019-10/Manual%20Interpretacio%CC%81n%20Mapas%20-%20WEB.pdf.

Wyndham, Felice. 2009. “Spheres of Relations, Lines of Interaction: Subtle Ecologies of the Rarámuri Landscape in Northern Mexico.” *Journal of Ethnobiology* 29, no. 2: 271–295.

Ybarra, Megan. 2013. “‘You cannot measure a Tzuultaq’a’: cultural politics at the limits of liberal legibility.” *Antipode* 45, no. 3: 584–601.

Climate Change in the Caribbean from 1950 to the Present

The Coloniality of Climate Crisis and Responses in the Greater Caribbean

Kevon Rhiney and Mimi Sheller

> Hurricane Irma's fury preceded Maria's by a deadly Caribbean second. Together they constitute the familiar sound of death and destruction reminiscent of a colonial past that cling to the present and is determined to possess and own the Caribbean future. The chain linked imperial legacy that still imprisons the islands, keeping them politically fragmented and economically divided, was exposed as both cause and effect of a fragile region still feeling the presence of an imperial ethos that assigns to them a reality of structural dependency. Irma-Maria blew away the roof of the long and ongoing imperial cover up, and critically, was revelatory of the horrific history that dwells in the ruins of the present. (Beckles 2017)

Vice-Chancellor of the University of the West Indies Hilary Beckles' statement was issued just days following the devastation hurricanes Irma and Maria inflicted across the Caribbean in Fall 2017. The statement made a forceful argument for climate reparations in the wake of what is now regarded as one of the deadliest and most destructive mid-Atlantic hurricane seasons in modern history. Beckles demonstrates the ways the region's colonial legacies continue to shape its material present and its dire implications for the Caribbean's future development trajectory. In drawing on what he termed the current "hurricane moment," Beckles – who is also chair of the CARICOM Reparations Commission – seeks to counter the dominant narratives shaping Caribbean regional relief efforts and policy responses to climate-related disasters, that increasingly frame these events as exceptional, extreme, and unprecedented, while paying scant regard to the ways these events map onto much longer colonial histories of genocide, enslavement, resource extractivism and ecological catastrophe.

In this chapter, we take up Beckles' provocation to situate regional discourses on climate change and climate justice within a broader politico-cultural context that foregrounds the current climate crisis as an extension of a colonial past that continues to shape the region's subordinate position in an uneven world system. We argue that the region's disproportionate vulnerability to the adverse effects of a changing climate cannot be separated from the historical conditions and logics that brought about the contemporary world and Western modernity. The expansion of industry in western Europe beginning in the late eighteenth century and the related shift towards fossil-based fuels, went hand in hand with European occupation in the Americas. The genocide of Indigenous peoples, African enslavement and the establishment of plantation economies paved the way for the Industrial Revolution – a period marked by the large-scale expansion of industry, mechanized manufacturing, and the establishment of the factory system. The discovery of new power sources and the invention of new technologies and ways of organizing work not only made existing industries more productive and efficient but helped to establish European slaving nations as global industrial centers at the dawn of the nineteenth century. None of this would have been possible without the accumulated wealth accrued from their colonies in the Americas commencing from the sixteenth century in what was largely an international mercantilist system.

In many ways, Beckles' reference to the "horrific history that dwells in the ruins of the present," disrupts attempts to theorize the contemporary moment as a radical rupture from the past. For Beckles and a growing number of Caribbean scholars and activists, discourses on and responses to climate change cannot be separated from these longer colonial histories that continue to structure present-day vulnerabilities throughout the region (see, for example, Baptiste and Rhiney 2016; García-López 2018; Bonilla 2015; Bonilla 2017; Bonilla 2020; Sheller 2018a; Sheller 2018b; Sheller 2020a; Robinson et al. 2022a; Robinson et al. 2022b; Robinson et al. 2022c; Ferdinand 2022). Growing calls for climate reparations are therefore tied to an understanding and recognition of an accumulated debt owed to former European colonies that now bear the brunt of the climate burden (see, for example, Perry 2021). The Industrial Revolution that is often celebrated as a watershed moment for European modernity and progress, also signals the beginning of the current climate crisis with mean global temperature increasing by around 1.4°C since the mid-1700s.

The consequences of this increase in global mean temperature are quite wide-ranging, with significant negative implications for Caribbean small island and low-lying coastal states. For this chapter, we will focus mainly on the insular Caribbean archipelago, rather than the Greater Caribbean. We also acknowledge the diversities across the fragmented sovereignties of these many islands, including ecological, (geo)political, linguistic, historical and cultural differences (Knight 2011), even as all face similar climate hazards and risks. In fact, the Caribbean is regarded as a climate change hotspot and is set to become one of the first and most severely impacted regions in the world as a direct result of global climate inaction (Sealey-Huggins 2017). In this sense, the inability of the international community to date, to establish effective multilateral action against climate change has placed many developing countries in a precarious position, including Caribbean Small Island Developing States (SIDS). Even if all the national pledges made at the Paris Climate Talks to curb emissions were to be met, the world would still be on track to warm between 2–3°C by end of century, which would have significant consequences for the Caribbean.

The Caribbean's disproportional vulnerability to climate change is well established, with many regarding this as an existential crisis for the region (Sealey-Huggins 2017). Growing threats from rising sea levels and extreme weather events like hurricanes and droughts in recent decades have now placed climate change at the center of regional development efforts and debates. In general, the records point to the emergence of a new regional climate regime, marked by warmer temperatures, shifting rainfall patterns, more intense storms and other climate extremes and higher sea levels (Taylor et al. 2017). Both global and regional model predictions suggest that the Caribbean's climate will continue to change in significant ways throughout the course of this century (Mycoo et al. 2022). In the main, these projections indicate a sort of deepening of this new and emerging climate characterized by a much warmer and drier regional climate regime, generating extreme heat surpassing historical norms (Boakye et al. 2024) as well as an increase in the intensity of hurricanes and tropical storms when they do occur, and additional increases in regional sea levels (Taylor et al. 2017). Recent hurricanes such as Irma and Maria (2017), Dorian (2019), and Fiona (2022) have been associated with extreme rainfall events, the triggering of landslides in hilly areas, and the disruption of power and water supplies for extended periods of time.

The risks associated with these climate-induced changes for the Caribbean are immense, with profound implications for the future, particularly in terms of regional development and sustainability. These impacts are likely to be negative, non-linear, and unevenly distributed across sub-regions, economic sectors, and socio-economic groups (Rhiney 2015; Thomas et al. 2020). The impacts on human health, water resources, biodiversity, coastal infrastructure, tourism, energy grids, and agriculture are expected to be amongst the worst, with dire implications for future regional development prospects. Rising sea levels and higher sea surface temperatures, for example, pose a severe threat to a range of coastal and marine ecosystems found throughout the Caribbean, especially coral reefs, and mangroves. Any widespread devastation of coral reefs will severely threaten the livelihoods of thousands of fisherfolk across the region, not to mention the profound implications for the Caribbean coastal tourism industry (Scott et al. 2012; Chen et al. 2015). Rising sea levels also enhances the risk of coastal flooding, biodiversity loss, saltwater intrusion and the disappearance of valuable coastal lands and beaches due to increased inundation and shoreline erosion (Cashman et al. 2010; Pulwarty et al. 2010; Scott et al. 2012). Likewise, future changes in the intensity and/or frequency of extreme weather events such as droughts, extreme heat, and hurricanes, will have a pronounced regional impact on available freshwater resources, agricultural production, tourism, and human health (Nurse et al. 2014; Boakye et al. 2024).

