Susana Herrera-Lima, Ricardo A. Gutiérrez, Lourdes Sofía Mendoza Bohne
(eds.)

Water –
Handbook of the Anthropocene in Latin America IV

[transcript]

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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.

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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 crisis 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. Omar was the main coordinator of the volume on Water. Rafael García Roncalla was responsible for formatting the texts. 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.

The publication of this series would have been impossible without the financial support of the German Federal Ministry of Education and Research (BMBF). We would especially like to thank Michael Sondermann from the BMBF and Ursula Bach from DLR for their trustful cooperation.

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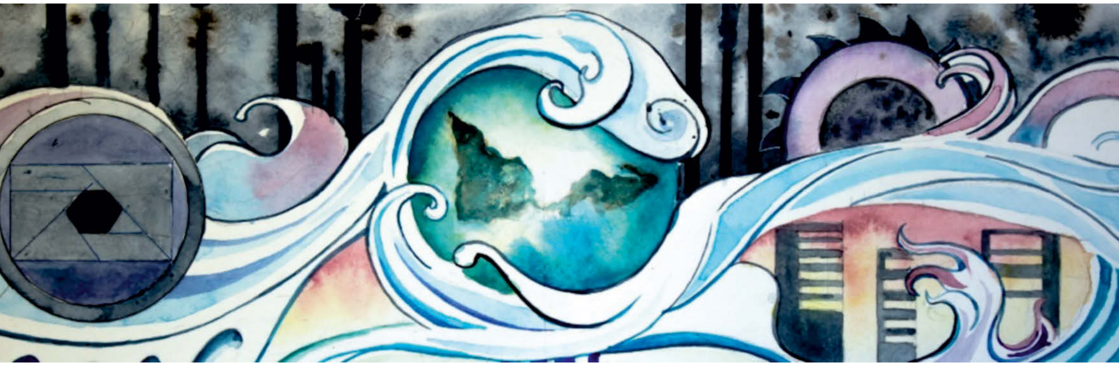
General Introduction



Source: Fernando Efrén Sandoval (2021).

The Anthropocene as Multiple Crisis

Latin American Perspectives on Water[1]

Olaf Kaltmeier, Eleonora Rohland, Gerardo Cham, Susana Herrera-Lima, Antoine Acker, León Enrique Ávila Romero, Arturo Camacho Becerra, Virginia García Acosta, Anthony Goebel McDermott, Ricardo A. Gutiérrez, Regina Horta Duarte, Cecilia Ibarra, María Fernanda López Sandoval, Lourdes 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 20 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-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

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.

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, Chtulocene, 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 water.

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 neodevelopmental 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 states'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

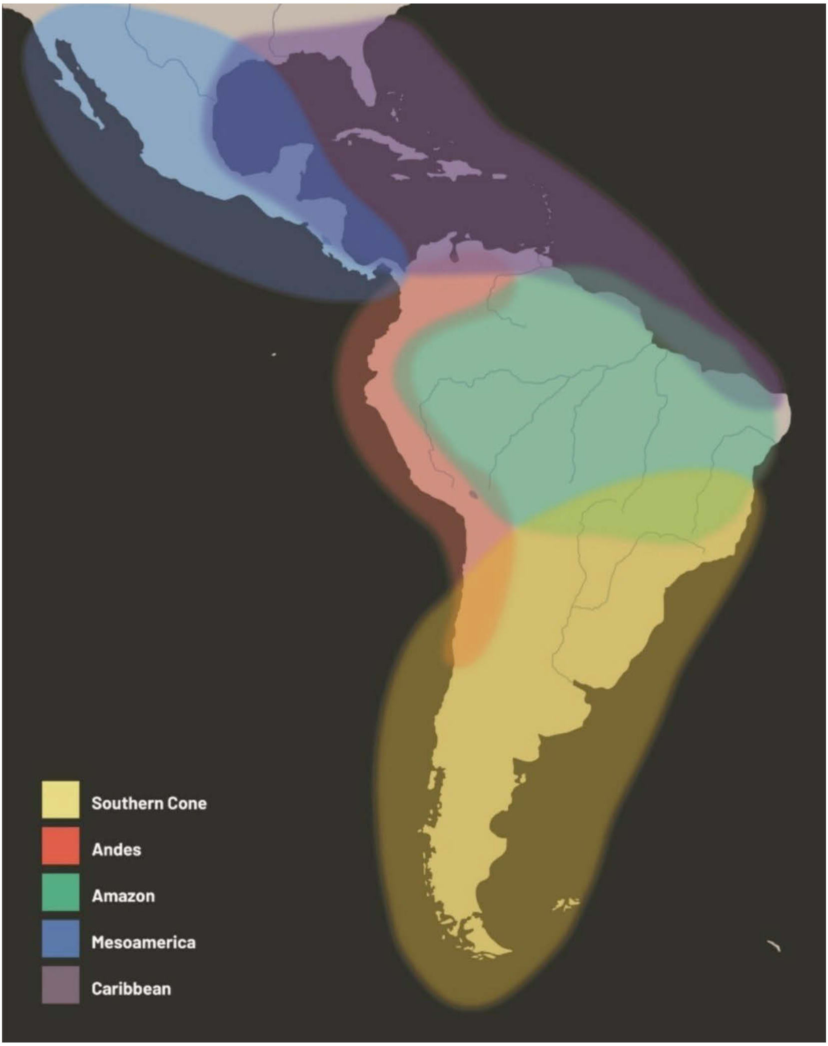
Regarding space, the handbook combines the perspective of planetary boundaries with a regional approach that takes into account the local and regional specificity of climates, ecosystems, and socioenvironmental relationships. The operationalization of this regional approach for the handbook project poses 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.

Figure 1: Anthropocene Regions in Latin America



Source: Own Elaboration.

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.

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.

Water

This volume of the CALAS Handbook series on the Anthropocene as a Multiple Crisis examines the complex evolution of the relationships between Latin American societies and water, considering their nuances and particularities in the various regions and historical periods. The analysis of the diversity of water uses and management is presented as a way to understand the shifting power relations in Latin America and the Caribbean throughout history. The problems underlying the socio-water crises in the region are addressed and historically framed within the colonial period, from the beginning of the nineteenth century to 1950 or from 1950 to the present. Water-related difficulties in the international division of nature are articulated to the transformations arising from the international division of labor and knowledge.

The current socio-water crisis in the region has manifested in the severe contamination of surface and groundwater, the growing need for sanitation, and the inequitable distribution of this resource, which limits universal access to drinking water. This situation favors overexploitation for productive purposes and results in the transformation or disappearance of aquatic ecosystems, such as wetlands, rivers, and lakes, as well as the degradation of socio-water basins.

This volume examines the thoughts and actions surrounding the Anthropocene, the uses and meanings of water, and the long history of coloniality in the region while highlighting the resistance and critical struggle of the peoples who defend water in Latin America and the Caribbean. This approach implies recognizing that the international division of nature is an intrinsic characteristic of modernity/coloniality of power and knowledge exercised since the sixteenth century.

The central themes are addressed into three main categories: the various forms of productive use of water and their impact on the availability and the contamination of the resource, the impact of urbanization, and the conflicts and struggles surrounding water. These problems are part of the processes of bio-geophysical, political, sociocultural, and economic transformation that have affected the relationship between Latin American and Caribbean societies with water from colonization to the present.

Between the colonial and the postcolonial periods, there is a notable continuity in methods of water supply and use. Despite the technological and political transformations of the nineteenth and early twentieth centuries, such as the steam engine, electrification, fossil energy, and the processes of independence and the formation of nation-states, tensions persisted in the relationship between society and nature that still give rise to long-standing socio-environmental crises.

The emergence and consolidation of modernity in Europe, and in the Global North more generally, correlates with the colonial world-system and especially the coloniality of nature in Latin America and the Caribbean. Between the end of the nineteenth and the beginning of the twentieth centuries, transformations occurred in the relations between human beings and nature, which occurred in parallel with the unequal integration of Latin American societies into the international economic system.

In the colonial world-system, transformations occurred in the bio-geophysical environment and the landscape, as well as radical changes in the relationship with water due to the introduction of forms of productive use that were foreign to the region, such as plantations and large mining operations. Likewise, imported urban development models implemented systems of access, supply, and distribution of water alien to the social groups that originally inhabited those territories. During the twentieth century, growing urbanization, accompanied by industrialization, required the creation of regulatory frameworks that, in the long run, led to dispossession and inequities, resulting in scarcity, pollution, and degradation of ecosystems.

This paradigm shift in the material relationship with water was accompanied by transformations in the symbolic relationships and imaginaries that gave meaning to the complex web of life and water. These tensions have festered since the earliest periods and are reflected today in the dichotomy between the idea of water as a resource and commodity and the imaginaries that see it as a common good and human right.

The Great Acceleration of the Anthropocene, characterized by a marked increase in economic activity and consumption by an ever-increasing population, exacerbates resource exploitation and water pollution. Together with new modes of exploiting raw materials, accelerated urbanization and industrialization have generated a greater demand for water, increasing the vulnerability of disadvantaged communities. This dynamic generates a cycle of vulnerability since the most disadvantaged populations settle in areas of high risk and scarcity of basic services, which affects their health and quality of life. The interaction between urbanization and natural disasters has also intensified, exacerbating the water crisis in the context of climate change. At this conjuncture, despite some areas having abundant water resources, others are beginning to suffer severe droughts; overuse and pollution challenge universal access to safe drinking water and implementing sustainable management practices, leaving the region facing a water crisis characterized by persistent social inequalities.

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.

Translated by Eric Rummelhoff and revised by Luisa Raquel Ellermeier.

Colonial Period

Source: Fernando Efrén Sandoval Herrera (2021)

Introduction: Water and the Anthropocene in Latin America during the Colonial Era

Lourdes Sofía Mendoza Bohne, Susana Herrera-Lima, Ricardo A. Gutiérrez

The world of water in pre-colonial times would have been shaped and permeated by a consecration of nature in the Indigenous territories of the Americas. The local ideology related water and forests to nature; thus, the precolonial infrastructure for water systems – and their collection and uses – was linked to seasonal calendars related to daily and long-term activities, such as agriculture or domestic life. For the Andean peoples, especially those from the Inca culture, "all nations were created in Lake Titicaca, where they received from the god Viracocha the main symbols of their ethnic group" (Sherbondy 2003: 91). In the region of Mesoamerica, Tláloc is seen as the origin of water and "as a temporal force, Tláloc came to Earth on days called quiahuitl, meaning rain, [...] a celestial god, owner of the eighth heaven [...] he was the god of the underworld, lord of the mountain and subterranean riches" (Alcina 2003: 42). In Patagonia, the Mapuche culture has been and continues to be a defender of the forests, which produce and care for the water that sustains those in the BioBio region. In the same way, the Caribbean is defined as the land of those who live alongside hurricanes and major storms. Delgado paraphrases Gerbi, who points out that "with the Indies there was a feeling of 'an expansion of the known world'" (Gerbi 1978: 26). This started

> breaking the existing spatial schemes while beginning another vision of the world in which there [was] room for 'the contemplation of the sphere without any more unknown regions or incalculable distances'; but even more, the historical fact of the 'New Indies' frames the meeting of lands that the Christian and Western worldview did not own. (Delgado 2008: 20)

These reflections expose the ideological landscape and the worldviews that the conquistadors found regarding the relationship between the societies of the New World and water.

During the conquest of the American territories, there was a violent appropriation of communities and nature. At the same time, conceptions of space, hydrological territory, and water were transformed, and Indigenous people were forced to use nature in ways unknown to them, being condemned to not inhabit nature and its aquiferous resources in their ancestral forms. Archaeology has provided evidence to current scientists demonstrating that hurricanes and cyclones have been an intrinsic part of the history of Caribbean civilizations since time immemorial. The Kalinago communities, who settled throughout the Caribbean islands, had various hierarchies of waters and even considered disasters such as hurricanes to be "cleansing the territory" and "purifying the environment." They lived in an unpredictable nature due to earthquakes, volcanic eruptions, hurricanes, and cyclones. These phenomena, however, were defined by how they were "useful" and by what benefits they granted to the peoples' continuity as communities. In Mexico and the Mesoamerican territories, the world was divided into five parts, one being the surface waters and the rains and another being groundwater. Thus, both water and its uses were linked to this procedure that was carefully articulated with nutrition, the weather, and the production and resilience of life, such that the conquistadors also had to adapt to these new hydrological territories, whether floods and shipwrecks or deserts and dunes.

This process of conquest and colonization imposed ancient Roman knowledge of aquifers in order to divert currents and avoid flooding to construct dams or to move and transform metals in mining. Riverbeds were also diverted to expand the cultivation of large wheat fields and vineyards. In the Andes, the great Potosí was key to initiating a massive destruction of the Andean landscape in Bolivia and Peru for the extraction of silver and gold. Through the use of mercury, these *haciendas de beneficio* poisoned not only the land and waters but also Indigenous communities. In the case of Mesoamerica, the arrival of the Spanish was not an obstacle to the continued use of those large aqueducts, canals, and sewers that already existed. The Mexicas, in the center of the region, and the Nahua peoples of the surrounding territory were experts in the use, management, and distribution of water courses, making their empire a sacred place of waters. The *chinampas* (floating agricultural plots on water), the *jagüeyes* (reservoirs that capture and distribute rainwater) in central Mesoamerica, the *chultunes* (large underground water deposits made of mud or stone) in the Mayan region, and the large lakes and water crops in the southern Mayan zone – corresponding partly to southern Mexico and some of the Central American countries – are a legacy that has managed to survive despite Spanish colonization. This highlights both the continuity of these precolonial technological cultures and their hybridization with the Roman culture brought by the Iberian conquerors to the New World.

In the region of Mesoamerica, Indigenous peoples managed to survive by using large ceramic receiving jugs to capture and conserve water for their daily domestic use and by taking water from *atarjeas* (canals) to grow their own food since they were under the control of Spanish *mercedados* (holders of royal land concessions). In the Caribbean, the situation was more dire as Afro-descendant and Indigenous communities were controlled through water shortages. If they did obtain any of the surplus water used by the large plantations, they suffered epidemics caused by its poor quality, such as typhus and smallpox. The term Plantationocene, proposed during a conversation between anthropologists and social scientists in 2014 by Donna Haraway and others (2016), is based on a critical discussion of the terms Anthropocene and Capitalocene. This neologism refers to the transformation of territories – animals, plants, soil, water, people – carried out by dominant countries (Europe and the United States) in colonized or dependent places from the conquest through to the end of the nineteenth century, whose jungles and forests were converted into large plantations, extensions of food crops or pastures for cattle. All this resulted in soil degradation, population displacement, the loss of local practices and relational forms, and a profound ecosystemic imbalance that would begin to affect the health of soils, water, and, consequently, all forms of life in the region. The Plantationocene explains how, from an anthropocenic perspective, the territory was modified to plant mainly bananas, coffee, cotton, and sugarcane. All of these monoculture crops required different types of soils and integration methods. Thus, water courses were transformed in such a way that, in times of drought, water was directed toward crops while leaving the streams and springs no time to recover. At the same time, deforestation increased between the sixteenth and seventeenth centuries due to an increased demand for livestock pastures and arable land for coffee, banana, cotton, and cocoa farms or haciendas.