Following the interruption of the COVID-19 pandemic, tourism arrivals in the region largely returned to and surpassed 2019 levels by 2023, with 11 destinations, Anguilla, Aruba, Curaçao, Dominican Republic, Grenada, Guyana, Jamaica, Puerto Rico, St. Maarten, Turks & Caicos Islands, and U.S. Virgin Islands performing better than in 2019 (Caribbean Tourism Organization [CTO] 2024). Yet many of these highly tourism-dependent destinations still face serious infrastructural vulnerabilities due to climate change, especially in urban areas where population is concentrated. As Michelle Mycoo, Stacy-Ann Robinson et al. (2021: 2) observe, Caribbean cities and ports are especially vulnerable:

> Climate change has increased the intensity and spatial patterns of coastal hazards faced by Caribbean cities such as Bridgetown (Barbados), Georgetown (Guyana), Port of Spain (Trinidad and Tobago), Kingston (Jamaica), and Castries (St. Lucia) (Mycoo 2014; Mycoo 2017; Mycoo and Donovan 2017). These cities are all located on the coast and the coastal hazards experienced include SLR [sea level rise], heavy precipitation events, tropical cyclones, and storm surges, and flooding. Based on various SLR models, it is projected that almost all coastal infrastructure in the Caribbean, including port and harbor facilities, will experience inundation in the future. (Nurse 2015; Cashman and Nagdee, 2017; Nurse, 2017)

Beyond tourism, diversified Caribbean-island economies also include financial services, mining, oil extraction and refining, agriculture and the ocean-based "blue economy," but these sectors are also threatened by climate change extremes. By and large, these trends point to a worrying and uncertain future for the Caribbean, made worse over the years by the inability of the international community to agree to common solutions in tackling this worsening global climate problem.

The chapter is organized into two main sections and a conclusion. In the first section we lay the groundwork for Caribbean Anthropocene thinking by acknowledging its origins in counter-plantation and decolonial projects that preceded the climate crisis yet foretold its coming. Here we show the significance of theories of underdevelopment and Caribbean alternative development movements as precursors to Anthropocene critique, and we situate the theorization of a Caribbean Anthropocene through these histories. In the second section, we turn to the more recent technical and political responses to climate change and climate adaptation across the region, including Caribbean leadership in the claims of Small Island Developing States at the UN Conference of Parties meetings, in the Alliance of Small Island States (AOSIS), in writing key aspects of the IPCC reports, and in advancing international calls for climate reparations, loss and damages, and other climate justice initiatives. The conclusion will address some of the tensions that persist in the Caribbean response to the Anthropocene.

Theorizing a Caribbean Anthropocene

We begin with the roots of the contemporary climate crisis in the longer history of Caribbean responses to colonial and capitalist ecological transformations driven by rampant processes of extraction including: primary deforestation, monocrop plantations, worldwide movement of people, flora and fauna, extractive industries, and the associated systems of Indigenous genocide and displacement, racialized slavery, indentured servitude of transplanted workers, and dependent development/underdevelopment through which the "New World" was incorporated into the global capitalist economy. It is generally accepted today that this grounding must be the starting point for any analysis of Caribbean climate change today (e.g., Cateau 2022; Ferdinand 2022; Sheller 2018b).

The transatlantic slave trade and the plantation economy that it supported were a key step in initiating European industrialization as a global project and fueling the great acceleration in unequal energy use that we now understand as the Anthropocene. The first internal critiques came from those living through it, in the form of resistance to slavery and rejection of the human and ecological exploitation of the transatlantic and transpacific plantation economy. The human crisis of enslavement, Indigenous genocide – and associated deforestation and clearing of land for, e.g., gold mining, monocrop sugarcane, coffee, and other plantations – instantiated the violence of ecocidal extraction, human disposability, and industrial ruination. This "consuming of the Caribbean" left its mark on the planet (Sheller 2003). The development of counter-plantation modes of life (e.g., Maroon and Afro-Indigenous escape to the margins and Caribbean interstitial peasant socio-ecologies) embodied alternative epistemologies and ontologies of being outside of capitalism (Mintz 1985). Arising out of a critique of the ecocidal and genocidal propensities that already existed in the proto-Anthropocene, Afro-Caribbean culture-making initiated a Caribbean critique of the socio-ecological crisis that we now recognize as a "man-made" planetary crisis (Wynter 2003; Ferdinand 2022).

The link between plantation slavery and capitalism was first academically established by Eric Williams in his famous study *Capitalism and Slavery* (1944) and was expanded upon by radical Caribbean thinkers such as C.L.R. James, Walter Rodney, Claudia Jones, and Sylvia Wynter. Williams noted the complete clearing of forests on Caribbean islands (e.g., Barbados was half cleared by 1650 and entirely so by the end of the century), the depletion of soils by sugar cultivation, the loss of topsoil on slopes that experienced severe erosion, and the environmental collapse of older sugar plantation islands, all of which contributed to the abolition of slavery in his view (Williams 1944). Massive deforestation left such islands more vulnerable to hurricanes and also depleted their water supply, leading to the very first European efforts at forest conservation in St. Vincent and Tobago (Grove 1995). It is important to situate the critique of man-made ecological transformation of the *entire planet* in these earlier Caribbean histories, which made clear the impact of monocrop plantations, extractive industries, sacrifice zones, and disposable labor in the emerging global economy (Sheller 2003; Sheller 2020a).

Critical Development Studies arose at the University of the West Indies as part of the wider Latin American and "Third World" critique of dependent development and underdevelopment (Beckford 1972; Girvan 1970; Girvan 1971). The New World Group identified the contemporary conditions of poverty and non-sovereignty in the Caribbean as "a legacy of the pervasive effects of the plantation system" (Girvan 2010: 8). Although largely understood through a political economy lens, we can see the beginnings of a political ecology also emerging. As both a political project of establishing sovereignty for Caribbean self-determination and an epistemological project of decolonising thought, the New World Group's economic critique of underdevelopment lay the groundwork for understanding the Anthropocene not as a generalized "man-made" condition, but specifically as an outcome of plantation economies, racialized labor exploitation, uneven development, and extractive capitalist industrialization. The kinds of planetary resource extraction and labor exploitation that were theorized by Guyanese radical thinker Walter Rodney in his book *How Europe Underdeveloped Africa*, are now taken up in new ways by Caribbean leaders like Beckles, who in a nod to Rodney titled his recent argument for European reparations to the Caribbean *How Britain Underdeveloped the Caribbean*.

When looked at from the perspective of the Caribbean, any discussion of climate change impacts, including theorizations of the Anthropocene, must take into consideration these multiple and conjoining histories. As Gabrielle Hecht (2018) has argued, the Anthropocene is a scalar project and how we engage with scalar stories matters. Geographical concepts such as "the New World," "the Americas," and "the Caribbean" are all important ways in which the region is located within global discourses of the Anthropocene; but so too are "interscalar vehicles" such as "the slave ship," "the plantation," "commodities", or "small islands" metaphors for understanding a Caribbean Anthropocene. "Extraction (of all kinds) has powered the large-scale rearrangement of substances that materially constitutes the Anthropocene," Hecht argues, and thinking "with an African Anthropocene reminds us of who pays the price for humanity's planetary footprints" (Hecht 2018: 135). The same can be said for thinking with a Caribbean Anthropocene, and from the multiple place-based perspectives of the Caribbean.

Caribbean responses to climate change and other crises of "the Anthropocene" are not homogenous – alongside the already noted ecological, (geo)political and cultural differences amongst islands, there are different strands, tempos, and discourses. While we focus on the 1950s and onwards (the period referred to as "the great acceleration"), we are cognizant of the many 'pre-histories' that inform the present moment and will at times refer to events that predate and disrupt any attempt at developing a supposedly neat periodization of the Anthropocene. We will not linger on whether we name this era as "Capitalocene" (Moore 2015), "Plantationocene" (Moore et al. 2019) or even "Chthulucene" (Haraway 2015), although each is relevant in different ways. Certainly, we agree with Martinican political ecologist Malcom Ferdinand who argues that the *anthropo*-centric naming of this new geological era – in which human activities have left a lasting mark on the Earth's ecosystems – conceals "the diversity of ecosystems, geographic locations, and the non-humans that constitute them [e.g.,] urban natures, slums, and plantations"; and at the same time "the terms 'Man' or *anthropos* mask the plurality of human beings" (Ferdinand 2022 [2019]: 5). Ferdinand's landmark book *Decolonial Ecology: Thinking from the Caribbean World*, overturns the "double fracture" of this "white Anthropocene" politics by foregrounding Maroon ecology, interspecies alliances, and the perspective from the hold of the slave ship.

What many Global North theorists of the Anthropocene have overlooked is that the critique of the plantation economy and colonial exploitation as a planetary socio-ecological catastrophe was already contained within popular discourses and cultural practices of those who survived it. Sylvia Wynter theorized a liberatory conceptualization beyond "Man1" of the Renaissance and "Man2" of the Enlightenment through the concept of the Human-After-Man: a rejection of Western, liberal, individualist, racist, and patriarchal assumptions that are by default built into the idea of "Anthros" as a universal humanity, which still taints the idea of the Anthropocene (Wynter 2003). Her complex arguments more fully elaborated in the unpublished work *Black Metamorphosis* are an effort to think beyond European modernity and beyond coloniality, which implies thinking of alternative futures after, beyond, or outside of the Anthropocene (McKittrick 2015; Kamugisha 2019). In many ways Malcom Ferdinand's recent work on *Decolonial Ecology* (2022) builds on and updates these arguments for a climate-challenged world. This strand of work recognizes that Caribbean people have been living through, analyzing, and challenging the global-scale colonial-imperial ecological transformation since its beginnings because their own lives and bodies were involuntarily implicated in it through displacement, disposability, and death within the transatlantic slave trade – which removed 12 million people from the African continent to the Americas, with a calculated loss of 2 million lives in the Middle Passage – and the colonial plantation societies that launched European modernization, industrialization, and genocidal/ecocidal growth.

Various strands of Caribbean radical politics and critical thought have long sought to stymie colonial and neocolonial capitalist extraction by generating creative ways of living in and against such worlds that would negate the extractive drives of the Anthropocene, restore ecological balance, and infuse socio-natures with spiritual meaning. These cultural prefigurations and imaginations of another world – by the enslaved, by Maroons (Price 2008), by Haitian revolutionaries (James 1963), by Caribbean 'proto-peasantries' (Mintz 1985), by enslaved women's resistance (Beckles 1989; Bush 1990; Reddock 1985; McKittrick 2006), and by counter-plantation practices (Casimir 2020) and culture building (Besson 2002) – would arrest the Anthropocene. Even if they appeared *avant la lettre*, in other words, Caribbean people were analyzing colonial and capitalist extractivist violence and constructing post-Anthropocene worlds long before white theorists recognized and bestowed names upon those processes of creating livable futures (Wynter and McKittrick 2015; Sheller 2020a; Ferdinand 2022).

It is also important to situate contemporary debates about the Anthropocene in relation to these earlier critiques of slavery and capitalism as a global system of uneven development because it informs the current Caribbean demands for responsibility, reparations, and payment of climate-linked loss and damages. Once we understand climate vulnerability as a product of colonial plantation economies and capitalist underdevelopment, this lays bare the coloniality of disaster (Bonilla 2020) and the coloniality of climate itself (Sheller 2018a; Sheller 2020a; Sultana 2022), which leads to a bridging of calls for slavery reparations and for climate reparations. Even though systems of colonialism and forms of resistance differed across these islands, with Maroons finding a foothold in only a few places, or revolutions and decolonization only occasionally meeting success, the presence of these options (and their suppression by colonial and enslaving powers) shaped the entire region. As Laura Pulido has observed, the Anthropocene is "a racial process" that continues to produce "racially uneven vulnerability and death" (Pulido 2017: 117).

Building on Quijano's notion of the coloniality of power (2000), the coloniality of climate refers to not only the distribution of climate risk and vulnerability as an artefact of uneven capitalist development and colonial underdevelopment, but also the ongoing imperial violence and ontological violence that continues to reproduce racialized (post)colonies whose populations are left to suffer climate-linked disasters, disposability and death, even under current global regimes of climate mitigation and climate adaptation. Even where some local elites may be thriving, moreover, or foreign expats moving into climate-secured bunkers and bubbles of self-provisioned infrastructure or libertarian crypto-secession (Simpson and Sheller 2022), ontological violence still shapes "green" transitions through processes of "climate coloniality" (Sultana 2022) that unevenly channel the distribution of vulnerabilities within the Caribbean region, protecting elites while hitting the racialized descendants of the formerly enslaved and indentured populations, along with Indigenous groups, the hardest.

If theories of underdevelopment and anti-colonial critique informed the main trajectories of Caribbean radical thought in the 1950s–1980s and remain influential in Caribbean understandings of the Anthropocene today, by the 1990s there was also occurring a shift to a more technocratic and managerial approach to climate change through the lens of sustainable development. In the following section we turn to this institutionalization of new nature-society relations through public policies for emergency management, disaster risk reduction and building resilience, all of which have fed into current Caribbean discourses and responses to the ongoing climate crisis.

The "Climate Turn" and the Growth of the Climate Justice Movement

While we have argued for a longer periodization of Caribbean thought on European impact on global human ecologies, the 1990s mark the period where work explicitly on "climate change" began in the Caribbean, though it was less known at the time how significant this was. Dr. Anthony Chen founded the Climate Studies Group, Mona (CSGM) in 1994 and then went on to win a Nobel Peace Prize in 2007, for efforts made to increase and disseminate greater knowledge of man-made climate change and to set the critical groundwork for the action required to address and counteract these changes. Chen was one of the first Caribbean scientists to contribute to the UN Intergovernmental Panel on Climate Change (IPCC) reports along with John Agard and Leonard Nurse. Agard and Nurse both served as lead authors on past IPCC Assessment Reports. Nurse was a Coordinating Lead Author for the "Small Islands" chapter in the Fifth Assessment Report. He also served as Vice-Chair of the Intergovernmental Oceanic Commission Sub-Commission for the Caribbean and Adjacent Regions (IOCARIBE) and was a member of the Scientific and Technical Advisory Panel of the Global Environment Facility. Agard served as Coordinating Lead Author on the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Much of the early work around climate change in the Caribbean was focused on developing the technical and scientific capacity to study the region's climate and the mechanisms that drive seasonal weather patterns as well as extreme weather events. This included adopting and developing statistical models using historical weather data to measure past changes and trends in the regional climate. The CSGM, housed in the Department of Physics at the UWI Mona Campus, investigated the mechanisms responsible for seasonal weather patterns, variability and climate extremes in Jamaica and the wider Caribbean. Other work was more focused around coastal zone management and marine ecology. For instance, Agard's work in tropical island ecology centered on investigating the effects of coastal pollution on marine life and ecosystems. And much of Nurse's early research focused on investigating the impacts of human activities on coastal and nearshore dynamics.

In retrospect, the contributions made by these regional scientists helped paved the way for greater global scientific attention on the unique circumstances driving climate vulnerability in SIDS. Their inclusion in these global scientific bodies was no doubt influenced by mounting efforts among leaders of several small island nations in raising global awareness on the greater vulnerability and special needs of SIDS under a changing climate. The formation of organizations such as the Alliance of Small Island States (AOSIS) marked the beginning of the growing influence of SIDS in climate politics and played a huge role in advocating for global action to address climate change. The AOSIS which was founded in 1990 played an important role in advocating for the establishment of the UN Framework Convention on Climate Change (UNFCCC) and was an important actor in the negotiations leading up to the creation of the Framework in 1992.