The anthropocenic process of mining and large plantations transformed hydro-territories and created a form of hydro-politics specialized in controlling water, not only to benefit the *criollos* but also to control life and death in Indigenous communities. Hydro-territories consist of the basins that define a country beyond its political-administrative divisions and borders since the very nature of geography is entangled in the rivers and lagoons shared by one or more countries. Such is the case of the Iguazú River shared by Paraguay, Argentina, and Brazil. Another emblematic case is the Orinoco River shared by Venezuela and Colombia. Thus, hydro-politics consists of both the regulations and governments around water basins and not just their respective countries.

In the Amazon, large areas were deforested, mainly in the area of Pantanal for extensive livestock farming in the eighteenth and into the nineteenth centuries. Farming, mining, and logging all influenced this territorial transformation. In Mesoamerica, deforestation was also extensive, mainly in southern Mexico – Tabasco, Campeche, Yucatán, Chiapas – and Guatemala, where forests were devastated at the beginning of the nineteenth century due to mining in other regions requiring large sums of carbon energy in purification and amalgamation. At the same time, rivers were used to transport these materials, so these conquered lands became disputed hydro-territories with Indigenous groups as well as the other Spaniards in search of natural resources. It is no coincidence that the great naturalist explorations – by Antonio de Alzate in the eighteenth century and in the nineteenth century by Alexander von Humboldt – were not only imbued with a need for genuine scientific knowledge; their findings were also published in Spanish gazettes and served to determine the next territories to explore and extract both mineral and natural resources from. For this purpose, knowledge of hydrological maps, known in the language of war as "*mapas de introducción*" (introductory maps), was important. In the process of extracting timber and crops and further conquering territories, water played a key role in determining the location of new outposts.

The overexploitation of water for the development of Spanish, Portuguese, and French settlements brought with it an urgent need for disposing of water from homes and industrial processes, such as textile production, paper factories, wheat and corn mills, mineral processing plants, etc. These waters went directly to the rivers, where Indigenous and Afro-descendant communities had made their neighborhoods and shanties. This discrimination against nature and the segregation of life linked to benefiting from it constitute one of the most violent faces of conquest and colonization. The concept of infinite water was seen by the colonizers as an opportunity to develop their foundations and colonies with the necessary resources. However, this large amount of water was not distributed equally among the native inhabitants and those brought from Africa. The latter could not enjoy the ecosystem benefits of clean and abundant water and controlled through its rationing and access. This was also reflected in the type of infrastructure and large hydraulic works in cities and towns, where there was sufficient water, especially for the colonizing population, but not so much for slaves, servants, Indigenous people, natives, etc.

In this anthropocenic process, power relations over the territory, nature, and its communities consolidated, with water being the main provider of life and food. In the culture of the Andes, *Uywaña* represents the awareness of the practices of mutual self-care of nature towards humanity as everything comes from the same place, the same world: *Mama Qocha*. In the Mapuche world of the Southern Cone, ancestral Indigenous people continue to care for the forests not only because of the wood but also because they produce water, "they make water come into being." This colonial anthropocenic process gave rise not only to early capitalism but also the destruction of original thought which, without romanticizing it, included in its policies what Lussault (2020) calls the politics of the land.

Translated by Eric Rummelhoff and revised by Luisa Raquel Ellermeier.

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Water in the Southern Cone in the Colonial Period

Socio-Natural Colonization: The Hydro-Social Legacy of the Sixteenth, Seventeenth, and Eighteenth Centuries

Gabriel Garnero

Water systems in all their forms – atmospheric, surface, and groundwater – are key to the economic, social, and political life of the Southern Cone. The Río de la Plata Basin, the sixth largest in the world, and others whose waters flow into the Atlantic and Pacific provide transportation, irrigation, drinking water, and energy to the main cities of Argentina, Chile, Uruguay, Paraguay, and southern Brazil. Historically, hydro-social conflicts around pollution, access inequality, and disastrous events such as droughts and floods have increased in severity and frequency as the current industrial socio-metabolic regime has consolidated (Bakker 2012: 618; Fischer-Kowalski and Weisz 2016: 22). However, the roots of this water relations system are older, and some of its fundamental elements can be traced back to the arrival of Europeans in the southern part of the continent. The water problem in the Southern Cone is linked to one of the central questions surrounding the Anthropocene: How does one define it, and when did it start as a distinctive era? In this sense, this chapter differs from the positions that limit their analysis of the period to the effects of human actions at a planetary level; this supposes the universalization of the human condition under the mold of the globalization of "the West" (Machado Aráoz 2023: 413). These reductionist logics circumscribe current problems to questions of substances and energy sources, which is insufficient; it is instead necessary to historicize the causes of concrete anthropogenic changes (Horn and Bergthaller 2020: 25; Machado Aráoz 2023: 410), and to critically analyze the cultural, historical, and economic diversity of human life and systems of socio-ecological relationships, temporally and spatially situated, as a starting point for understanding the trajectories that led to the Anthropocene (Horn and Bergthaller 2020: 37: De Hoop et al. 2022: 200; Machado Aráoz 2023: 413).

Consequently, this chapter begins from the understanding of Anthropocene's history as a sequence of thresholds or "leaps" that represent a prolonged process towards the transformation of landscapes, forms of energy, economic and social regimes – the beginning of industrialization here not only as an asynchronous transition from an energy regime of cyclical sources (such as wind, water, and solar) to fossil fuels but also as an era of new forms of technology and social organization (Horn and Bergthaller 2020: 160; De Hoop et al. 2022: 201). Thus, the Anthropocene is the product of a more complex, multi-scale geographic process imbricated in the synchronized transformations of multiple local, regional, and global spaces. From this approach, the European expansion into the Americas triggered a process of interconnection and reconfiguration of enormous geographical relevance within the framework of a colonial management system for the organization and administration of commodified energies and living beings (Machado Aráoz 2023: 416). Without the profound transformations in scale and significance acquired by mercantile and war practices in the shift from the Mediterranean to the Atlantic and Indian Ocean economies, it is impossible to understand the transformation of the American territories and their current insertion in the world system (Wallerstein 1979).

This chapter will give an account of the entanglement between the social and biophysical dynamics of water in the shaping of a distinctive hydro-social territory in the southern part of the Spanish and Portuguese empires within the frame of this global multi-scale reconfiguration, from their arrival in the sixteenth century until the end of the eighteenth century (Boelens et al. 2022: 11). Water marked the possibilities and limits for the emergence and reproduction of the colonial system discussed in this chapter, and social dynamics were entangled and in turn influenced water dynamics. These socio-environmental transformations of early modernity played a key role in the modality of the occupation and production of geographical space, conceived more as a zone of exploitation than as a habitat (Machado Aráoz 2023: 424; Moore 2017: 27). In this sense, these territories were colonized by the Spanish and Portuguese through the foundation of cities and their jurisdictions, which were "socio-natural sites" constituted through a reordering of the nexus between practices and assemblages (arrangements) of water's biophysical, infrastructural, and social elements, guided by pre-reflexive elements (interests and traditions) (Winiwarter and Schmid 2020). Sustaining these systems of interactions required the constant work of humans, animals, and machines, as well as a continuous "colonization of nature" that was crossed by power relations, conflicts and resistances, vulnerabilities, risks, and impacts whose spiral effects defined the continent's place both at that time and in the anthropocenic world system of the twenty-first century. The correlation between these foundational nodes' importance and their current relevance explains the centuries-old continuities in their link and the hydro-social problems (Grau and Foguet 2021: 126). Therefore, it is necessary to interpret these systems' historical genesis to critically examine the present and envision new possible paths (Garnero 2018).

Hydrologically Unequal Territories

Southern Cone landscapes at the beginning of the sixteenth century offered, as today, a strong contrast between dry and humid areas. The Arid Diagonal of South America covered the current northern part of Chile (Atacama), northwestern and central western Argentina, and eastern Patagonia, while rainy areas corresponded mainly to the great basin of La Plata and its tributaries, with its plains (Pampa and Chaco), savannas, wetlands (Iberá and Pantanal), and forests (Tucuman and Atlantic), as well as western Patagonia (Valdivian Forest). This area concentrates more than 85 percent of the world's largest surface flows and wetlands. Significant latitudinal extension explains its climatic amplitude, from tropical to cold. North of 40° S, the humidity provided by the Atlantic winds decreases in an east-west direction to the Andes' great orographic barrier, and on the other side lies the Atacama Desert. South of 40° S, the reverse phenomenon occurs with the humid winds from the Pacific reaching the arid Patagonian plateaus.

These factors explain the contrasting distribution and drainage of surface waters. On the one hand, in the northeast, long, fast-flowing, navigable rivers formed the Río de la Plata basin. In contrast, the rivers of the Arid Diagonal have low flow and are shorter, with significant summer floods due to snowmelt. In southern Patagonia, the rivers that drain into the Pacific are abundant but short, while those that flow into the Atlantic, such as the Chubut or the Santa Cruz, cross the arid plateau without major tributaries. In the center of the Southern Cone, the great Pantanal and the Chaco-Pampa plains – with their gentle slopes towards the estuary of La Plata – made the currents that cross it changeable, with seasonal lagoons and extensive wetlands. This general description is key to understanding how the European settlers entered and founded their cities and the different links they established with the hydrologies and societies that already existed there, dynamic elements subject to annual and long-term cycles. This chapter will focus on the former but recognizes that the perception and impacts of their effects were different between the sixteenth and eighteenth centuries. The following sections will describe the possibilities and limitations that water availability in its various forms offered to this incipient network of interconnected cities, both in the arid and wetter zones outlined above, and then analyze how these societies coped with contrasting water dynamics. The climatic and hydrographic characteristics, their spaciality and temporality, entangled with the Hispanic and Portuguese colonizing process, were key factors in the appropriation, linkage, settlement, economic activities, and these territories' structuring in the modern world system.

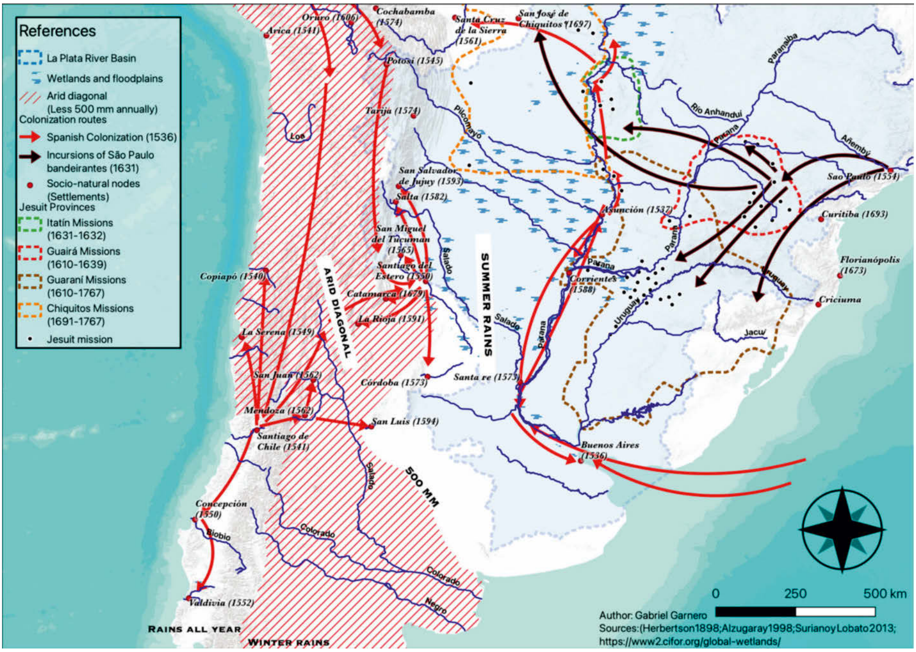
Water as an Opportunity and Constraint in the Shaping of the Colonial Socio-Natural Regime

Water for the Cities: Socio-Natural Nodes

The distribution of both Indigenous societies and Hispanic and Portuguese colonization was marked by the influence of climatic and hydrological disparities. Their effects can be analytically divided between opportunities and constraints to social, economic, and cultural processes and developments. Among the main opportunities was that of founding towns. Since the sixteenth century, these nuclei on the periphery of their respective empires housed most of the European population, concentrated commercial activities and institutions, and acted as centers for the organization of productive activities in their respective jurisdictions or hinterlands (Map 1). This development was the result of a larger-scale geographical process that overlapped and transformed vast local, regional, and global territories within the framework of a colonial system, and these first urbanizations became spatial technologies for the control of territories and populations subjected to the dynamics of forced mercantilization (Machado Aráoz 2023: 416). The Europeans selected healthy, fertile areas with pastures for their crops and livestock, forests for firewood, water for irrigation and drinking, Indigenous people to convert, and good land and sea communication.

The impetus for settling in the Southern Cone was the strategic interest in connecting the metalliferous centers of Peru with the metropolis, and this was carried out in waves. The first wave, lasting until 1650, took place via three routes: the Atlantic, the Pacific, and the North. The Atlantic route, from 1536, used the La Plata River Basin as a channel of entry, establishing cities such as Buenos Aires (1536), Asunción (1537), Santa Cruz de la Sierra (1561), Santa Fe (1573), and Corrientes (1588). In addition, an extensive network of Jesuit missions was established in the upper basins in Paraguay, Guaira, Itatí, and Chiquitos. River exploration continued northward until reaching non-navigable stretches in the Pantanal area. Throughout the basin, mighty rivers such as the Paraná, Paraguay, and Uruguay, as well as their tributaries, offered water in large quantities, but ironically, supply quality was a significant problem (Concolorcorvo 1773; González Fasani 2015). For much of the period, major cities had no public water or sanitation systems, and those who wanted clean water had to pay water carriers or settle for cloudy water carried in jars. Another way of collecting water in these cities was through *aljibes* (tanks), cisterns, or wells that stored rainwater, but only some families could afford to build them. Paradoxically, despite being close to some of the largest rivers in the world, drinking water was an expensive commodity with unequal access (Paniagua Pérez and Arciello 2020: 297). For their part, the Indigenous people of the basin moved around, taking advantage of the seasonality of water, which varied the availability of animal and plant species and had an impact on demographic dynamics, defining communities' grouping or dispersion (Nesis 2005; Sartori, Galligani, and Balducci 2016: 87).

Map 1: Water and the Conquest of the Southern Cone (Sixteenth to Seventeenth Century)



Source: Author's elaboration from Herbertson (1898); Alzugaray and Alzugaray (1998); Suriano and Lobato (2013); SWAMP (n.d.)

Simultaneously, from the Pacific, a dynamic nucleus was established in the central zone of Chile with Santiago (1541) and Valparaíso (1543), which later translated into the foundation of other settlements. To the south, Concepción (1550) and Valdivia (1552) were established in the rainy Patagonian forests; to the north, in the Arid Diagonal, La Serena (1544) and Copiapó (1549); and to the west, Mendoza (1561) and San Juan (1562). In these regions, where rainfall was scarce, Indigenous groups such as the Atacamas, Diaguitas, and Huarpes took advantage of small rivers and streams with scarce but good-quality water for consumption and production by using complex hydraulic systems composed of dams and conduction systems (Giovannetti and Raffino 2014; García and Damiani 2020; Ponte 2015). In the systems of the Mapocho, Aconcagua, Coquimbo, Copiapó, Cuyo, and San Juan rivers, the Spaniards built their own hydraulic systems, with large canals and their *hijuelas* or irrigation ditches channeled directly from the rivers, which became the axis of these cities' urban fabric (Varela 1993: 355; Sánchez-Rodríguez 2015: 42).

In southern Chile, abundant rainfall nourished the mighty Biobío River, and in the flooded areas of the Valdivia basin, important works were carried out to drain and order water circulation (Adán Alfaro, Urbina Araya, and Alvarado Pérez 2017: 372). In this region, the Mapuche-Huilliche communities were dispersed and associated with lake and riverine environments; the Europeans were surprised by their abundant water use, their elaborate hygiene customs, and their swimming habits (Molina 1788: 117; Solari et al. 2011: 60). Finally, from the north of the Southern Cone, colonization began with the founding of Alto Perú, Chuquisaca (1540) and Potosí (1545) and then extended southward into the valleys, pockets, and foothills of the sub-Andean sierras with their mountain rivers (the Arias, Grande, Salí, Suquía, among others). Salta (1580), Jujuy (1593), Tucumán (1565), and Córdoba (1573) were founded. Moving to the Chaco plains and wetlands of the Salado and Dulce rivers, several other settlements were established, of which only Santiago del Estero (1553) has survived (Fradkin and Garavaglia 2009: 25). The three great colonizing currents were connected through the formation of commercial links and routes between the arid and semi-arid zones of the west and those linked to the Río de la Plata basin's great rivers.

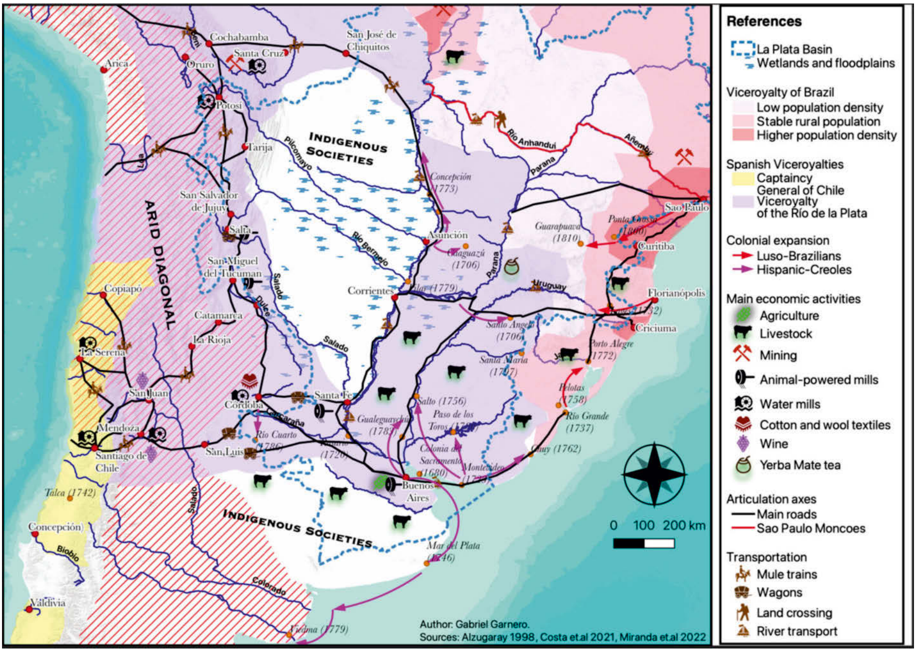
During the seventeenth century, the wave of Hispanic settlement weakened, and the Portuguese advance strengthened. After overcoming the Serra do Mar and settling in São Paulo, *bandeirantes* at the forefront of expansion penetrated the territories of La Plata, descending into its tributaries to obtain gold, Indigenous people, and a route to the mines of Upper Peru (Spósito 2012; Plens and Porto 2016: 111). This advance delineated a riverine frontier of conflict in the upper Paraná and Paraguay basins and resulted in the destruction of dozens of Jesuit missions, the abandonment of Guaira and Itatín, and the consolidation of major cities such as São Paulo and Curitiba (Owens 1993: 28; Souza 2019: 23). In the eighteenth century, the Bourbon reorganization and the foundation of the Viceroyalty of the Río de la Plata marked a new Spanish push (Map 2). Although pressure from Indigenous groups attacking via the tributaries of the Paraguay River increased, progress was made in the Chaco-Pampean plains, the Atlantic forest, and the eastern plains of the Río de la Plata, with the establishment of Montevideo (1726) being especially important. In addition, the Treaties of Madrid (1750) and San Ildefonso (1777) defined the boundary between the Spanish and Portuguese possessions following the course of rivers and watersheds (Corral 2015; Cherubini 2021: 241). Thus, the territorial framework was marked by the cities, socio-natural nodes, and political-economic devices of control and colonization that "dotted" these vast water spaces with which they were linked and attempted to transform (Suriano and Lobato 2013: 54; Sovarzo 2019: 119). Finally, in the gigantic expanses of plains, plateaus, and wetlands to the south and north of the core areas, European presence was marginal; these spaces would only become part of the nation-states in the nineteenth century.

Water for Transportation: Territorial Articulation Axes

The rivers of La Plata were "highways" for the penetration of humans, animals, and plants from the Old World, as well as for Indigenous societies' exchange and mobility (Siqueira 2009: 7; Silvestri and Williams 2016: 9). For the Europeans, canoes and other Indigenous knowledge were essential in the intensely aquatic environment that seasonally changed configuration due to the waters' rhythm (Costa 1999: 207; Saccone 2020: 243). Initially, the Spanish believed they could connect the Atlantic and Pacific front fluvially, which was of great geostrategic interest (Gascón 2017: 444). Although this proved impossible, the cities of La Plata persisted, and river exchange was vital for their survival, enabling the emergence of an internal market and transatlantic trade that linked them to the world system (Errecart 2019: 255; Gascón 2017: 447; Jumar and Biangardi 2014: 32; Moore 2014). River transport was significantly faster than overland, especially in densely jungled areas, and this was directly related to the circulation speed of goods and commercial capital turnover (Rosal 1990: 137; Reitano 2016: 140). At the end of the eighteenth century, the La Plata River port complex reached its peak as an axis of regional articulation, both upstream and downstream and between both shores (Jumar and Biangardi 2014: 76). In addition, the borders of the Paraná and Paraguay's upper basins were areas of circulation and incursions into river territories inhabited by Guaycurúes, Mbayás, and Payaguas Indians (Funes 1816: 16; Alves de Arruda 2018).

Water dynamics were also entangled with the interconnection of land. The rivers of the Río de la Plata basin often served as boundaries for cross-communication, requiring the construction of bridges or the use of rafts to cross them (Levinton 2009). For example, the Luso-Brazilians advanced westward by moving canoes overland from the Paraná to the Paraguay basin, and seasonal Monçõense river expeditions connected the Pantanal with the Paulista power center (Costa 1999; Pedroni 2012: 4; Lucidio 2013: 38). The Spanish also established commercial and military connections between their Pacific possessions and the Río de la Plata basin through overland routes. The royal road from Buenos Aires to Upper Peru acted as the main axis, linking the socio-natural cities/sites created by the northern edge of colonization and ensuring a water supply during the journey (Errecart 2019: 238). Another important axis was located on the southern border, linking the dry and humid areas. Caravans traveled between Chile and Santa Fe and then sailed to Paraguay, exchanging wines and yerba mate (Gascón 2017: 447; Sovarzo 2019: 347). From Buenos Aires to Mendoza, they traveled more than 900 km on progressively more arid plains, overcoming long stretches of salty land without drinking water, meaning they had to carry it with them (Cioccale 1999: 258; Lacoste 2005: 182; Martínez de Sánchez 2019: 294). In addition, seasonal variability – the recurrent fluctuations of climatic variables during the seasons of the year, influencing aspects such as agriculture, ecosystems, and human health – influenced the availability of livestock pasture and drinking water for people and animals. Therefore, trips in search of water sources were made after the rains and the paths had varied, sometimes going deep into Indigenous territories inhabited by the Querandíes and Puelches (Gascón 2014: 53; Martínez de Sánchez 2019: 294). The crossing of the Andes through the Uspallata pass represented another challenge, taking a full week and only being possible in summer. In the Andean and sub-Andean mountain ranges of the Southern Cone, snow, heavy rains, or rushing rivers made the roads difficult to maintain and impassable for wheeled vehicles, thus becoming the domain of mule drivers (Gascón 2017: 441; Lacoste 2005: 111).

Map 2: Iberian Viceroyalties and Southern Cone Water (Eighteenth Century)



Source: Author's Elaboration from Alzugaray and Alzugaray (1998); Costa, Andrade, and Maluly (2021); Salas Miranda et al. (2022)

Water for Production: Hinterlands

Water was also central to economic production, whether for subsistence or exchange. First, its spatial and temporal distribution helps to explain the agricultural expansion of European crops during the sixteenth, seventeenth, and eighteenth centuries (Crosby 2009). Ecological colonization involved using native and introduced crops and substantially differed between the humid areas east of the 600 or 700 mm isohyet lines, where rainfed agriculture was practiced, and the arid areas, where irrigation was used. In the former, crops that required more water predominated, such as wheat, barley, rice, and in the northeast, cotton, bananas, beans, sugar cane, and yerba mate, as well (Jorge and Ulloa 1748: 123; López de Albornoz 1997: 141; Prieto and Herrera 2001; Giovannetti 2005; Arruda 2015: 221). On the other hand, in the latter zones, where irrigation was relied upon, there was an abundance of potatoes, corn, and fruit trees such as apples and peaches, in addition to vines, citrus fruits, flowers such as lilies, lilies and carnations, and vegetables (Sánchez-Rodríguez 2015: 44). Europeans took advantage of Indigenous waterworks for the establishment and expansion of their own plantations, and these works served both for the provision of drinking water and the production and irrigation of fields and gardens (willows and poplar groves) (Parish 1853: 100; Giovannetti and Raffino 2014; Sánchez-Rodríguez 2015: 44; Quiroga 2015: 12; Lacoste 2018: 7). Added to this was the expansion of cattle, horse, goat, and sheep farming, which also related to water dynamics (Prieto and Jorba 1991; Serres 2018: 49; Maeder 2021).

In the border plains of the Pampas-Patagonian and Chaco regions, this increase of large herbivores had an impact on inter-ethnic relations, mainly due to the movement of cattle in search of water and pasture. The concentration of cattle, Indigenous groups, and Hispanic-Creole cattle ranches around rivers, lagoons, and wetlands generated deep tensions (Gascón 2014: 51; Frias and Montserrat 2017: 51). Within the Indigenous communities themselves, horses began to play a central role; this meant that mediating water access was tantamount to controlling animals and people (Villar and Jiménez 2013: 12). Finally, the rivers and wetlands of the Río de la Plata were used for hunting and fishing, which was of secondary importance to Europeans but fundamental to the subsistence practices of Indigenous peoples such as the Guaycurúes and Tupí-Guaraníes, who also benefited from the environment's humid conditions in their resistance to colonization. Traveling through their river territories was dangerous, and during the rainy season, they would make incursions and then take refuge among islands and wetlands (de Sousa 2004: 19; Prieto 2010; Lucidio 2013: 99). In short, water had a profound impact on the redefinition of the positions, distances, connectivities, rhythms, flows, and borders that shaped the colonial domination process of these territories.

Water Scarcity: Droughts

Cities, jurisdictions, and axes of articulation faced limits entangled with extreme water events, with water scarcity being one facet. Here, it is necessary to distinguish between aridity (a structural aspect of the environment) and drought or "dryness" (when rainfall is lower than average over a large area for a long period of time, generating imbalances in water's social use). The correlation between one phenomenon and the other is not direct and unequivocal but rather contextual (Prieto and Herrera 2001: 138; Noria Peña 2018: 147; Quiroga and Lapido 2011: 46). The thresholds for drought or "dryness" definition are more geographical than climatic, deriving from the territorial contrasts analyzed in terms of water demand and consumption, without being exclusive to the arid region. In rainfed areas, the problem of "dryness" was significant, given that rainfall determined agriculture and livestock farming in large territorial extensions (Prieto and Jorba 1991; Noria Peña 2018: 328). Where irrigated agriculture was practiced, water generally came from snow and glaciers, providing more regularity and reducing the risk of water shortage (Prieto and Herrera 2001: 138; Jumar and Biangardi 2014: 145). Although there were drier periods during the sixteenth century, droughts were recurrent in the seventeenth and eighteenth centuries, linked to demographic and productive transformations such as dependence on a particularly affected crop, population increase, or competition with other uses. Shortages could stop mining and flour mills, as well as drive livestock away from urban centers. This economic paralysis had a profound effect on prices (Buechler 1989: 71; Gómez Saavedra 2022: 659). Finally, extreme scarcity sometimes affected urban supply and combined with social inequalities that hindered drinking water access (Varela 1993; Gayán, Castillo, and Figueroa 2019).

Excess Water: Floods and Flooding

On the other extreme were tidal surges and floods, increased water volume in streams, or prolonged ground accumulation. The flat regions of the Río de la Plata basin were among the most exposed to the risk of flood-related disasters in South America (Prieto and Jorba 1991; Prieto 2007: 40; Noria Peña 2022). The extensive floodplains, river lowlands, and wetlands were periodically reconfigured by slight hydrological changes, and the society's agricultural base was particularly vulnerable to these events (Prieto and Herrera 2001; Prieto 2010: 23; Silvestri and Williams 2016: 3). Since the sixteenth century, flooding in the cities of the river coast and nearby plains was recurrent, and several Jesuit missions had to be relocated because they were surrounded by swampy waters or flood zones (Páez 2013: 168). In addition, vast flooded areas could isolate towns or cities by both river and land from other urban centers, reducing vital trade and resulting either in the loss of livestock or their stranding by land from these centers of consumption. Parasitic and fungal diseases such as rust (*Puccinia graminis tritici*) could also decimate crops (Prieto and Jorba 1991; Prieto 2010: 25). On the other hand, seasonal avenues impacted the nodes of this colonial fabric (Salas 2014; Simón Ruiz and Noria Peña 2017).

Although the significance of human and material loss does not compare with those of today, the floods from the mountain rivers constituted significant threats, as they destroyed water infrastructure, streets, farms, and crops essential for subsistence. In some cases, the magnitude of their impact forced entire cities to relocate. The Spanish-Creole and Portuguese-Brazilian populations used different strategies to confront these threats. Defensive infrastructures such as cutwaters and embankments were built, which gave a sense of "cities against the water" (Buechler 1989: 71). Otherwise, specific rules were instituted to protect livestock, such as sheltering them on islands during dry periods but keeping them on dry land when the rivers rose. Indigenous societies were affected differently due to their land use, population density, and subsistence systems. In the La Plata system, these groups moved through the territories according to seasonal water variability. During floods, they sheltered in boats – some even with living spaces –staying in them until the waters receded or built houses in tall trees (Prieto 2010: 30).