Despite the early achievements of the AOSIS in raising the political profile of SIDS in global climate negotiations – culminating in the staging of the first ever United Nations conference devoted entirely to small island states, held in 1994 in Barbados – the organization's efforts to secure clear and actionable commitments from developed nations were thwarted partly by the absence of a scientific basis. For instance, the AOSIS' proposal at the 1992 Earth Summit for the creation of an international insurance fund, funded by developed countries to compensate SIDS for damage caused by climate change was quickly shut down partly on the basis of a lack of evidence to justify the setting up of such fund. Up to 2001, very little climate change science information existed for the Caribbean at a scale deemed appropriate to the needs of the region's small island states (Taylor et al. 2013a). What was known about the Caribbean climate at the time was gleaned from global climate models (GCMs), that were too coarse in resolution to have any significant value for regional decision makers and climate negotiators, "who were increasingly demanding finer-scale projections with subregional and, if possible, island-scale differentiation" (Taylor et al. 2013: 1065).

In many ways, this impasse laid the foundation for a new wave of research and regional policy initiatives focused explicitly on the human and biophysical threats climate change posed for Caribbean SIDS. This new body of work was necessarily tailored towards the policy community since there was a clear need to establish an evidence base and rationale for advancing climate action in the region. The establishment of the Caribbean Community Climate Change Centre (5Cs) in February 2002 signaled yet another significant step in efforts to mainstream climate change considerations in the regional policy and development landscape (Rhiney and Baptiste 2019). One of the main purposes for setting up a regional climate change center was to serve as a repository and clearing house for regional climate change data and providing technical and advisory support for advancing national strategies within CARICOM related to adaptation and mitigation initiatives. And later, in September 2003, the PRECIS-Caribbean initiative was started at a workshop in Havana, Cuba, convened by a group of regional climate scientists with the aim of addressing this knowledge gap through the establishment of a multi-country collaborative initiative that could quickly generate the suite of regional high-resolution climate projections needed. The Providing Regional Climates for Impacts Studies (PRECIS) regional climate model, which had recently been released from the Hadley Centre in the UK, was acquired, and installed at three regional institutions: the Instituto de Meterología in Cuba, the 5Cs in Belize, and the three main campuses of the University of the West Indies spanning Barbados, Jamaica, and Trinidad.

The PRECIS-Caribbean initiative led to the generation of the Caribbean's first suite of regional climate models. In 2007 a sensitization document was produced that offered initial results for use by policymakers (see, Taylor et al. 2007). Since then, there has been a slew of scientific publications and technical reports documenting the downscaled model results (see, for example, Charlery and Nurse 2010; Campbell et al. 2011; Taylor et al. 2011; Taylor et al. 2013b). This included some of the first downscaled future climate change projections for the region. The outputs from these models confirmed what many had suspected already, but with a greater degree of confidence, backed up by the available climate science. In sum, the models depicted an overall warming and drying trend for the Caribbean with distinct regional and seasonal variations in temperature and precipitation.

The establishment of a regional climate database and the outputs produced from the PRECIS-Caribbean initiative, formed the basis for a growing body of regional climate impact studies. These include sector-specific studies on the economic cost of climate change and examinations of the impacts and threats of climate change on regionally important sectors such as agriculture (Gamble et al. 2010; Campbell et al. 2011), fisheries (Nurse 2011; Baptiste 2013), water resources (Cashman et al. 2010), and tourism (Scott et al. 2012). By the mid-2000s more funding and policy attention shifted towards research focused explicitly on assessing climate related impacts (Bishop and Payne 2012; Popke et al. 2016). This went hand in hand with a growing strand of research in the social and applied sciences that investigated factors driving vulnerability to climate change impacts, particularly among historically marginalized groups and communities. Much of this research was community based and was informed by social theory and methodologies. For the most part, these studies showed that the impacts of a changing climate were already being felt by different social groups, the majority of which had limited capacity and resources to adapt to the observed changes.

Much of this work was an extension of an already established body of scholarship rooted in disaster studies and Caribbean political economy. The devastating impacts inflicted on Jamaica by Hurricane Gilbert in 1988 and a spate of severe drought events that occurred across the Caribbean throughout the early 1990s had already sparked regional academic interest in natural disasters and their development implications. This led to a flurry of academic work looking at community-based disaster risk management approaches. This strand of scholarship drew strongly from the emerging field of entitlement studies that had started to influence research globally around the social determinants of natural disasters. Concepts such as the Sustainable Livelihoods Framework became central to community-level analyses of the factors that were driving vulnerability in marginalized communities, including explorations of how various socio-economic and environmental processes interacted to determine different livelihood outcomes. Early climate impact studies were therefore preoccupied with understanding and measuring the conditions that were driving vulnerability to climatic shocks among historically marginalized communities (i.e., small farmers, fisher folk, Indigenous and rural communities etc.). Studies showed, for instance, that small resource poor farmers were being disproportionately impacted by extreme climate events such as droughts, partly due to underlying historical and structural forces that were reducing their ability to sustain their livelihoods in the face of changing climatic conditions (Campbell et al. 2011). Building on the work of regional thinkers such as George Beckford and anthropologists Michel-Rolph Trouillot and Sidney Mintz (Trouillot 2025; Mintz 1960), these studies showed how small-scale farmers' disproportional vulnerabilities to climatic shocks were shaped in large part by underlying structural legacies handed down over centuries from a colonial past that was antithetical to the development of a local Caribbean peasantry (Barker 2012; Rhiney et al. 2018).

By 2010, there was a noticeable shift from a predominantly vulnerability framework to a focus on resilience, aligning with growing interests in the global scientific and donor communities to support work that were more solutions-oriented and explicitly focused on identifying suitable climate adaptation pathways. Unlike vulnerability, the concept of resilience starts with the resources, skills and capacities that already exist in local communities and households that could be identified and enhanced to overcome or even take advantage of an external threat. Over the past decade, this has spurred much technical and academic work centered on exploring different adaptation pathways and strategies for building resilience in poor and marginalized communities and economic sectors. For instance, there has been initiatives aimed at identifying and promoting new or hybrid cultivars of regionally important crops that are better suited for a warmer, drier and variable Caribbean climate. At the policy level, there has been a focus on capacity building initiatives and promoting state of the art scientific and technological innovations across key sectors.

In general, these studies have shown that the Caribbean is disproportionally vulnerable to anthropogenic climate change and has provided a scientific basis for calling for more ambitious climate adaptation and mitigation targets at the international level. Indeed, Caribbean leaders and activists have been extremely vocal at the annual UN Conference of Parties (COP) meetings and have worked alongside leaders from other SIDS regions to lobby for more ambitious global action around climate change. There is now an entire chapter dedicated to small islands states in the IPCC report, and Caribbean leaders were instrumental in shaping the decision to produce a special IPCC report on the implications of 1.5°C global warming (SR1.5C). Several regional scientists contributed to the IPCC Special Report on Global Warming of 1.5°C (SR1.5C), as well as the Sixth Assessment Report (AR6). The Caribbean-led "1.5 to Stay Alive" campaign at the 2015 Paris Accord was considered a major reason for global leaders to agree to the ambitious targets that were set at the end of that meeting. Barbados Prime Minister Mia Mottley has been a leading voice at the COP meetings, at the United Nations, and at the International Monetary Fund demanding new forms of climate financing for loss and damage and climate reparations at the international level (Lustgarten 2022).