Water Extremes and Bodies: Health and Disease

Water extremes also had synergistic effects: torrential rains, floods, droughts, and plagues; price increases and generalized hunger recurrently impacted Chile, Tucumán, and the Río de la Plata basin. Hunger and malnutrition facilitated the emergence of pockets of poverty, immunological weakening, and increased deaths from infectious diseases such as smallpox, typhoid, leprosy, and cholera, which affected food production capacity, thus closing negative feedback loops (López de Albornoz 1997: 4; Prieto and Herrera 2001: 140). This was entangled with organizational and infrastructural deficiencies in the settlements, where there was a lack of minimum hygiene conditions or prevention despite knowledge of the "putrid miasmas" effects on health (Rezende, Heller, and Queiroz 2009: 61; Frías and Montserrat 2017: 30). The epidemiological impact was greater among African and Indigenous people, who were especially vulnerable due to the breakdown of their adaptive systems and their immunological deficiencies against introduced pathogens. Furthermore, their enslavement and concentration in *estancias* or *haciendas*, as well as their relocation to missions, facilitated contagions (Fajardo-Ortiz and Ferrer-Burgos 2003: 618). Diseases also circulated along the analyzed axes of articulation. However, their impact on the nodes was less than in Europe or other parts of the Americas due to the settlements' small size and dispersion (Frias and Montserrat 2017: 57). During the eighteenth century, the Bourbon reformist zeal involved initiatives establishing the monarchs' responsibility for public health and sought to avoid "infections" by relocating or eliminating concentrations of corruptible elements (González Fasani 2015; Rezende, Heller, and Queiroz 2009: 62).

The Reconfiguration of the Hydro-Social Territories of the Southern Cone

Portuguese and Spanish authorities, guided by their metropolises' needs, established a fundamentally extractivist matrix of organization and exploitation of the water commons (Kauffer Michel 2018: 36). As a whole, the colonial system's structuring redefined on a large scale the biophysical elements and practices around water throughout the territory. In addition to its temporal and spatial distribution, other axes of analysis serve to demonstrate the unprecedented transformation that conquest and colonization implied. Among them, this section highlights the reconfiguration of the organization (forms of allocation and distribution), the socio-technical apparatus (technology and infrastructure), and the power relations around water (control and resistance) (Garnero 2022).

Organizational Reconfiguration: Water Law and Governance

The first capitulations of the sixteenth century had water as a common good, although, with the *Derecho de Indias,* it acquired the status of a real estate asset (Sanjurjo 2012: 160; Ferreyra 2017; Gayán et al. 2019: 118). Thus, officials authorized by the king granted concessions, *repartimientos,* or royal grants to reward those who rendered services to the Crown (Figueroa 2018: 99). Titles of this type allowed land and water access and remained in force until the eighteenth century. The *Ordenanzas De Alfaro* (1611) – a set of laws enacted by Francisco de Alfaro in compliance with a royal ordinance of Felipe II, with the objective of mending abuses against the Indigenous, prohibiting their sale and purchase, establishing remuneration, and regulating the *mita*, among other provisions – provided a legal basis, but the demographic, cultural, and geographic heterogeneity of the Southern Cone meant that local regulations had to be adapted to these realities. The *cabildos*, the centers of political and economic government in the cities, were also in charge of planning, executing, and controlling water assets (Martínez de Sánchez 2011: 233; Sanjurjo 2012: 163; Barriera 2019: 66). If a contentious issue arose, it could become a matter of justice and require the intervention of the courts, with the ordinary mayor's offices playing a central role. Mayors or water judges were in charge of distributing, constructing, and maintaining the irrigation networks and arbitrating conflicts between irrigators, and in the seventeenth century, they were joined by the Water Commissioners (Palerm 2009: 254; Quiroga and Lapido 2011: 48; González Fasani 2015). In the centralizing context of the Crown during the eighteenth century, the *Ordenanza de Intendentes del Río de la Plata* (1782) brought together the various existing codes in terms of water rights, and the *intendentes* became responsible for controlling irrigation and water supply systems, delegating to the local authorities the application of the rules and the arbitration of conflicts.

Socio-Technical Reconfiguration: Water Technology and Infrastructure

In addition to legal and organizational changes, there were important infrastructural transformations (Brailovsky and Foguelman 2009: 25; Ponte 2015: 321; Lacoste and Salas Miranda 2021: 6). In this sense, the main environmental alterations resulted from the scale and rapidity of technological transformation, including physical objects and the processes of the design, production, maintenance, and knowledge involved in their creation (Jorgensen 2014: 480). Thus, European colonization implied a reconfiguration of local technological systems and their alignment with the interests of regional and global actors, representing a highly relevant qualitative change in the framework of the Anthropocene transformations. As mentioned above, the Europeans took advantage of the Indigenous hydraulic systems of the arid and semi-arid regions and reconfigured them to their advantage. Cities such as Santiago de Chile, Mendoza, San Juan, San Luis, La Rioja, and Catamarca created rudimentary systems of irrigation ditches and water intakes to divert the flow with gravity from mountain rivers (Quiroga and Lapido 2011: 50). In addition, hydraulic mill technology was introduced to harness the rivers' energy, and the implementation of an extensive network of these devices transformed Chuquisaca and Cochabamba into the milling center of the Americas in the sixteenth century, defining the Alto Peruvian mining landscape (Lacoste 2018: 118). Artisans and carpenters who mastered the art and the prestige that its possession granted brought the process to Chile, Tucumán, and the La Plata River (Lacoste and Salas Miranda 2021: 19).

Likewise, there was a notable geographic division between the water mills near mountain rivers and the animal-powered mills (*tahonas*) on the flat plains, whose milling costs were much higher (García and Damiani 2020; Lacoste and Salas Miranda 2021: 19). Financing and controlling these hydraulic devices were expensive and associated with the political and religious elite. However, locals carried out construction, and when possible, Indigenous or slave labor was used (Quiroga and Lapido 2011: 50; Tell and Olañeta 2011). Hydraulic infrastructure's reconfiguration and maintenance caused one of the greatest sixteenth-century environmental changes, contributing to the Europeanization of the landscape and identity of the Spanish cities founded in the arid region. Finally, attempts to control water also included a ritual facet. Hydrological dynamics were seen as part of divine design in the deeply Catholic society, and to alleviate their effects, residents attempted to mediate providence through prayer (Noria Peña 2018: 331). These public liturgical practices, generally in the Hispanic world, were prayers for the cessation of droughts and epidemics, although in the Río de la Plata Basin, those that prayed for the end of rains and floods were also important (Lopez de Albornoz 1997: 10; Prieto and Herrera 2001: 142; Gascón 2014: 50).

Reconfiguration of the Power System: Conflicts and Resistance over Water

The restructuring of hydro-social dynamics meant controlling activities of production and social reproduction, generating profound inequalities, conflicts, and impacts. In this sense, far from universalizing human agency, historicizing water in the Anthropocene involves highlighting differential human experiences, responsibilities, and policies (De Hoop et al. 2022: 197). The Southern Cone's hydro-social fabric was not an "act of the human species," as the term Anthropocene might portray it (De Hoop et al. 2022: 198). Rather, the tensions uncovered a markedly asymmetrical social fabric in terms of land and water access as well as environmental impacts, in which officials, *encomenderos,* and religious orders made obtaining and controlling water one of the bases of their privileged social position (Plens and Porto 2016: 111; Ferreyra 2017; Astudillo Pizarro 2018; Gayán, Castillo, and Figueroa 2019). Thus, there was a proliferation of disputes between neighbors, institutions, millers, encomenderos, and peasants over the distribution and use of drinking and irrigation water. It was common for well-connected Spanish-Creole or Portuguese-Brazilian families to bring together economic power with government and justice functions, this being a fertile ground for arbitrariness in distribution (Varela 1993: 354; Sanjurjo 2019: 177).

In the arid region (Chile, Cuyo, and Tucumán), water was as important, if not more so, than land access since production could not take place without it, and water problems remained recurrent from the sixteenth century onwards. Where Indian villages were created, conflicts abounded around Hispanic-Creole monopolization (Tell and Olañeta 2011; Astudillo Pizarro 2017; Escolar 2021). Additionally, the cleaning and reconstruction of hydraulic infrastructure was another source of ongoing conflict. Canals became clogged with mud and limescale, ponds filled with debris or algae, and torrential rains and mountain thaws damaged conduction and distribution systems (Bell 2015; Noria Peña 2018: 158). These conflicts were also entangled with commercial disputes between farmers and ranchers for political hegemony as well as inter-ethnic conflicts (Varela 1993: 357; Briones Valentin 1999; Trettel and Oviedo 2007). A proliferation of petitions, complaints, commissioners' opinions, and chapter documents captured this collision between diverse interests and evidenced the power disparities within these colonial societies (Astudillo Pizarro 2017; Farberman and Boixadós 2015).

Control over water often fell to legally authorized actors, while others whose economic and political power allowed them to transgress the general provisions employed water thieves or force (Noria Peña 2018: 339). In doing so, they attempted to ensure a continuous water supply to increase their lands' productive capacity. During droughts, this generated vicious cycles: shortages were compounded by hoarding, the deficit worsened, and conflict broke out. On the other hand, subaltern sectors such as impoverished Hispanic-Creole, Indigenous, and Black populations also resisted, complaining to the authorities, rioting, and freeing currents that had been seized by force or through transgressions in daily practices. The claimed right to water was recognized by the *Real Audiencias* of Chile and Buenos Aires, but local Spanish-Creole power networks usually managed to undermine or dismantle organized resistance (Escolar 2021: 35). These sectors, through judicial processes or the use of force, reasserted their social control over the flow of water (Astudillo Pizarro 2017; Briones Valentin 1999; García and Damiani 2020; Gayán, Castillo, and Figueroa 2019).

Impacts, Vulnerability, and Water Risk Spirals

For all these reasons, cities – colonial socio-natural nodes – generated impacts and acted as axes of the social construction of risks and vulnerability associated with water and its dynamics (García Acosta 2004; Gascón 2005). Silver mining in Upper Peru and gold mining in Brazil, focal points of the extractive metalliferous economy, transformed neighboring territories and impacted the fluvial landscapes of tributaries of the La Plata River, with the construction of hydraulic works such as dams, aqueducts, mills, and the use of large quantities of water, coal and firewood from neighboring areas (Plens and Porto 2016: 95; Gómez Saavedra 2022: 668). In Upper Peru as well as in Chile, Tucumán, and the great basin of La Plata, the Indigenous systems of social organization and linkage with water were broken down, and the Indigenous were either concentrated into villages or enslaved and organized for production according to European systems. In the Río de la Plata Basin, those incorporated into the colonial system had to abandon fishing, hunting, slash-and-burn agriculture, and seasonal mobility patterns according to water cycles. Likewise, water restructuring around economic, domestic, and disaster practices in the colonial nodes had an impact on water flows, both in quantity and quality (Bravo 2005: 77; González Fasani 2015).

The impacts of extractive and productive activities such as silver and gold mining, farm irrigation, cattle raising, grain and sugar milling, and tanning and dyeing, among others, were especially significant. For example, the "*copajira* waters" resulting from mining in Potosí contained numerous chemical elements such as copper, iron, lead, and tin, and other toxic residues used in metalliferous processing such as mercury, which ended up in the upper watersheds of La Plata (Bravo 2005: 78). Likewise, people bathed and washed their clothes and horses in irrigation ditches; they also openly dumped urine and sewage, and garbage and dead animals accumulated in the streets (Ardanaz 2003). Added to this was a lack of water treatment and the proliferation of waterborne disease vectors (Frias and Montserrat 2017: 30; Paniagua Perez and Arciello 2020: 148). Since the seventeenth century, there began to be some awareness of prophylaxis, although its progress was slow and precarious from today's perspective; cities such as Buenos Aires were among "the most pestiferous in the world" (González Fasani 2015).

Exceptional events also occurred, whose consequences were entangled with the historically constructed conditions of vulnerability. The eruption of the Villarrica volcano in 1640, for example, polluted the headwaters of watercourses and made fishing and drinking impossible (Gascón 2005: 10); in 1626, the rupture of the San Ildefonso reservoir in Potosí, the most significant colonial hydraulic disaster, killed more than 2,000 people, destroyed or affected 132 sugar mills, and caused monumental economic loss (Gómez Saavedra 2022: 668). Although the impacts have generally been attested to in urban nodes, these changes undoubtedly radiated into the hinterlands. The effects of incipient land clearing in the arid and some of the forested areas, as well as agro-livestock expansion in the plains, are difficult to measure but probably had an impact on runoff dynamics, water infiltration, and fire frequency, processes in which hydrological dynamics are entangled with the intended and unintended effects of these economic activities. Far from being isolated, these factors were articulated among themselves and marked the emergence of a new system of links with water dynamics, marked by these territories' transformation into colonial domains of continental scope.

Final Considerations

As evidenced, the water linkage systems in the Southern Cone resulted from a territorial co-construction process that inextricably entangled spatial and temporal differences of biophysical water dynamics with Indigenous, African, and Iberian socioeconomic and cultural patterns. The link between water dynamics, catastrophic effects, and hydrological alterations in this part of America was not the result of a natural development or a pre-established civilizing process of the human species. Instead, European conquest and colonization broke down the Indigenous adaptive systems and reconfigured those hydro-social territories based on peninsular economic, geopolitical, and social interests within the framework of a system of global interconnections. At this stage, the interactions of urbanization, mercantilization, and other elements shared in the American territories in relation to how to approach and relate to water dynamics are not the result of a natural or supernatural mandate but emerged as a product of a contingent historical, geographical, and political process. This progressive contingency, rooted in history, politics, and geography, in which water became the object of colonization and exploitation, marks a qualitative difference from previous processes and can be considered evidence of the emergence of the Anthropocene. Likewise, this system of interactions was articulated with other territories on a global scale, representing a subordinate space subject to plundering.

The process was based on a system of interconnected cities, socio-natural nodes of novel extractive practices, and impacts related to water: regulations, power relations, socio-technical elements, conflicts, and environmental effects that radiated to a greater or lesser degree towards their extensive jurisdictions. In general, major cities such as Santiago de Chile, Buenos Aires, Asunción, Montevideo, and São Paulo retained their predominance, and the hydro-social configuration of the period was a good predictor of future problems. Despite the convergence mentioned above, the socio-natural restructuring differed based on interests, possibilities, and limits that originated in the entanglement with the distinctive water dynamics of the arid region, the Chaco-Pampa plains, the Atlantic and Valdivian forests, and the gigantic wetlands. Finally, the regime under analysis produced significant inequalities based on ethnic and social differences that persisted over time. The colonial foundations, far from being irrelevant, fed back, spiraled, and deepened throughout the nineteenth and twentieth centuries so that understanding the origins of this specific hydro-social fabric between the sixteenth and eighteenth centuries is an inescapable necessity to understanding the subsequent stages in the Anthropocene's current configuration.

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Water in the Andes in the Colonial Period

The *Potosí System* and the Hydropolitical Origins of the "Anthropocene"

Horacio Machado Aráoz

1492: *Orbis Peak* as a Mark of the Original Hydrogenocide

In his research on modern water, James Linton states that

> in the encounter [sic] between European and non-European cultures in the colonial context, indigenous relations with water were often liquidated and replaced by Western hydrological discourses […] Because the imposition of imperial water on such people and places had a profound impact on hydrological discourse generally, modern water is in part the legacy of imperialism. (Linton 2006: 99)

However, this analysis refers to the expansionist processes of the nineteenth century onward. Like other contributions to this discourse (Goubert 1986; Worster 2006; Worster 2008; Gras 2009), it is a view that focuses on metropolitical-imperial societies and disregards the triggering ontological-political role of the entity "America" as the space-time of the original Conquest.

Although it could indeed be said that modern water's conquest was the work and creation of white European men, these individuals were less a group of scientists, chemists, hydraulic engineers, or great visionaries with public functions than a "*band of conquerors* […] generally men with modest means and little formal education, whose [sic] independent spirits were matched by their ruthless ambition" (Robbins 2011: 13). Trained in the long "*Reconquista*" of the Moorish Iberia, the "*adelantados* and *bandeirantes*" (conquistadors and explorers, respectively, in charge of scouting the land to search for wealth and subdue the natives in the Portuguese colonies) from these proto-modern states – "predatory states" – were precisely for that reason violent, unscrupulous subjects, specialized in "seizing external resources by military means" (Wolf 1984: 138).

Gligo and Morello (1980) analyze the conquest in terms of its destruction of the principal "hydraulic civilizations" that produced the conditions of the continent's human habitability. These were cultures that developed "around water as a basic good" and that, based on a "millenary empirical ecology," built territorialities that combined "their great productivity with conservation," whether in ecosystems with excess water (*agroculturas de camellones*), regions with abundant rainfall (jungle polycultures: Yucatán and Amazonia), or extremely arid areas, such as the Andean region of Incario (Gligo and Morello 1980; Gligo 2001).

The arrival of the conquistadors meant the imposition of "'mining' development, extractive and deleterious, that was not concerned with the conservation of resources" (Gligo and Morello 1980: 112); "the extractive strategy oriented toward the metropolis focused on mining activity. Although crops were of great importance for self-consumption and export" (Gligo 2001: 68). In any case,

> the way in which America was occupied by the "new owners" was based on two fundamental fallacies: the first, the belief that both the culture and technology of the subjugated peoples were inferior and backward compared to the European one and, the second, that the resources of the new continent were practically unlimited. In this way, the destruction and elimination of pre-existing forms and systems were fully justified. (Gligo 2001: 60, author's emphasis)

The political economy of the conquistador assumed and imposed an extractive relationship over water. Extractivism refers to a territorial pattern of power based on the appropriation and oligarchic concentration of land, water, and labor. These assets are administered in an authoritarian way by use of direct or indirect coercion for the monocultural production of goods with higher immediate income, destined for and dependent on exogenous decision-making, valuation, and consumption centers; economies, therefore, become completely disconnected from the livelihood of local populations and their living environments (Machado Aráoz 2015; Machado Aráoz 2024). The determining feature of the socio-hydrological regime of (colonial)-modernity consists, precisely, in the confiscation, control, and use of water as an energy input for machinery in the production of goods for external markets. The enterprise of the Conquista and the economy of colonization were based entirely on the oligarchic appropriation and forced transvasing of water from circuits, flows, and forms of use linked to subsistence production to the extraction of profitable commodities: silver and sugar. This constitutes a precursor and a foundational chapter in the process of modernization/appropriation/imperialist transformation of waters.

Certainly, the colonialist invasion, invention, conquest, and occupation of "America" was a distinctly hydropolitical event. Among other foundational dimensions of the pattern of colonial-modern power, it represented the first time that pre-existing socio-hydrological systems had been crushed and a new framework governing the conception, mode of use, and administration of native socio-water flows and, therefore, of the populations whose way of life depended on them had been imposed. The conquistadors' treatment of various sources of water and their peoples began to form the structuring contours and shape of what, in the end, would be defined as the "Western hydrological discourse" (Linton 2006). The mode of appropriation of the conquered "America's" waters would be a key vector of the new pattern of power that would prevail over the world: the basis of the socio-hydrological regime of the "West" and its hegemonic condition-position on a global scale.

Abstraction and *deviation* were two key operations in modern imperial water's conquest. Abstraction deals with simplification and homogenization (commodification): it involves disengagement and crushing of water's various local uses and meanings. It is a rupture in the constitutive relationships of territorialized ways of life; it is deterritorialization and de-historization: a disregard and a flattening of the socio-hydrological relations typical of an inhabited territory; alienation from the multispecies water flows that make up specific communities of life (Strang 2004; Linton 2006). Abstraction is complemented and realized in diversion: the transvasing of water. For Donald Worster, imperial water is basically diverted water expropriated from "traditional agrarian users" and redirected to "cash crops" (2006: 13) as well as towards other uses governed by the logic of profitability.

The direct and lethal effect of this process of abstraction and diversion of water was (and is) the destruction of living hydrosocial territories, an inseparably epistemic, ecological, and political act. It is thus also an epistemicide – hydrogenocide. The imposition of the "Western hydrological discourse" was then – and recursively throughout subsequent history has been – a necropolitical event. The Spanish conquest brought about the demographic collapse of the populations of the "New World" (Borah 1970; Wechtel 1971; Crosby 1972; Crosby 1986; Cook and Borah 1974; Gligo and Morello 1980; Cook 1981; Vitale 1983; Escudero 1992; Tudela 1992). This imposition triggered the greatest socio-ecological and human catastrophe in the entire history of the species, involving the death of 90 percent of the continent's native population, equivalent to 10 percent of the world's population at the time, and later the "transvasing" of 12 million enslaved humans from Africa (Maslin and Lewis 2015: 2020).

The Great Dying left its mark on the atmosphere in the *Orbis Peak* and the Little Ice Age (Lewis and Maslin 2015; Le Roy Ladurie 2018; Blom 2019). In this way, it caused the first major localized water disturbance with global reach; the diversion of water altered the carbon cycle, which in turn affected the climate and the general dynamics of the biosphere. Modern imperial water was making its catastrophic entry into history. With its origins in the Conquista of the Americas, it would later go through a phase of consolidation and its first moment of globalization with the exploitation of the Cerro Rico de Potosí.

Cerro Rico as a Source of Modern Imperial Water

There are well-founded reasons to think that the contemporary climate debacle has its founding *moment* with the hydrogenocide of *humus-producing communities* that made the vast Andean region, which was integrated into the Incan cultural composition, humanly habitable. This catastrophic event was triggered by the "discovery" of Cerro Rico de Potosí. Viewed in retrospect, between the Conquista at the beginning of the sixteenth century and the explosion of fossil industrialism at the end of the eighteenth century, the exploitation of this spectacular concentration of silver appears to be a critical link that articulates the serpentine process of the socio-hydrological emergence of the Capitalocene.

It is nothing new to argue that the origins of capitalism reside in the silver revolution of the sixteenth century. In 1934, Lewis Mumford points out that "more closely than any other industry, mining was bound with the first development of modern capitalism. By the sixteenth century it had definitely set the pattern for capitalist exploitation" (2010 [1934]: 74). Fernand Braudel (1949) assigns the flow of precious metals a decisive role in the global expansion of the Mediterranean's mercantile economy. For Jason Moore, "the transformation of Potosí was a pivotal moment in the formation of this capitalist world-ecology" (2010: 59). Nicholas Robbins points out that "the silver that flowed from Potosí and other mining centers in Latin America would not only help Spain consolidate its position as a global power but would play a key role in the emergence of the industrial revolution and ultimately, modern, global capitalism" (2011: 4). This chapter's author has even elsewhere argued that the exploitation of Potosí was the environment that helped forge the pattern of power, the matrix of social relations, and the geometabolic regime typical of the colonial system of capital (Machado Aráoz 2012; Machado Aráoz 2014).

It seems necessary, however, to highlight with greater emphasis and clarity that the Potosí Mineral Revolution also marked a drastic change in the way of conceiving, treating, and relating to water, which would be decisive in subsequent processes and the nascent geological-political evolution of Modernity. To make the extractive enterprise viable (that is, profitable), the implementation of an entire socio-hydrological system built and designed for this exclusive purpose was crucial. Like any mineral extraction, the Potosí mine was an eminently hydro-intensive and hydro-dependent undertaking. Its success depended on the creation and imposition of a complete hydro-political technological complex, dealing with the regulation of water in all its forms and states; its control and administration; and consequently, the populations that relied on them.

The object and meaning of this technological complex were none other than the confiscation, abstraction, and diversion of water from its socio-ecological cycles of subsistence production into the new currents of abstract valuation. Based on the control of native waters and their channeling (abstraction and diversion) as an input to wash rocks and move mountains, the conquistadors made Potosí "a global economic vortex, spinning fastest as it drew in goods and people in the Andes, yet casting its current as far away as Africa, the Middle East, and China, while showering the globe with a deluge of silver" (Robbins 2011: 39–40).

Roughly after the Toledo Reforms (1570), with the imposition of the *mita* (system of forced labor) and introduction of mercury amalgamation, Potosí became the seat of a lethal great transformation: there, a system of practices began consolidating that went on to normalize the sacrificial transmutation of currents and bodies of water – even waters in a living state – to obtain means of power and abstract wealth.

Uywaña: The "*Crianza*" of the Waters as a Substrate of the Andean World

In order to measure the magnitude of the transformations in the treatment of water caused by the conquistadors' invasion, occupation, and exploitation of the Andes centered in Potosí, it is necessary to take into account that the Andean world had an *agrocentric hydroculture,* whose material and spiritual support for its way of life was an integral cosmology centered on *crianza* (upbringing, nurturing, childrearing, education) of the waters as sacred entities par excellence (Urton 1981; Greslou 1990; Grillo 1994; Apaza 1998).

Being the origin of life and the very culture born from the depths of Lake Titicaca, the waters are sacred entities in the Andean world. This world is divided horizontally into four parts (their own) and vertically into three parts, the world above, the world in the center, and the one below, all connected by water cycles that, in their circulation, align with the rhythms of life (Greslou 1990; Sherbondy 1992). In the Andean vision, all beings form a living communal world, and everything is born from the world below or the great sea (*Mama Qocha*). The universe originates in this sea, and the sun, the moon, the stars, and humanity have all emerged from its womb. From there, the waters that come to the surface form springs, rivers, lakes, and streams, which are considered sacred places (*parqarinas*), where life, different peoples, and *ayllus* (the basic form of Andean social organization) originate (Sherbondy 1992; Ramírez González 2019). Within this cosmology and world of life, the concept of *Uywaña* is central.

Uywaña refers to practices of *mutual care*, relationships of respect, affection, and reciprocal care that exist between all the beings that make up a community within a living territory (Arnold 2016; Lema 2013; Torres Lezama 2020; Espejo Ayca 2022). *Crianza* has to do with participation in the production of life itself; the work of each being aimed at caring for and "continuing the flow of energies in cohabitation, reciprocity, and maximum care for the environment" (Álvarez Quinteros 2022: 342). It is not an exclusively human activity nor is it solely focused on children. Rather, it is a practice of all beings that cohabitate a living territory: the earth, the wind, the sun, the plants, the animals and humans, and the waters all participate in the mutual *cri-*

anza on which the abundance of life in the world depends (Greslou 1990; Arnold 2016; Apaza 1998).

Water, like other living beings, is "something" that *is criada* and, at the same time, *nos cría* (nurtures, raises, educates us). To *criar* and let yourself be *criado*, you have to learn to converse:

> Like any living person, water deserves respect and affection, it is complemented by plants, animals, the wind, the sun, and other beings but it is also capricious, depending on its 'moods', some days it might be kind and lavish favors, other days it might be upset and do harm; this means it is necessary to establish a close conversation to understand each other and be able to live together in harmony. (Apaza 1998: 18)

In circulating the *criadoras* energies from the waters, the main thing is to know how to converse and reciprocate with them. Each *ayllu* is born from water; the *charca* (large pool naturally or artificially made) is the place where this *crianza* takes place, and irrigation constitutes its key practice and moment (Urton 1981; Sherbondy 1992; Greslou 1990; Grillo 1994). *Crianza* involves the

> concerted participation of the human communities, the communities of the *saqlla* (nature), and the communities of the *huacas* (deities) concerned [...] This *crianza* takes place with the full participation of people (whether humans, trees, or stones), who in some way or another will change their way of life with the presence of irrigation. It is done in the way they continue to ask for [...] The *crianza* of irrigation is done to the rhythm of life, which is sometimes fast and sometimes slow but is always alien to immediacy [...] It is something that is convenient for everyone and is shared by all [...] conversation, reciprocity, and dance flow in this festival of life, which is community *crianza* of irrigation. (Grillo 1994: 145)

Within this ontological framework, the Inca universe emerged and prospered as "a globally unique hydro-agricultural system of arid regions with immeasurable value to the agrarian heritage of humanity" (Mazoyer and Roudat 2008: 224). The Inca world stood out for its exceptional hydrological and edaphological (related to the composition and nature of the soil) technologies for manufacturing agricultural land (Murra 1975). Gligo and Morello (1980) point out "four outstanding spectra of the Inca development style": macro-regional energy efficiency; the organizational dynamics of agricultural work; the collective orientation and regulation of production; agronomic technology and food knowledge. The first aspect concerns the coordination of balanced exchanges between ecological floors and eco-regions, for which both irrigation systems and the infrastructure for transportation, communication, and storage were key. The second deals with a sound labor discipline, which articulated "the minimum individual components (*ayllus*) with the community composed of the whole" of Tawantinsuyu. The third aspect refers to the communal base for the appropriation of basic territorial assets (land, water, etc.) and the administration and distribution of production based on the maintenance of the populational-territorial group. Finally, agronomic technology combined physico-chemical soil adaptation, plant physiology, and seed and cultivar selection; phytosanitary protection and soil fertilization techniques; the creation of a seasonal and astronomical agricultural calendar; meteorological knowledge and climate forecasting; and knowledge of both food sources and the nutritional value of native flora and fauna (Gligo 2001: 61–65).

Based on this, a highly efficient hydro-agrifood "archipelago" could be articulated within vast areas that were extremely arid, cold, and/or directly inhospitable (Murra 1975; Gligo and Morello 1980; Brailovsky 2006). This archipelago consisted of irrigated cultivation systems based on corn, beans, and cotton in the coastal plains; irrigated cultivation systems based on corn, beans, lupins, beans, and quinoa in the Quechua area (Andean valleys up to 3600 meters above sea level); potato cultivation in the Suni area (mountain slopes between 3,600 and 4,200 meters above sea level); and the pastoral system of the Puna area (plateaus ranging from 4,200 to 4,500 meters above sea level). This was complemented by fruit harvesting, counter-season corn, and coca crops in the Amazon foothills (Mazoyer and Roudart 2008: 228–232). Each bioclimatic region provided the system with products critical for the energetic and economic equilibrium: guano and cotton from coastal areas; corn and quinoa from the Quechua area; potatoes and medicinal herbs from Sunni areas; and salt, wool, meat, and pack animals from the *puna*.