The most recent scholarship in the field includes work on international climate negotiations and policies concerning loss and damage from scholars of international environmental policy and global climate policy like Stacy-Ann Robinson, Michelle Mycoo and Adelle Thomas. This new wave of scholars has studied the mainstreaming of climate adaptation policies in SIDS (Robinson 2019); climate justice for SIDS through the appropriate financing of loss and damage (Lai et al. 2021; Thomas and Benjamin 2018; Thomas et al. 2021); adaptation to coastal hazards (Mycoo et al. 2022), policies to build urban resiliency (Mycoo 2022), and the concept of a "Blue Urban Agenda" for coastal cities in Caribbean and Pacific SIDS (Mycoo and Donovan 2017); and frameworks for assessing the design, implementation and management of the institutional arrangements for climate change adaptation in SIDS in the Atlantic and Indian Oceans (Robinson et al. 2022a; Robinson et al. 2022b). Robinson was a Contributing Author to Chapter 15 (Small Islands) of Working Group II's contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, which was released in February 2022. Similarly, Thomas and Mycoo have both served as lead authors on several IPCC reports including SR1.5C and the recent Sixth Assessment Report. This entire body of scholarship led to important contributions by SIDS to center policies for payment of loss and damages at the 27th Conference of Parties in Sharm el-Sheikh, Egypt in November 2022. This new vein of research aligns with growing calls for climate reparations – building on the already existing demand for slavery reparations, thus linking current vulnerabilities to climate crises and demands for loss and damages to longer histories of slavery, colonial extraction, and neocolonial debt (Sheller 2023). Climate justice frameworks are also increasingly integrating gender-sensitive approaches that take cognizance of the unequal experiences of climate vulnerability especially among female-headed households in informal settlements across the region (Mycoo 2022).

Since the devastating 2017 hurricane season, there has been a growing climate justice movement across the Caribbean, raising awareness around the uneven impacts of climate change and calling for more equitable solutions at the national, regional, and global level. In Puerto Rico, for instance, a network of grassroots organizations called for just recovery in the rebuilding efforts post hurricane Maria and have pushed for transformational changes in the island's energy and food sectors (Bonilla and Lebron 2019). This has seen greater calls for food sovereignty, sustainable energy solutions, energy democracy, and community self-determination. Expanding networks of agro-ecologists, labor activists and community leaders are working in communities to promote rural kitchen gardens, urban farms and community brigades that can provide more rapid and effective support to impacted communities in case of future disasters (Molinari and Sheller 2026). Tied to this are increasing calls to rethink dominant discourses around disaster recovery and climate adaptation that are often rooted in neoliberal framings of resilience, advocating instead for a kind of bottom-up form of recovery and climate action that builds on longstanding traditions of mutual aid and grassroots mobilization (Moulton and Machado 2019; Rosa-Rosa et al. 2025).

In sum, the last three decades have seen the rise and cementing of a vibrant climate justice movement in the Caribbean, premised against the growing recognition of the region's disproportional vulnerability to the ongoing global climate crisis and rooted in the region's anti-colonial and decolonial political histories. There is now a growing network of scholars, activists, artists, and other thought leaders who are at the forefront of discourses around climate change and its uneven impacts and are at the forefront of calls rallying world leaders to keep future global mean temperature to well below 2 degrees Celsius above pre-industrial levels. Yet, as the Caribbean takes the lead in arguing for loss and damages, debt relief/swap, and reparations, it poses the problem of where do we go from here? Is investment in climate adaptation through international financing mechanisms enough to preserve a habitable future? We conclude by offering some brief reactions to these questions, connecting the particularities of the Caribbean and the period under study, with broader global discourses and imaginaries around resolving the current climate crisis.

Rethinking the Anthropocene from its Ruins

We return to Beckles' reference to the ways the devastation caused by hurricanes Irma and Maria was revelatory of the "horrific history that dwells in the ruins of the present." Such statement draws attention to the ways the current climate crisis maps onto a *longue durée* of colonial violence and subjugation in ways that disrupt teleological notions of temporality shaped in large part by a modernist conceptualization of time that is held together by clearly defined distinctions between the past and the present. Instead, the present moment reveals the multiple colonial afterlives that persist in the here and now and works in unique ways to counter postcolonial imaginaries of sovereignty and progress – imaginaries that often erase longer histories of structural and racial violence that have been central to the un/making of the Caribbean. A Caribbean Anthropocene, we have argued, offers counter-imaginaries of the past, present and future, arising out of its "demonic grounds" (McKittrick 2006) and alternative praxis of "being human" (Wynter and McKittrick 2015).

In line with decolonial critiques, Caribbean theorizations of the current climate crisis as an extension of a kind of colonial past-present, has important implications for how we come to understand the Anthropocene. Decolonial scholars' attention to the ways western knowledge and modernity have worked to displace, downplay, and erase other modes of living, thinking and being in this world is particularly useful in reframing the universalizing discourses on climate change. Thus, re-imagining alternatives to the present conjuncture based more around principles of healing and self-empowerment, for instance, while taking seriously questions of repair and reparations, are fundamental aspects of decolonial thinking. This raises critical questions regarding the political, historical, and onto-epistemic assumptions/logics that undergird contemporary discourses around the global climate crisis and its attendant solutions.

The notion of a singular and undifferentiated "humanity" for instance (assumed in concepts like the Anthropocene) fails to recognize the ways western modernity is marked by a long history of colonialism that was fueled by indigenous genocide, plantation slavery, racial violence and resource extractivism. These experiences point to the need to break away from the universalizing, Eurocentric and techno-scientific discourses that animate current understandings of climate change (and their discursive and material implications), or as Karsten Schulz (2017) puts it "imagining *collective becomings otherwise*, in the sense of a transformation towards less destructive and more just forms of co-existence, and thus avoiding superficial conjoining – or the mere reshuffling – of what is presently deemed 'natural' or 'social' *within* the commodifying logic of the modern capitalist world-ecology" (emphasis added by authors).

Much of these critiques argue that there is a need to deconstruct the 'human' in these grand narratives to highlight the uneven historical ways different groups (or genres) of humans and nation states have been *forcefully* inserted in the global economy and how these continue to shape contemporary climate inequities. These global insertions and inequities take many different forms in the wide range of different Caribbean societies, yet they all point toward the same diagnosis: other worlds are possible, as the political slogan goes. And tied to this is an understanding that the solution to our current climate problem may very well lie outside of Western modernity's ways of knowing, being and relating: of course, the obvious paradox being our struggle to save a *world* that was founded on the subjugation, decimation, and ending of other *worlds*.

Finally, we note that despite the many promising Caribbean contributions to critical thought and action in response to the Anthropocene, there also remain many contradictions and tensions around climate change within the region. Perhaps most glaring of all is the opening of new deep-sea oil fields off the coasts of Guyana and

Suriname, and the growth of fossil fuel extractive industries in Trinidad & Tobago, and other potential locations (Hughes 2017). ExxonMobil's offshore drilling has opened one of the largest oil fields in the world and is incompatible with remaining in a 2.0 degrees Celsius target of global warming, let alone the more desirable 1.5 degrees. Another contradiction is that international climate financing for adaptation projects is tied to mitigation strategies to install renewable energy, even though the Caribbean has made miniscule contributions to global GHG. Barbados, for example, seeks to be the first 100 percent green and fossil-fuel-free island state in the world, while Jamaica is targeting 25 percent reduction in GHG emission by 2030, or up to 29 percent emissions reduction with international support (Government of Barbados 2021; Government of Jamaica 2020, cited in Shah 2022). Meanwhile extractive mining developments continue to expand in many places, with demand for new bauxite mining leases in Jamaica and Suriname, gold prospecting in Haiti, and continuing deforestation and sand-mining for the building of tourism resorts (Sheller 2020b). Urbanization continues to increase in the region. Even the Chinese Belt and Road Initiative has reached across the Pacific and seeks to open the Caribbean to the building of logistics hubs, deep seaports, and more highways, many of which will lock in further fossil fuel infrastructure.

We can conclude with Michelle Mycoo that, "At no other time in the Caribbean's history has visionary urban planning and management been so needed as now, to confront the challenges brought on by the pandemic, climate change, unequal socio-economic development, and environmental degradation as a product of colonialism, and subsequently anthropogenic pressures" (Mycoo 2022). More pointedly, as Sylvia Wynter explains, we need to move beyond "the liberal monohumanist Man2" that assumes "*the human population as a whole*" is responsible for destroying the planet, when in fact it is "*homo oeconomicus,*" a subset of Western bourgeois liberalism which imagines the Anthropocene as universal (Wynter and McKittrick 2016: 24, italics in original). This contemporary moment of visionary planning, we suggest, must move beyond neoliberal framings of climate adaptation and mitigation to instead draw on the intellectual, cultural, and activist resources of the Caribbean people's centuries-long struggles to *actively bring ruination upon* racial capitalism and colonialism, and to rebuild other worlds of regenerative possibility. Whether new international climate loss and damage financing mechanisms can advance such a radical vision of transformation is questionable, yet they remain the main policy proposition up for discussion.

References

Baptiste, April Karen. 2013. "Climate change adaptation among small-scale fishers in Trinidad and Tobago and Jamaica." *Caribbean Geography* 18, no. 1: 39–63.

Baptiste, April Karen, and Kevon Rhiney. 2016. "Climate justice and the Caribbean: an introduction." *Geoforum* 73: 17–21.

Barker, David. 2012. "Caribbean agriculture in a period of global change: Vulnerabilities and opportunities." *Caribbean Studies* 40, no. 2: 41–61.

Beckford, George. 1972. *Persistent Poverty: Underdevelopment in Plantation Economies of the Third World*. Oxford: Oxford University Press.

Beckles, Hillary. 1989. *Natural Rebels: A Social History of Enslaved Black Women in Barbados*. New Brunswick: Rutgers University Press.

———. 2017. "Irma-Maria: A Reparations Requiem for Caribbean Poverty." *The University of the West Indies: Campus News*, September 22. https://sta.uwi.edu/news/releases/release.asp?id=21727.

Besson, Jean. 2002. *Martha Brae's Two Histories: European Expansion and Caribbean Culture-Building in Jamaica*. Chapel Hill: University of North Carolina Press.

Bishop, Matthew Louis, and Anthony Payne. 2012. "Climate Change and the Future of Caribbean Development." *The Journal of Development Studies* 48, no. 10: 1536–1553.

Boakye, Frederick Oppong, Keneshia Hibbert, and Jorge Gonzalez-Cruz. 2024. "Extreme Heat in the Caribbean: Impacts on Wellbeing and Buildings Energy Infrastructure – The 2023 Summer Case." *J. Eng. Sustain. Bldgs. Cities* 5, no. 3, Paper No: JESBC-24-1034. https://doi.org/10.1115/1.4066382.

Bonilla, Yarimar. 2015. *Non-Sovereign Futures: French Caribbean Politics in the Wake of Disenchantment*. Chicago: University of Chicago Press.

———. 2017. "Why would anyone in Puerto Rico want a hurricane? Because someone will get rich," *Washington Post*, 22 September 2017.

———. 2020. "The coloniality of disaster: Race, empire and the temporal logics of emergency in Puerto Rico, USA." *Political Geography* 78: 1–12.

Bonilla, Yarimar, and Marisol LeBron, eds. 2019. *Aftershocks of Disaster: Puerto Rico Before and After the Storm*, New York: Haymarket Books.

Bush, Barbara. 1990. *Slave Women in Caribbean Society 1650–1838*. Bloomington: Indiana University Press.

Cashman, Adrian, Leonard Nurse, and John Charlery. 2010. "Climate change in the Caribbean: The water management implications." *Journal of Environment and Development* 19, no. 1: 42–67.

Cashman, Adrian, and Mohammad R. Nagdee. 2017. "Impacts of Climate Change on Settlements and Infrastructure in the Coastal and Marine Environments of Caribbean Small Island Developing States (SIDS)." *Caribbean Marine Climate Change Report Card: Science Review*: 155–173.

Casimir, Jean. 2020. *The Haitians: A Decolonial History*. Trans. Laurent Dubois. Chapel Hill: Duke University Press.

Campbell, Jayaka, Michael A. Taylor, Tannecia S. Stephenson, et al. 2011. "Future climate of the Caribbean from a regional climate model." *International Journal of Climatology*, 31: 1866–1878.

Campbell, Donovan, David Barker, and Duncan McGregor. 2011. "Dealing with drought: Small farmers and environmental hazards in southern St. Elizabeth, Jamaica." *Applied Geography* 31, no. 1: 146–158.

Caribbean Tourism Organization (CTO). 2024. "Caribbean Tourism Experiences Strong Growth in 2023, Recovery to Continue into 2024." March 15. https://www.onecaribbean.org/caribbean-tourism-experiences-strong-growth-in-2023-recovery-to-continue-into-2024/.

Cateau, Heather. 2022. "Towards Environmental Justice in an Era of Climate Change: The Nexus between History and Impactful Policy Formation in the Caribbean," in *Islands on the Climate Frontline: Risk and Resilience*, Perry World House Report (Spring 2022). https://perryworldhouse.upenn.edu/programs-and-reports/reports/islands-on-the-climate-front-line-risk-and-resilience/.

Charlery, John, and Leonard Nurse. 2010. "Areal downscaling of global climate models: An approach that avoids data remodeling." *Climate Research* 43: 241–249.

Ferdinand, Malcom. 2022. *Decolonial Ecology: Thinking from the Caribbean World*. Trans. Anthony P. Smith. Cambridge: Polity Press. Orig. pub. 2019.

Gamble, Douglas, Donovan Campbell, Teddy Allen, et al. 2010. "Climate change, drought, and Jamaican agriculture: local knowledge and the climate record." *Annals of the American Association of Geographers* 100, no. 4: 880–893.

García-López, Gustavo A. 2018. "The multiple layers of environmental injustice in contexts of (un)natural disasters: The case of Puerto Rico post-hurricane Maria." *Environmental Justice* 11: 101–108.

Girvan, Norman. 1970. "Multinational Corporations and Dependent Underdevelopment in Mineral-Export Economies." *Social and Economic Studies* 19, no. 4: 490–526.

———. 1971. *Foreign Capital and Economic Underdevelopment in Jamaica*. Kingston: ISER/UWI.

———. 2010. "New World and its critics." In *Caribbean reasonings: The thought of New World: The quest for decolonization*, ed. Brian Meeks and Norman Girvan, 3–29. Kingston: Ian Randle Publishers.

Government of Barbados. 2021. "Update of the First Nationally Determined Contribution." https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Barbados%20First/2021%20Barbados%20NDC%20update%20-%2021%20July%202021.pdf.

Government of Jamaica. 2020. "Update of Nationally Determined Contribution (NDC) of Jamaica to the UNFCCC." https://www4.unfccc.int/sites/ndcstaging/

PublishedDocuments/Jamaica%20First/Updated%20NDC%20Jamaica%20-%20ICTU%20Guidance.pdf.

Grove, Richard. 1995. *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism*. Cambridge: Cambridge University Press.

Haraway, Donna. 2015. "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin." *Environmental Humanities* 6, no. 1: 159–165.

Hecht, Gabrielle. 2018. "Interscalar Vehicles for an African Anthropocene: On Waste, Temporality, and Violence." *Cultural Anthropology* 33, no. 1: 109–141.

Hughes, David M. 2017. *Energy without conscience: oil, climate change and complicity*. Durham: Duke University Press.

James, Cyril Lionel Robert. 1963. *The Black Jacobins: Toussaint L'Ouverture and the San Domingo Revolution*. New York: Random House.

Kamugisha, Aaron. 2019. *Beyond Coloniality: Citizenship and Freedom in the Caribbean Intellectual Tradition*. Bloomington: Indiana University Press.

Knight, Franklin W. 2011. *The Caribbean: The Genesis of a Fragmented Nationalism*. Oxford: Oxford University Press.

Lai, Matthew, Stacy-Ann Robinson, Emmanuel Salas, et al. 2022. "Climate justice for small island developing states: identifying appropriate international financing mechanisms for loss and damage." *Climate Policy* 22, no. 1–2: 1213–1224.

Lustgarten, Abrahm. 2022. "Barbados Resists Climate Colonialism in an Effort to Survive the Costs of Global Warming." *ProPublica*, June 27. https://www.propublica.org/article/mia-mottley-barbados-imf-climate-change.