This diversity (whether biological, cultural, climatic, edaphological (soil), or of the ecological floors themselves) together with economic and political coordination and planning were the basis of a highly efficient and productive sociometabolic system. Comprehensive water management and soil fertility were key to balancing the energy of this geosocial formation (Murra 1975; Antunez de Mayolo 1981; Mayozer and Roudart 2008). Through their unique cosmology, technologies and political forms of work organization and social integration, the peoples of the region managed to build a *sociometabolic regime of bioaccumulative energy surpluses* (Vitale 1983).

"That Great Mountain of Silver" and the Great Original Transvasing: From Vital Waters to Water-Metal

It can be said that Potosí was the site of the first systematic episode of disenchantment of the waters' world. A fundamental aspect of the imposition of modern water consists in the annihilation of hydrocultures that consider it a vital entity, even a sacred one, converting it to a mere resource, an abstract formula at the service of instrumental reason. Although it involves a profoundly religious and spiritual dimension, the desacralization of waters was not so much the product of an intellectual, discursive operation as it was a purely political creation: the emerging result of new practices and forms of relationship within the framework of a new matrix of power. The disanimation and liquidation of pre-modern water cultures had to do with violent practices that appropriated, dispossessed, and ruptured the relational flows that made the waters a material and spiritual source of living territories. This process took place during the long sixteenth century with the exploitation of the Cerro Rico de Potosí.

In fact, Potosí was the first modern site of exploitation, exploitation being the first and main form of treatment that coloniality-modernity gave to water. The extraction of silver was a hydro-intensive process; it required a spectacular operation of abstracting, concentrating, and diverting water. The conquistadors appropriated the waters and diverted them from the Indigenous peoples' communal schemes and circuits for the *crianza* of life, damming, channeling, and using them to empty out the mountains.

> Between 1550 and 1800, at least 136,000 metric tons of silver were produced in Latin America, which represented 80 percent of global production during that period. [...] Although Cerro Rico was the font from which such legendary riches flowed [...] Between 1575 and 1600, Potosí produced about 70 percent of all Peruvian silver, and about half of all silver produced in the Americas. (Robbins 2011: 4, 17, 39)

Potosí, thus, was the first large-scale industrial mining operation. It was the first place where vital waters were diverted to the "satanic mill" of accumulation (Polanyi 1949). The magnitude of this exploitation/diversion constituted a scalar leap in the volumes of water mobilized and the consumption of materials and human and non-human bodies and labor involved in the extractive process. This great hydro-energetic leap unfolded "the extension of commercial networks already on a global scale and the birth of capitalism" (Fernández Durán and Gonzáles Reyes 2021: 175).

The silver mined went beyond geographical scales and spread throughout the (new) world.

> On any given day in the seventeenth century in the markets of Europe and the Middle East, one could hear the heavy, dull clang of silver as it was exchanged for myriad products. It was literally the sound of the leading edge of modern capitalism and global integration. Like a restless traveler on a global journey, silver was itinerant, making its way ever more eastward through Persia, India, and China, exchanged along the way for tea, spices, porcelain, silks, satin, dyes, incense, gemstones, and other high-value, low-volume products. The eastward flow *was like a rising tide*, increasing from approximately 114 metric tons in 1600 to 220 metric

> tons in 1700, before reaching 382 metric tons in 1780. (Robbins 2011: 5, author's emphasis)

The first major geometabolic disorder of the Capitalocene took the form of a worldwide flood of silver, and various facets of this exploitation in Potosí demonstrate its role in creating modern imperial water.

Potosí and its Hydroenergyvorous Metabolism

A central feature of modern colonial mining is its hydro-energy-intensive nature. Extractive exploitation involves a drastic hydro-energetic imbalance that alters the circuits for the production of use values, depending on the dominant requirements for the extraction of abstract value. Like any extractive form, the exploitation of Potosí required the appropriation and oligarchic use of vital hydro-energetic flows. The enormous hydro-energetic volumes required for the exploitation of the Potosí mine were mainly supplied by living beings and bodies of water. This began with human bodies being subjected to conditions of forced and/or enslaved labor, first through the *encomienda* (1540–1570) and then through the more effective *mita* system (1572). Through this, between 13,000 and 17,000 *mitayos* (workers in the *mita* system) were recruited per year for general operations in Potosí, 4,600 of them working daily and directly under the sinkholes (Bakewell 1990; Dore 1994; Contreras Carranza 1994; Robbins 2011).

Beyond humans, the exploitation system involved a complex of 13,000 wagons moved by mules that transported ore from the quarry to the processing mills and from there to the shipping ports; an estimated 350,000 llama and 100,000 mules per year (Moore 2016: 134). To this, the more than 100 tons of animal fat per year must be accounted for, which were used in the mine as lubricants for the mills and machines and to manufacture the huge number of candles needed for work underground (Moore 2016: 133).

Another important component of the hydro-energetic flows consumed in Potosí was from vegetal beings, both indirectly and directly. On the one hand, the large number of cargo animals required caused a drastic alteration of landscapes, and "forests and fields were transformed into grass for the mules that carried the mineral"; on the other, "forests were cut down for the construction of wells and mine tunnels" (Dore 1994: 56), above all, for foundries. The sinkholes formed "a vast underground forest" that needed to be renovated every six years (Moore 2016: 129). From the use of *wayras* (small Andean cylindrical clay furnaces, which could reach more than one thousand two hundred degrees centigrade in temperature) in the amalgam method, the smelting of the metal involved a huge consumption of firewood throughout this process, which led to the destruction of all types of vegetation: "little by little we went from the fuel of trees to firewood from shrubs or *tolares* [a name for a variety of different shrub species], and even to the use of perennial grasses such as *ichu* (*Stipa ichu*)" (Gligo 2001: 74). Thus, "all forest resources close to the foundries were consumed. The mines were then abandoned not because they were exhausted but because of problems related to the volumes of water needed for concentration and the depletion of the firewood resource for smelting" (Gligo 2001: 74). The domestic demand for firewood consumption, estimated at 25,000 tons per year, must be added to this direct consumption by mining activities as well (Moore 2016: 128).

As living organisms, bodies of water (Neimanis 2017), or rather, waters in a "living state" (Porto Goncalves 2020) are being discussed; it should be noted that in every one of these flows, enormous volumes of water were involved, which were extracted from distant locations to be consumed finally in the extractive process. Emanating from remote places, humans, pack animals, food for humans and non-humans, trees, shrubs, and pastures – whose tracks outlined a new and strange "hydrographic basin" – were absorbed and diverted to the mine. Entire socio-hydrological systems, with their own lives, were being eroded, progressively fragmented, and dismembered to supply the living water (in plant, animal, or mineral state) required by the Conquista's extractive enterprise.

The dismemberment of living territorialities left a trail of death and deserted landscapes. Beyond its immeasurable impacts on biodiversity and ecosystems (Gligo 2001), the conquest and exploitation of Potosí meant the collapse of native populations. Cook points out that "in terms of the number of people who died, it was the greatest human catastrophe in history" (1998: 13).

> In the region of present-day Peru, the total population fell from approximately 9,000,000 people in 1520 to about 1,000,000 in 1580, reaching a nadir of only 600,000 in 1620. [...] In the highlands of present-day Bolivia, the population decreased by approximately 60 percent between 1532 and 1550, and 75 percent between 1532 and 1720. (Robbins 2011: 15)

Beyond the impact of infectious and contagious diseases, the demographic implosion was deepened by the labor exploitation regime. The *mita* system destroyed agricultural communities by expropriating huge numbers of men at peak productive age and causing mass migrations intending to flee from this work regime as feared as it was lethal (Bakewell 1990; Moore 2010; Robbins 2011). It operated as a bloody system of concentration and sacrifice of human bodies of water, which were extracted from their circuits of production and subsistence, only to be condemned to get sick and die in the service of this nascent imperial machinery.

The Potosí Hydraulic Complex: Waters at the Service of Silver

Although, according to Linton, "the control of water is the physical manifestation of its modern intellectual abstraction" (2006: 46), the formula could well be reversed. Historically, the scientific abstraction of water developed very late as a rationalization of a process of empirical control motivated by the spirit of conquest and the forces of commodification. Two centuries before the rise of modern hydraulic science, the Potosí mining industrial complex created under the command of the Viceroy Toledo was the scene of the development of a vast techno-hydraulic system for the extraction of silver. The size and complexity of its structures, its operational characteristics, its functional effectiveness, the principles and purposes for which it was designed, clearly make it *the first modern imperial machinery.*

By the middle of the sixteenth century, high-concentration veins (silver chloride) had been exhausted and silver sulfides, which had a lower mineral grade and were under phreatic zones (an accumulation of groundwater at a shallow depth) began to be exploited (Bakewell 1990). Within this framework, with the objective of reactivating silver mining, Viceroy Toledo promoted a new extraction method based on mercury amalgamation. This method, in addition to the enormous amounts of labor (provided by the *mita*), required a significant increase in water availability. To this end, it was ordered "by royal decree, the construction of eighteen lagoons and reservoirs in the ravines of the Kari Kari Mountain Range, and the subsequent channeling of water through the La Ribera River" (Gómez Saavedra 2021: 660). "Toledo assigned some 20,000 Indians to this massive construction project" (Robbins 2011: 27). The project began in 1573. A system of dikes interconnected by aqueducts was built with retaining walls of moraine (an accumulation of earth and stones carried and deposited by a glacier) and rocks up to nine meters wide, which took advantage of the natural topography to capture rainwater and runoff. The channels were eleven miles long, 75 cm long and 80 cm deep, with a slope of 1 percent and a flow of 160 liters per second (Gómez Saavedra 2021: 662). Downstream, this complex provided energy equivalent to about 600 horsepower (Robbins 2011: 27), enough to move large, heavy stone wheels and hard, resistant woods to grind raw ore in more than 120 mills built around La Ribera (Bakewell 1990; Robbins 2011; Gómez Saavedra 2021).

Although these were much more expensive, hydraulic mills soon completely replaced those powered by Indians and draft animals, as they "gave a higher return per unit of capital and labor invested" (Bakewell 1990: 59); these mills yielded three times more than those moved by humans and twice as much as those powered by mules. By 1600, almost all the energy used in mineral milling was of hydraulic origin; by 1620, thirty-two dams had already been built to feed the canals leading to the mills. As a whole, this technohydraulic complex comprised 65 km^2. If dams are the symbol par excellence of "the religion of progress" (Worster 2006), if indeed "they are concrete, rock and earth expressions of the dominant ideology of the technological age: icons of economic development and scientific progress" (McCully 1996: 2–3), the first sites of these machines of imperial globalization took place around the colonial-mineral exploitation of Potosí.

Potosí: the Sinkhole City and its Sacrificial Hinterland

As is well known, Potosí was one of the largest and most impressive cities in the world in the seventeenth century (Galeano 1971; Dore 1994; Moore 2010; Robbins 2011); perhaps the first prototypically colonial-capitalist urbanization (Machado Aráoz 2014). The sharp separation (spatial, functional, economic-productive, sociocultural, and ecological-political) between the countryside and the city was identified by Marx (1975[1867]) as the critical metabolic fracture that fully characterizes and supports the capitalist process of managing social life. It makes the city a node of appropriation and concentration of vital (primary and social) energies that are subsumed in the process of commercial manufacturing/abstract valuation (Foster 2000; Machado Aráoz 2016). Urban concentration (of the labor force; of technologies and productive force; of production inputs; of consumption, distinction, and luxury; of symbolic and material, economic and political power) is the effect and another face of the dispossession of rural communities, here structured as mere supply areas. At the local level, the extractive socio-metabolism of capital works based on this territorial, ecological-political division. The first systematic configuration of this design took place with the construction of Villa Rica de Potosí, a city built from nothing, which reached 120,000 inhabitants by 1570 and later surpassed 200,000 by the end of the seventeenth century. The city only functioned because of the vast supply hinterland, which nearly encompassed the entire stretch of the former Inca empire.

As a mining city, Potosí would be impossible to conceive without its structural-functional connection to the city of Huancavelica, the extractive center of mercury, a key input in the silver process. The brilliance of Potosí depended absolutely on the gray Huancavelica. "Despite its modest size and humble buildings, this town at 12,103 feet above sea level was nonetheless a vital part of the imperial machinery" (Robbins 2011: 30). Because of the very lethality of mercury, Huancavelica was a much more fatal and costly mining center in terms of human and non-human lives than Cerro Rico itself.

Potosí was also dependent on an entire system of *haciendas* that provided all the material and energy requirements to support such a concentration of people and extractive machinery. This concentric circle of estates provided food, wool, leather, firewood, timber, tools, transport, and animal labor on a large scale; these estates were, in turn, made into nodes for the concentrated appropriation and redirection of local resources to the mining center. Through the hacienda system (Florescano 1975), colonial agriculture and livestock operated as an ecological-political factor of systemic degradation of pre-existing agroecological systems (Vitale 1983; Gligo and

Morello 1980; Frank 1965). The introduction of livestock and the cultivation of alfalfa, wheat, and grapevines, and in general, the prioritization of production for commercial use, involved the suppression and/or disappearance of food crops, resulted in a demographic disaster, extending lethal famines and morbidity as well as producing a subsequent collapse of Andean farming systems. Except for corn, tomatoes, and potatoes, a vast wealth of food crops fell into disrepair: among them, quinoa, *tarwi*, *madi*, amaranth, *ajipa*, *yacón* (Brailovsky 2006: 140–141). The abandonment of the Inca agrifood system also meant, to a large extent, the implosion of the vast socio-hydrological complex on which it was based.

Thus, as an extractive system, Potosí involved a whole new spatial and social geometry. It was not only the mine. The urban concentration and the hinterland which supplied it were involved as well. As such, this extensive supply network expanded like a large cone of destruction and death.

Water-Metal: Source of Pollution and Hydropolitical Catastrophes

Water was not only necessary as an energy source for the exploitation of Potosí but also "essential for the washing of refined minerals" (Bakewell,1990: 62). The mineral when ground was mixed with salt (100 kg of salt per 1,000 kg of concentrate), magistral (calcined chalcopyrites), and mercury (4.5 to 5.5 kg) then "kneaded" (*amasada*) by the Indigenous workers. This formed a "pineapple" (*piña*) of five parts mercury and one part silver, which had to be washed in the channels and then allowed to evaporate.

> The Potosinos were ever-cognizant that increased silver production and the renewed prosperity of the city depended on water almost as much as native labor or mercury. As one chronicler explained in 1590, in Potosí "men ask for a good year of rain… as in other parts they ask for bread." (Robbins 2011: 28)

Washing the pineapple made the waters lethal, and these waters would begin to spread their toxicity over whole ecosystems hundreds and even thousands of kilometers away. Although the deadly toxicity of mercury was already known at the time, it mattered little to the extractivist enterprise. Silver mining was the first "national interest."