McKittrick, Katherine. 2006. *Demonic Grounds: Black Women and the Cartographies of Struggle*. Minneapolis: University of Minnesota Press.

———, ed. 2015. *Sylvia Wynter: On Being Human as Praxis*. Durham: Duke University Press.

Mintz, Sidney Wilfred. 1960. *Worker in the Cane: A Puerto Rican Life History*. New Haven: Yale University Press.

———. 1985. "From Plantations to Peasantries in the Caribbean." In *Caribbean Contours*, ed. Sidney Mintz and Sally Price, 127–153. Baltimore: Johns Hopkins University Press.

Molinari, Sarah and Sheller, Mimi, eds. 2026. *Building Equitable Climate Adaptation Partnerships in the U.S. Caribbean*. Cham: Springer Nature.

Moore, Jason W. 2015. *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. New York: Verso.

Moore, Sophie Sapp, Monique Allewaert, Pablo F. Gómez, et al. 2019. "Plantation Legacies." *Edge Effects*, January 22. http://edgeeffects.net /plantation-legacies-plantationocene/.

Moulton, Alex A., and Mario R. Machado. 2019. "Bouncing forward after Irma and Maria: Acknowledging colonialism, problematizing resilience and thinking climate justice." *Journal of Extreme Events* 6, no. 1: 1–22.

Mycoo, Michelle. 2014. “Sustainable Tourism, Climate Change and Sea Level Rise Adaptation Policies in Barbados.” *Natural Resources Forum* 38: 47–57.

———. 2017. “A Caribbean New Urban Agenda Post-habitat III: Closing the Gaps.” *Habitat International* 69: 68–77.

———. 2022. “Building Urban Resilience in the Caribbean: Policies, Practices and Prospects.” *International Institute for Sustainable Development, SDG Knowledge Hub*, June 22. https://sdg.iisd.org/commentary/guest-articles/building-urban-resilience-in-the-caribbean-policies-practices-and-prospects/.

Mycoo, Michelle, and Donovan Campbell. 2017. *A Blue Urban Agenda: Adapting to Climate Change in the Coastal Cities of the Caribbean and Pacific Small Island Developing States*. Washington, D.C.: Inter-American Development Bank. https://publications.iadb.org/en/blue-urban-agenda-adapting-climate-change-coastalcities-caribbean-and-pacific-small-island.

Mycoo, Michelle, Morgan Wairiu, Donovan Campbell, et al. 2022. “Small Islands.” In *Climate Change 2022: Impacts, Adaptation, and Vulnerability*, ed. IPCC, 2043–2122. Cambridge: Cambridge University Press.

Nurse, Leonard. 2011. “The implications of global climate change for fisheries management in the Caribbean.” *Climate and Development* 3: 228–241.

———. 2015. “Assessing the Vulnerability of Air and Seaports in Small Islands: Risk Factors and Adaptation Guidelines.” Paper presented at International Scientific Conference: Our Common Future under Climate Change, UNESCO and UPMC, Paris, July 7–10.

———. 2017. “Climate Change Projections for the Caribbean and Implications for Air and Sea Ports.” Paper presented at UNCTAD National Workshop “Climate Change Impacts & Adaptation for Coastal Transport Infrastructure in Caribbean SIDS,” Castries, May 24–26.

Nurse, Leonard, Roger F. McLean, John Agard, et al. 2014. “Small Islands.” In *AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability*, ed. IPCC, 1613–1654. Cambridge: Cambridge University Press.

Perry, Keston K. 2021. “The new ‘Bond-age’, climate crisis and the case for climate reparations: unpicking old/new colonialities of finance for development within the SDGs.” *Geoforum* 126: 361–371.

Popke, Jeff, Scott Curtis, and Douglas W. Gamble. 2016. “A social justice framing of climate change discourse and policy: Adaptation, resilience and vulnerability in a Jamaican agricultural landscape.” *Geoforum* 73: 70–80.

Pulido, Laura. 2017. “Racism and the Anthropocene.” In *Future Remains: A Cabinet of Curiosities for the Anthropocene*, ed. Gregg Mitman, Marco Armiero, and Robert S. Emmett, 116–128. Chicago: University of Chicago Press.

Quijano, Anibal. 2000. “Coloniality of power, Eurocentrism, and Latin America.” *Nepantla: Views From South* 1, no. 3: 533–580.

Reddock, Rhoda. 1985. "Women and Slavery in the Caribbean: A Feminist Perspective." *Latin American Perspectives* 12, no. 1: 63–80.

Rhiney, Kevon, Anton Eitzinger, Aidan D. Farrell, et al. 2018. "Assessing the biophysical and socio-economic consequences of a 1.5C world on Jamaica's agriculture sector." *Regional Environmental Change* 18, no. 8: 2313–2327.

Rhiney, Kevon, and April Karen Baptiste. 2019. "Adapting to Climate Change in the Caribbean: Existential Threat or Development Crossroads." *Caribbean Studies* 47, no. 2: 59–80.

Robinson Stacy-ann. 2019. Mainstreaming climate change adaptation in small island developing states. *Climate Development* 11, no. 1: 47–59.

Robinson, Stacy-ann, Emma Bouton, Mara Dolan, et al. 2022a. "A new framework for rapidly assessing national adaptation policies: an application to SIDS in the Atlantic and Indian Oceans." *Regional Environmental Change* 22, no. 37: 1–15.

Robinson, Stacy-ann, D'Arcy Carlson, Emma Bouton, et al. 2022b. "The dynamics of institutional arrangements for climate change adaptation in small island developing states in the Atlantic and Indian Oceans." *Sustainability Science* 18: 251–264.

Robinson, Stacy-ann, Andrea Vega Troncoso, J. Timmons Roberts, et al. 2022c. "'We are a people': Sovereignty and disposability in the context of Puerto Rico's post-Hurricane Maria experience." *The Geographical Journal* 189, no. 4: 575–583.

Rosa-Rosa, Laurian, Barbara Lopez-Gonzales, and Kevon Rhiney. 2025. "Towards a relational reading of resilience: community networks and the politics of disaster recovery in Puerto Rico in the aftermath of Hurricane Maria." *Geoforum 163*. https://doi.org/10.1016/j.geoforum.2025.104315.

Sealey-Huggins, Leon. 2017. "'1.5C to stay alive': climate change, imperialism and justice for the Caribbean." *Third World Quarterly* 38, no. 11: 2444–2463.

Scott, Daniel, Murray Charles Simpson, and Ryan Sim. 2012. "The vulnerability of Caribbean coastal tourism to scenarios of climate change related sea level rise." *Journal of Sustainable Tourism* 20, no. 6: 883–898.

Shah, Kalim. 2022. "Renewables and Energy Transitions in Small Island States." *International Institute for Sustainable Development SDG Knowledge Hub*, June 8. http://sdg.iisd.org/commentary/guest-articles/renewables-and-energy-transitions-in-small-island-states/.

Sheller, Mimi. 2003. *Consuming the Caribbean: From Arawaks to Zombies*. London: Routledge.

———. 2018a. "Caribbean Reconstruction and Climate Justice: Transnational Insurgent Intellectual Networks and post-Hurricane Transformation." *Journal of Extreme Events* 5, no. 4: 1–18.

———. 2018b. "Caribbean Futures in the Offshore Anthropocene: Debt, Disaster, and Duration." *Environment and Planning D: Society and Space* 36, no. 6: 971–986.

———. 2020a. *Island Futures: Caribbean Survival in the Anthropocene*. Durham: Duke University Press.

———. 2020b. "Reconstructing Tourism in the Caribbean: Connecting pandemic recovery, climate resilience, and sustainable tourism through mobility justice." *Journal of Sustainable Tourism* 29, no. 9: 1436–1449.