The water utilized in Potosí, the "soul of the machines" that ground the mineral, was poison to living beings. Mercury was transported from Huancavelica in leather bags. Throughout the colonial period, "Huancavelica produced approximately 68,200 metric tons of mercury, and a total of approximately 45,000 metric tons, from all sources, were consumed in the city of Potosí. Of this, approximately 39,000 were volatilized, and the rest became uncaptured runoff. All of this was absorbed by the atmosphere, watershed, people, animals, and plants" (Robbins 2011: 8).

Historical estimates indicate that between 1580 and 1640, the annual "losses" of mercury were 300 tons. Such a volume "represented a powerful toxic invasion of regional ecologies [...] it not only altered the nutrient cycle; it poisoned it" (Moore 2010: 79). Thus, the "revolution of productivity" brought about by Viceroy Toledo's reforms (which involved the combination of *mita* as a form of labor force recruitment and the technique of mercury amalgamation for leaching of silver) was lethal to the populations that inhabited these territories. The splendor of Potosí was realized at the cost of spreading death and destruction on vast scales of space and time. Described at the time as the source that fertilizes everything, mercury also poisoned and killed hundreds of thousands of people (Dore 1994). Thus, it revealed the two extremes of the new system's chain of production: death and desolation on the one hand and the concentration of wealth and power on the other.

> Just as we cannot understand the rise of Spain and the emergence of the modern global economy without examining the key role of mercury in the production of silver, we cannot fully understand colonial Latin American society without accounting for the impact that quicksilver had on the environment, people, and their relationships. Insidious, subtle, and multifaceted in its noxious effects, mercury was an exacerbating element of what was already a violent, ruthless, and brutally exploitative society. (Robbins 2011: 8)

Beyond this source of pollution that persists to this day, a perpetually toxic hot spot, the imperial hydraulic machinery installed in the Potosí also caused the first hydropolitical catastrophes of colonial-modernity. On March 17, 1622, the San Salvador dam collapsed and destroyed the city's Indian slums, killing 200 people. Four years later, on March 15, 1626, the San Ildefonso dam collapsed. The torrent of water cascaded from an elevation of 4,400 meters razed the city away, destroying 122 mills, "360 Spanish houses and more than 800 Indigenous ranches" while leaving more than half of the city under water contaminated with "mercury, pure silver, salt, copper sulfate, lime, iron, tin, lead, minerals to be treated, and tailings or gangue" (Serrano and Gioda 1999: 79).

More than hydro-intensive, the exploitation of Potosí was hydro-eco-genocidal. It operated through the oligarchic concentration of water, its reduction to a rational of exploitation, and the large-scale pollution and irreversible destruction of entire socio-hydrological basins.

The *Potosí Principle* and the "Falling Sky"

Although certainly extraordinary, the Potosí hydro-eco-genocide was not just a sporadic event; it produced long-lasting historical-structural effects. Properly, it can be considered the main tributary of modern water. The establishment of modern water can be analyzed as a hydrogeosocial emergency resulting from a contingent, concatenated, processual, and emerging series of practices and operations of power over waters and peoples that, in its cumulative trajectory and its performative effects, ended up triggering a radical change in water's ontological status and, with it, ultimately, a drastic alteration in the dynamics, rhythms, circuits, and flows of the Earth's vital hydro-energetic processes. Although, in fact, capitalism emerges from and is nourished by modern water – which sprung from urbanization and large metropolises; from textile mills and the steam engine; from the great damming of water; from its channeling as a key input for agricultural goods, as a source of energy and means of transport for the global market; from the technocratic scientific discourse that codified it as a mere abstract resource, from its chemical formula to its current nomenclature as a financial asset. The configuration of the Potosí system constitutes an unavoidable fundamental event in this genealogy.

The centrality of Potosí concerning a genealogy of the Hydro-capitalocene has to do with the type of social practices that were formed there and were instituted (producing institutionalities and subjectivities) as a "normal," "modern," and "rational" way of treating water, ontologically reducing it and creating modern imperial water. Its exploitation resulted in a new pattern of power and a new hydrogeometabolic regime. The mine was the great altar of modern civilization around which the sacrifice of living water was offered. Metal-water could only flow in large quantities to the imperial metropolis by exploiting, milling, and mineralizing the hydrocommunities that produced subsistence/habitability.

Potosí inaugurated the era of extractivism and one of systematic and continuous transvasing of socio-hydrographic basins, already at an intercontinental scale: water in the form of enslaved human bodies, of llama and mules, of forests consumed for infrastructure and milling, of leached metal used as mere exchange value. Potosí inaugurated the era of unequal socio-ecological exchanges: between groups of humans, between humans and non-humans, and between regions, countries, and continents. It created the geography of global water inequality we currently see now.

The sociometabolic fracture that Marx identified at the root of the regime of capital (Marx [1975]1867; Foster 2000; Machado Aráoz 2016) did not originate in the treatment of European soils but instead of Andean waters. It was actually a hydrosocial fracture. Locally, this began with the devastation of an agro-community hydroenergy regime to impose another of a mineral-mercantile nature, where the primacy of exchange value prevailed over the value of use; the logic of the conquering individual, over that of the community of life; in short, a sociometabolic regime where the principle of habitability was seen as obsolete and sacrificed to maximize profitability. Finally, globally and structurally, it provoked the social emergence of a new geological-political time, a time where life has been placed in a critical state of emergency. Potosí is at the origin of the Conquista's "Anthropocene" as a hydrogeosocial emergency and a diluvial event. It is at the origins of the commodification of water and the ontological-political genesis of the "People of Merchandise" (Kopenawa and Albert 2010).

The atmospheric heat from modern fires, whether from the military or industry, has had a profound impact, causing a cumbersome disturbance in socio-hydrological cycles that sustain the biosphere as an "indivisible and indissoluble whole [...] which contains life in its entirety [...] throughout all geological periods, from their oldest manifestations, from the Archaeozoic eon" (Vernadsky 2023[1926]: 208) to date. The machine of fire that activated "industrial civilization" – the "civil" society that is, in fact, a military-mercantile society – heated the air and the waters, the soils and the bodies. Before the steam engine began to warm the atmosphere, the fever for gold and silver heated certain bodies and forged with that heat the conquering subjectivity that was the protagonist of the current climate upheaval.

This accumulated heat ended up causing severe disturbances in waters immemorial. They have begun to show profound changes in their physical states and millenary cycles: unpredictable movement, gigantic volumes, and uncontrolled forces and speeds. Thus, like the acceleration and intensification of extreme weather events, the "Anthropocene" reveals itself as a properly diluvial event. The human species inhabiting the twenty-first century faces, materially and symbolically, the imminent *"falling sky"* (Kopenawa and Albert 2010): it is not only the collapse of the climate and meteorological patterns of the Holocene but also the collapse of modern imperial water.

Heat is speed. It accelerates flows, both of waters and winds, of substances and organisms. Warming/acceleration disrupts vital hydroenergetic flows and rhythms. The air and water that circulate at a higher speed alter the materiality of bodies and the interactions and connections between organisms, the ligaments of biotic communities. Today, heat causes a temporary increase in circulating fresh water and, with it, the meteorological processes and phenomena that we see and suffer from in the form of major floods, severe droughts, storms, tornados, and cyclones that occur with increasing frequency and violence.

On a particular scale, speed is violence. Beyond a specific range, the increase in the speed of circulation – the emblematic effect of capital's industrial metabolism, an acceleration of time/shrinking of space (Harvey 1998) – becomes a force that destroys inhabited places, violating the rhythms and flows that make up the fabric of terrestrial life as an integrated totality. The force of speed causes ruptures in relationships, alters synchrony, breaks symbioses, produces decouplings, and destroys complementarities and circularities. In short, destroying relationships of mutualism and cohabitation corrodes the Earth's socio-biodiversity and habitability. Our time is such: metallic heat erodes the communal sympoiesis – defined by Haraway (2015; 2019) as the specific practice of becoming-with and making-with in coexistence – on Earth and causes the sky to fall.

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Water in the Amazon in the Colonial Period

Frederik Schulze

The Amazon region – or Amazonia – is one of the most water-abundant regions in the world. 10.5 to 12 percent of the world's freshwater is to be found in its three river basins: the Amazon basin, the Orinoco basin, and the Tocantins basin. The Amazon is the largest river on Earth, with an average water flow of up to 300,000 m^3/s in its estuary. The Amazon River system originates in the Andes and is fed by several huge tributaries. The Ucayali, Marañón, Putumayo, and Caquetá are the Amazon's main Andean source rivers, while the Purus, Negro, Madeira, Tapajós, and Xingu are the most important tributaries in Brazil. Even though it is a diverse region with different biomes, 8 million km^2 are (still) covered with tropical rainforest, 80 percent of it alone in the Amazon basin. Therefore, precipitation is another important source of water for the region. Rainfall reaches 250 mm/month during the rainy season from February to May and drops to 50mm/month during the dry season from September to November (Souza, Rocha, and Cohen 2004: 40–41).

It comes as no surprise that humans perceived the Amazon for millennia as a land of abundant water and created legends, discourses, and scientific knowledge about its vast water resources (Pizarro 2012: 18). It was only in the last few decades that anthropogenic impacts became increasingly visible. Deforestation, urbanization, agrarian colonization, and infrastructure projects started to affect water quality and alter water regimes of the region's rivers, and periods of drought point to the region's vulnerability to climate change (Aragón and Clüsener-Godt 2004).

To what extent can these recent problems be traced back to colonial or even precolonial times? Did colonial regimes lay the ground for developments to come? Did water regimes suffer from environmental degradation, and did contemporaries reflect on that? This chapter cannot claim to offer comprehensive answers. The region is immense and diverse, and scholarship on water use during the colonial era is regionally fragmented and more than rare. Even though a systematic overview of early anthropogenic impacts on Amazon waters is not possible, this chapter focuses on the Brazilian part of the Amazon basin and aims to shed light on several topics that can serve as points of departure for further research. After briefly discussing the precolonial era, it looks at early European explorations, the implementation of the colonial regime, and the first scientific expeditions that made the Amazon legible for subsequent development efforts. It will be argued that there is no teleological account of the Anthropocene in the Amazon, but rather a fragmentary and non-linear history of water use that corresponded to practicalities and imaginaries of past centuries.

The Amazon in Precolonial Times

For a long time, scholars interpreted the European conquest and rule as a fundamental "remaking of Amazonia" which not only exacerbated the situation of the Indigenous population but also initiated a process of environmental devastation (Bunker 1985; Schmink and Wood 1992). While this narrative stemmed from postcolonial and environmental historians who assumed that Indigenous groups had lived for centuries in harmony with nature or at least had applied sustainable techniques when using natural resources, other scholars questioned the huge impact of early European colonization or even assumed that conquest led to a decline of Indigenous populations, stopped the precolonial agrarian use of the region, and triggered an era of environmental regeneration (Pádua 2000: 80; Hemming 2008: 17; Acker 2021: 5).

Yet, the impact of Indigenous groups on the ecosystems during precolonial times cannot easily be uncovered since written documents and archaeological evidence are rare. Climate researchers have shown, however, that precolonial times were not a static era. Instead, they have uncovered frequent changes in the water cycle by analyzing charcoal deposits and tree rings. Several El Niño affected the region severely, causing periods of drought and huge forest fires. Events of such magnitude occurred around 1200 BC, 110 BC, and 1500 AD, to name just a few (Alves, Marengo, and Cavalcanti 2013: 21–22). Indigenous groups had to live with such an unstable climate for millennia and were repeatedly forced to migrate. Cave paintings and ceramics evidence human activities along the Amazon River for almost 15,000 years (Veloso 2018: 37–38). Even though substantial information about Indigenous water use is limited to fishing and fluvial transportation, ancestral mythologies are evidence of the importance of water in Indigenous life (Rodríguez 2011).

What archaeological findings reveal, however, is that various Indigenous groups established well-functioning societies with huge settlements and agriculture. As Mark Harris (2021: 156–158) has argued, these communities maintained a circular relationship to the river system. Even though most settlements were located in the hinterland, they relied on the seasonal water cycle that allowed hunting and fishing. In particular, the floodplain (*várzea*) constituted an important biome for such activities (Ferreira 2016: 34–36). The riverine landscape, with its "watersheds, rapids, seasonal lakes, and interfluves," allowed for fishing and communication between groups, while the tidal procession required the construction of temporary huts (Harris 2021: 161, 165). Yet, human exchange was not limited to the local. The Amazon River was much more a "transitional zone" that served as a crossroads for contacts between the Brazilian highlands and the Guayanas (Ibáñez-Bonillo 2019: 34).

Europeans Learn about the Amazon

Europeans arrived in the region for the first time in 1500 when Spanish explorer Vicente Yáñez Pinzón sailed through the Amazon's estuary area. Stunned by the amount of freshwater flowing for dozens of miles into the sea, he named the river "*Santa María [sic] de la mar dulce*" (Holy Mary of the Freshwater Sea) (Isabel I and Fernando II 1987[1501]; Meirelles Filho 2009: 22–23). However, the Portuguese claimed the Brazilian coast as their sphere of influence and did little to further investigate the lower Amazon.

Therefore, explorations of the Amazon in the sixteenth century started upstream in Ecuador and Peru. Spanish expeditions had an exploitative character but failed badly, mainly because they lacked hydrographical knowledge (Bénat-Tachot 2016: 33–35). They were searching for the legendary city of gold, El Dorado, and the Cinnamon Land, where precious goods were to be expected (Slater 2002: 29–53; Pizarro 2012: 79–84). Francisco de Orellana and his party were the first Europeans to sail the Amazon from the Andes to its mouth (1541–1542). The Black Friar Gaspar de Carvajal wrote an account about the journey. In this first text about the huge river, he provided some basic information, described some of its tributaries, and named the river after a belligerent Indigenous group of women the Spaniards believed to be the legendary Amazons (Meirelles Filho 2009: 24–27; Pizarro 2012: 38–44, 71–72; Neves 2020: 90–121). A second expedition under Pedro de Ursúa (1560–1561) repeated Orellano's route but struggled with internal conflicts that ended in a mutiny led by Lope de Aguirre (Pizarro 2012: 38–50). During these two endeavors, thousands of men died, and valuable equipment was lost, preventing the region from being conquered further for almost a century. The early history of conquest contributed to the popular image of the Amazon as an impenetrable jungle, Werner Herzog's movie *Aguirre: The Wrath of God* (1972) being a more recent example.

Conquest and Colonial Expansion

Colonialism started to gain momentum only in the seventeenth century, when, in 1654, the Portuguese founded the Estado do Maranhão e Grão-Pará, a colonial body directly subordinated to Lisbon. The journey of Pedro Teixeira in 1637 and 1638, who sailed for the first time from Belém to Quito and back again, underscored the determination of the Portuguese to expand their dominion (Hecht 2013: 109). The report written by the Jesuit Cristóbal de Acuña (1641) reflected this new and more realistic perception of the region. Instead of describing the travel route and fabulous adventures, Acuña collected useful knowledge for later exploitation. He offered general information about "the largest and most famous [river] of the world" and its abundant water resources and described useful primary goods (Acuña 2009[1641]: 79). The expedition also produced the first detailed map of the Amazon (Meirelles Filho 2009: 38–41; Pizarro 2012: 58–61; Veloso 2018: 79–80; Neves 2020: 137–164).