———. 2023. "Infrastructural Reparations: Reimagining Reparative Justice in Haiti and Puerto Rico." In *Infrastructuring Urban Futures: The Politics of Remaking Cities*, ed. A. Wiig, et al. Bristol: Bristol University Press, 85–108.

Simpson, Isabelle, and Mimi Sheller. 2022. "Islands as interstitial encrypted geographies: Making (and failing) cryptosecessionist exits." *Political Geography* 99: 1–10.

Sultana, Farhana. 2022. "The unbearable heaviness of climate coloniality." *Political Geography* 99: 1–14.

Sultana, Farhana, ed. 2024. *Confronting Climate Coloniality: Decolonizing Pathways for Climate Justice*. London and New York: Routledge.

Taylor, Michael A., Abel Centella-Artola, John Charlery, et al. 2007. "Glimpses of the Future: A briefing from the PRECIS Caribbean Climate Change Project." Caribbean Community Climate Change Centre.

Taylor, Michael A. 2017. "Climate change in the Caribbean – learning lessons from Irma and Maria." *The Guardian*, October 6. https://www.theguardian.com/environment/2017/oct/06/climate-change-in-the-caribbean-learning-lessons-from-irma-and-maria.

Taylor, Michael A., Tannecia S. Stephenson, Albert Owino, et al. 2011. "Tropical gradient influences on Caribbean rainfall." *Journal of Geophysical Research* 116: 1–14.

Taylor, Michael A., Abel Centella, John Charlery, et al. 2013a. "The Precis Caribbean Story: Lessons and Legacies." *American Meteorological Society* 94, no. 7: 1065–1073.

Taylor, Michael A., Felicia S. Whyte, Tannecia S. Stephenson, et al. 2013b. "Why dry? Investigating the future evolution of the Caribbean low level jet to explain projected Caribbean drying." *International Journal of Climatology* 33, no. 3: 784–792.

Thomas, Adelle, and Lisa Benjamin. 2018. "Management of loss and damage in small island developing states: implications for a 1.5 C or warmer world." *Regional Environmental Change* 18, no. 8: 2369–2378.

Thomas, Adelle, April Baptiste, Rosanne Martyr-Koller, et al. 2020. "Climate Change and Small Island Developing States." *Annual Review of Environment and Resources* 45: 1–27.

Trouillot, Michel-Rolph. 2025. *Peasants and Capital: Dominica in the World Economy, New Edition*. Chicago: University of Chicago Press.

Williams, Eric. 1944. *Capitalism and Slavery*. London: Andre Deusch.

Wynter, Sylvia. 2003. "Unsettling the Coloniality of Being/Power/Truth/Freedom: Towards the Human after Man; Its Overrepresentation – An Argument." *CR: The New Centennial Review* 3, no. 3: 257–337.

Wynter, Sylvia, and Katherine McKittrick. 2015. "Unparalleled Catastrophe for our Species? Or, to Give Humanness a Different Future: Conversations." In *Sylvia*

Wynter: On Being Human as Praxis, ed. Katherine McKittrick, 9–89. Durham: Duke University Press.

Appendix

Biographical Notes

Luis Alberto Arrioja Díaz Viruell holds a Ph.D. in History from the Center for Historical Studies at El Colegio de México (2008). He is a member of the National System of Researchers, Level 2. Since 2009, he has been a full-time professor and researcher at the Center for Historical Studies at El Colegio de Michoacán. He has published 13 books and more than 45 articles and chapters in specialized academic journals and books on indigenous peoples and agrarian structures in Mexico during the colonial and republican periods, and on the history of climate and disaster management in Central America and Mexico, from the eighteenth to the twentieth centuries. He has been a fellow at the Latin American Library at Tulane University, the Netie Lee Benson Library at the University of Texas at Austin, and the American Philosophical Society in Philadelphia. He has also served as a visiting professor at University of Alicante (Spain), University of San Carlos in Guatemala, Autonomous University Benito Juárez of Oaxaca, Metropolitan Autonomous University (CDMX), and CIESAS. In 2021, he received the Francisco Javier Clavijero Prize for best research in History and Ethnohistory, awarded by the INAH (National Institute of Anthropology and History). He has served as president of El Colegio de Michoacán since 2021.

André Secchieri Bailão has been a postdoctoral fellow at Casa de Oswaldo Cruz (COC/Fiocruz – Fundação Oswaldo Cruz, Rio de Janeiro) since February 2023. He is currently part of the bilateral project *Ecologias insubmissas no Antropoceno*, between Fiocruz and Portuguese institutions, in which he researches the history of fire, climate, and vegetation sciences in the Amazon and in the Cerrado and has completed a previous research project on the history of climate sciences in the Amazon at the same institution. He holds a Ph.D. degree in Social Anthropology from the University of São Paulo (USP), where he is one of the editors and project coordinators of the *Enciclopédia de Antropologia* (EA), an online, open-access encyclopaedia of Anthropology, with entries in Portuguese and English. His research interest lies in the history and social studies of science and technology, environmental humanities, Anthropocene, climate change, and landscapes. He has published in Portuguese and English in edited volumes and journals of History and Anthropology.

Carlos Augusto de Castro Bastos is professor at Universidade Federal do Pará, Brazil, and holds a Ph.D. in History at Universidade de São Paulo (2013). His lines of research are history of Amazonia (eighteenth–nineteenth century), frontiers and boundaries. He is author of *No Limiar dos Impérios. A fronteira entre a Capitania do Rio Negro e a Província de Maynas: projetos, circulações e experiências (c.1780–c.1820)* (São Paulo: Editora Hucitec, 2017).

Fernando Bravo Alarcón is a Peruvian sociologist with Master's degrees in Environmental Development, and Political Science and Government. He completed his Ph.D. in Anthropology at the Pontifical Catholic University of Peru, where he later also taught. He currently serves as a parliamentary specialist in the Peruvian Congress. His research focuses on climate change, environmental issues, and disasters in relation to power and public policy, topics he also addresses in his opinion columns for Peruvian newspaper *El Comercio*. He has published several academic articles on these subjects, including "El proceso político de las iniciativas legislativas climáticas en el Perú: la tortuosa travesía de la Ley Marco sobre Cambio Climático (2008–2018)" in the journal *Kawsaypacha*, and "Los asuntos ambientales en la teoría antropológica" in the *Revista Peruana de Antropología*. He is the author of the book *El pacto fáustico de La Oroya: El derecho a la contaminación beneficiosa* (INTE-PUCP, 2015); the chapter "Negacionismo y antiintelectualismo en Trump" in *Del oasis al desierto: la política anticlimática de Donald Trump* (UNAM, 2018); and the chapter "Is there an Anthropology of Risks and Disasters in Peru?" in *Anthropology of Risks and Disasters in Latin America* (2020).

Antonio Escobar Ohmstede has been a professor-researcher at the Center for Research and Advanced Studies in Social Anthropology (CIESAS, Mexico) since 1986. He completed his doctoral studies at El Colegio de México. He was director of the Historical Water Archive (CIESAS-CONAGUA), and since 2020 he has coordinated the Special Program in Geographic Information Systems in Social Sciences and Humanities at CIESAS, Mexico City. In 2002, he received a John Simon Guggenheim Memorial Foundation Fellowship for academic excellence. He is a member of the Mexican Academy of Sciences and the National System of Researchers, and has taught courses in the United States, Spain, Colombia, Chile, and Argentina. His research has focused on indigenous communities and power groups in the Huasteca region, on water issues, and the territorial adjustments of communities and private properties. He has also investigated conflicts over natural resources involving collective and individual social actors during the liberal reforms of the nineteenth century and the processes of territorial reorganization following the agrarian reform of 1910 in the Central Valleys of Oaxaca. Among his recent publications are, in co-authorship with Luis Castro, *Independencias, repúblicas y espacios regionales: América Latina en el siglo XIX* (Vervuert-Iberoamericana, 2022); and with

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