By the early seventeenth century, the Portuguese had defeated the French and the Dutch, who also tried to settle down in the Amazon region. The Portuguese had taken advantage of the multiethnic setting of the Amazon and formed alliances with some Indigenous groups who helped them fight their enemies, be they Europeans or Indigenous (Ibáñez-Bonillo 2016). In the following decades, the Portuguese used the river system to slowly branch out and founded several settlements and fortresses along the rivers, the Forte do Presépio being the most important (1616, the later regional capital Belém). Their presence on the river margins and the control of navigation enabled them to organize expeditions to capture Indigenous slaves and extract natural resources such as spices or turtles (Sommer 2005; Dias 2019; Harris 2021: 158–164). In this context, Harris has referred to an "aquatic assemblage" of forts, settlements, missions, and riverine trade (2021: 162). Enslavement, mission, and diseases pushed many Indigenous groups away from the river.

Also, numerous religious orders, such as the Franciscans and Carmelites, participated in the colonial endeavor and established missions along the rivers. The Jesuits were particularly active in the Portuguese dominion along the Xingu and Tapajós rivers until the late eighteenth century (Cardoso 2008; Guzmán 2008; Valdizán et al. 2012: 41; Cabral 2013: 20–30; San Román 2015; Díaz Palacios et al. 2016: 215; Arenz 2022). Jesuits such as António Vieira and Samuel Fritz continued exploring the region and used Indigenous knowledge for their own ends (Meirelles Filho 2009: 46–49, 52–55). João Daniel, for instance, collected information about the climate, hydrographic aspects (such as blackwater and whitewater rivers which differ because of their chemical composition), and human interaction with the river. Due to its natural resources, Daniel believed that the Amazon "enriches and endows all of Europe" (Daniel 1976a[1741-1757]: 56, see also 52).

In 1773, however, the Marquês de Pombal, the Portuguese Prime Minister with extensive powers and his own political agenda, banned the Jesuits from the colony after having reorganized the colonial administration with the creation of the Estado do Grão-Pará e Rio Negro a year earlier (Schmink and Wood 1992: 39–40; Paim 2009; Veloso 2018: 92–97). Already in 1755, the newly founded trading company Companhia Geral do Comércio do Grão-Pará e Maranhão (General Trade Company of Grão-Pará and Maranhão) had started to incorporate the Amazon region further into the Atlantic market. The Indigenous groups were supposed to be free and more extensively integrated into the colonial system but the Diretório dos Índios (1758, Directorate of Indians), which assumed some formerly Jesuit activities, aimed for state control (Coelho 2006; Souza Júnior 2016).

Finally, Portugal managed to renegotiate borders. With the Treaties of Madrid (1750) and Ildefonso (1777), Spain waived older territorial claims over the Amazon region. Now, several rivers were defined as new borders, and joint boundary commissions traveled the frontier region to demarcate the border (Hecht 2013: 90–95). Spain and Portugal finally granted free navigation on their rivers (Garfield 2013: 12–15; Díaz Palacios et al. 2016: 233).

Fluvial Transportation

Travel reports from the seventeenth and eighteenth centuries focus on three main aspects of early anthropogenic interactions involving water: river transport, spice extraction, and fishing. Already the first European explorers had described in detail Indigenous canoes and water transportation techniques (Acuña 2009[1641]: 108; Daniel 1976b[1741-1757]: 32–40). Indeed, Indigenous technology helped the Portuguese empire to expand: During the war against the French and the Dutch, the Portuguese relied on Indigenous canoes, rowers, and knowledge about the water regime like the notorious tidal bore *pororoca* (Cardoso 2015: 45–47; Harris 2021: 162). When Pedro Teixeira sailed to Quito in 1637 and 1638, he had forty-seven canoes and 1,200 Indigenous rowers at his disposal (Ferreira 2016: 102).

In colonial Amazonia, Indigenous people remained crucial for inland navigation, because without Indigenous canoes and crew members, neither trade nor transportation was possible (Cardoso 2012: 183–185). Indigenous knowledge comprised the construction of canoes, suitable wood types, and hydrography. The canoe pilots were notable Indigenous men who knew where and how to go by boat (Ferreira 2016). With time, canoes were also equipped with sails.

Fluvial transportation was not just appropriated by the colonialists but also allowed Indigenous persons to maintain a certain level of independence, as Heather Roller (2014) has argued recently. In the late seventeenth century, Indigenous were very mobile, sustained personal networks across space, and were able to decide whether to interact with the few Portuguese settlements and missions. They even changed the environment to their needs, “hav[ing] dug channels to create shortcuts to other rivers; drained swamps, and deepened, widened, and cleared brush from waterways.” (Roller 2014: 11)

The Portuguese used shipping to connect their scattered settlements and for trade. Apart from mercantilist activities promoted by Pombal, itinerant traders (*regatões*) started to connect several trading posts and were common figures until the nineteenth century (Goulart 1968). Many Portuguese merchants owned huge canoes for inland trade. In 1826, there were 1,034 such owners and 1,432 canoes in the Portuguese Amazon (Lopes 2013: 57, 63). This quantity points to the steady expansion of fluvial networks. From 1752 on, for instance, the Portuguese established shipping on the more distant Guaporé, Mamoré, and Madeira rivers to connect Mato Grosso with Belém. Upstream journeys were normally scheduled for high water season and downstream journeys for dry season (Melo 2022: 32, 152). While the Amazon was in large parts navigable, its tributaries often impeded the use of boats due to waterfalls and rapids that constituted a constant challenge for explorers and missionaries (Daniel 1976a[1741-1757]: 28–29; Cabral 2013: 24). The Madeira River was notorious for its rapids, and the production of useful knowledge to avoid being shipwrecked was an arduous task (Melo 2022: 158–163).

Spice Extraction

Indigenous canoes enabled a second anthropogenic interaction with the Amazon region: spice extraction. After the Portuguese learned that the Amazon biome was not suitable for the plantation system that they had installed on the Brazilian coast, they used Indigenous slave labor and knowledge to harvest spices, the so-called *drogas do sertão*. Spices like bark-clove (*cravo do Maranhão*) had to be found in the rainforest and brought back to Belém in time-consuming expeditions. Usually, Indigenous rowers and skilled pilots were needed for such an expedition, but in some instances, settlers would also embark to find spices. In addition, the Jesuits equipped such expeditions and forced missionized Indigenous communities to build canoes. Over decades, the Jesuits dominated the market for canoes. After their expulsion, Indigenous communities were allowed to organize spice expeditions by themselves. Approximately 25–50 rowers participated in a single tour and collected spices in the woods. Since an expedition lasted several months, it was a popular job because it provided relative personal freedom and good revenue (Chambouleyron 2014; Pompeu 2021; Chambouleyron 2022).

However, these expeditions had a direct impact on biodiversity. Many settlers and Indigenous collectors used to cut down the clove trees to get the bark more easily. Soon, the stock of clove trees declined, and possible harvest areas became more and more distant. In 1686, King Pedro II complained to the Governor of Grão-Pará about the excessive harvesting and warned against the extinction of the tree. A year later, the Governor banned tree cutting at the Capim River; but at the end of the seventeenth century, the tree had almost disappeared, and the trade declined significantly (Chamboureylon 2014: 14; Chambouleyron 2022: 340).

Fishing

Fishing was the most visible early anthropogenic impact on the Amazon region. Due to the lack of farming, the basic diet of both the Indigenous and the Portuguese populations relied on fish, turtles, and manatees. As Marlon Marcel Fiori and Christian Fausto Moraes dos Santos have highlighted, aquatic life and fishing methods varied greatly in the region, depending on different types of water, biomes, and available materials for fishing equipment (Fiori and dos Santos 2015). The use of metal utensils and the operation of royal fishing posts (*pesqueiros*) increased the repercussion of fishing in the seventeenth century. Not just fish such as the gigantic Pirarucu, but also turtles, turtle eggs, and manatees were frequently hunted, both for their protein and fat. The latter was processed into butter and oil to use in lamps and other technical equipment.

While early travelers listed different species of fish, turtles, and other aquatic life, they expressed their astonishment about the "abundance of fish" and excellent fishing opportunities, as well as describing Indigenous fishing methods (Acuña 2009[1641]: 81, see also 90–94; Daniel 1976a[1741-1757]: 85–109). Accounts from the eighteenth and early nineteenth centuries were more concerned about sustainability. Already in 1762, a friar informed the Governor about the turtle hunt and raised concerns about the extinction of the species (Pompeu 2021: 96).

An even more remarkable text in this regard is the conglomerate of reports written in the 1780s by Alexandre Rodrigues Ferreira, a traveler from Bahia, who studied the region on behalf of the Portuguese Crown. Rodrigues Ferreira collected knowledge of all possible kinds and even recommended the expansion of water infrastructure in big cities like Belém to improve the sanitarian situation and water-connected health issues (Pataca 2018: 98). Like other earlier explorers, Ferreira also drafted a catalog of aquatic species, including pictures, but then criticized excessive fishing, in particular of turtles. He provided lists of *pesqueiros* to show the quantity of captured and killed turtles. Near Barcelos in the Captaincy of Rio Negro, Ferreira counted 53,468 turtles for the years 1780 to 1785 that had been collected and held captive in corrals for further use. However, 17,461 of them had died without being processed. In sum, Ferreira lamented that

> [t]his amphibian that is so useful to the state has not yet received the care or measures that are required to avoid abuses against it. A turtle to reach its proper growth takes a few years. Annually, there are innumerable ones that are wasted at the absolute arbitrariness of the Indians; all the hatchlings are discovered, trampled underfoot, and most of the turtles are eaten unnecessarily, all of which together contributes to their rarity in the course of time. (1972[1786-1787])

In 1769, the Governor of the Captaincy of Rio Negro prohibited the turtle hunt in some areas, but when Ferreira visited the region, this regulation had been suspended (Ferreira 1972[1786-1787]: 41, see also 42).

According to Ferreira, another endangered animal was the manatee, or sea cow, which was excessively hunted, too. The Bahian criticized that even pregnant females were killed, a practice that resulted in “its rarity in some lakes where we do not find them for several years” (Ferreira 1972[1786-1787]: 62). Also, the European travelers Johann Baptist von Spix and Carl Friedrich Philipp von Martius commented on the rampant turtle hunt and were surprised that they encountered so many of these animals even though their eggs were so exaggeratedly collected. They predicted the turtle’s extinction but acknowledged efforts by the government to regulate turtle hunting (Spix and Martius 1966[1831]: 1142–1143).

First Scientific Expeditions

Ferreira, Spix, and Martius represented a new form of Amazonian traveler who emerged around 1800, the scientific explorer (Souza 1994: 76–90; Meirelles Filho 2009: 58–95). These men systematized knowledge about geology, biology, anthropology, and water resources, laying the foundation for the systematic exploitation of the region that started in the late nineteenth century or even later. They produced detailed maps that facilitated the expansion of steam navigation, further studied aquatic life, collected indigenous artifacts that showed human adaption to water landscapes, and hinted at possibilities for economic expansion. Thomaz de Souza, for instance, published a description of the unnavigable Itaboca Falls on the Tocantins River where almost two hundred years later Brazil would build the Tucuruí dam, aiming at enabling fluvial transportation, apart from hydroelectricity (Cabral 2013: 47). However, as the last subchapters indicated, some of the scientific travelers reflected on the impact of humans on water biomes and lamented environmental destruction.

The first scientifically interested travelers were the Frenchman Charles Marie de La Condamine and the Ecuadorian Vicente Maldonado who sailed down the Amazon in 1743 and 1744 on behalf of the Académie Royale des Sciences in Paris to sketch a map (La Condamine 1986[1778]). Between 1783 and 1792, Alexandre Rodrigues Ferreira undertook several voyages in the region, collected systematic data for the Portuguese Crown, and explored possible economic opportunities. He relied on Indigenous rowers during his trip and reported on the rapids that hindered the further advancement of European conquest. He also described Indigenous hunting techniques and the processing of turtles and turtle eggs by Indigenous groups (Carvalho Júnior 2011: 54–63).

One of the most famous travelers of his time was Alexander von Humboldt who only briefly visited the Amazon basin (Humboldt 1990[1859-1860]: 320–362; Pizarro 2012: 103–112; Ette 2019). Coming from the Orinoco River, he proved, together with his travel fellow Aimé Bonpland, that the Orinoco and the Rio Negro (and thus the Amazon) were connected by a river connection, the Casiquiare. He noticed, though, that the Spanish and the Portuguese both claimed parts of the Rio Negro which impeded the production of knowledge and maps. Also, frequent floods prevented further human activity in the region. Humboldt's account of the journey underscored the hardships of river transportation in the early nineteenth century. Having spent thirty-six days in small canoes, impeded by rapids and waterfalls, and struck by fever, Humboldt expressed ambivalence about human activities in the aquatic landscape of the Amazon. On the one hand, he stated that "looking at the vibrant nature, in which man is nothing, has something strange and depressing." (Humboldt 1990[1859-1860]: 338) On the other hand, he predicted excellent trading opportunities for European powers due to the connection of both river systems.

Spix and Martius explored the Amazon from 1819 to 1820. In their travel account, they offered not just a description of their journey, but also several detailed maps and systematical information about the Amazon, including its geography, hydrography, main tributaries, and water regime. They admitted that some information was difficult to obtain, due to the size of the river. In some places, the river was so wide, that common methods of measuring at that time could not be used to determine its width (Spix and Martius 1966[1831]: 1340–1375).

Conclusion

At the turn of the nineteenth century, the Portuguese and the Spanish had consolidated their colonial possessions in the Amazon region, even though their activities remained relatively limited. Rivers both facilitated and impeded further expansion, but most travelers and colonial actors continuously dreamt about future economic exploitation and produced knowledge that could be used for further action such as the expansion of agriculture. Apart from fluvial transportation, the only visible and impactful anthropogenic interaction with the region during colonial times was spice collecting, fishing, and hunting. While plants and fish seemed to be abundant during this era, contemporaries reflected on the decline of spice trees, turtles, and manatees. Officials even started to regulate harvesting and hunting but could not install an effective regime of control. As a result, the local extinction of clove trees, turtles, and sea cows originated in the seventeenth century, and in most areas, their stock could not recover from predatory human intervention. Whereas these effects were biological, humans could not yet alter the Amazon region geologically, albeit some Indigenous communities were building canals and drainage swamps. However, human presence in the region was not significant enough to cause greater damage to the biome as a whole.

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Water in Mesoamerica in the Colonial Period

Ecological Emergence and the Impact of Colonization (1492–1820)

Diana Birrichaga

In the Anthropocene, in which human influence has left an irreversible mark on the terrestrial landscape, it is essential to reflect on how Mesoamerican civilizations managed their water resources. The practices of these pre-Hispanic civilizations reflect a deep respect and understanding of water's importance.

Some researchers argue that 1610 may have marked the beginning of the Anthropocene due to a decrease in atmospheric carbon dioxide concentrations. This change is linked to the European colonization of Mesoamerica, which resulted in a drastic reduction of the Indigenous population due to disease and conflict. As a consequence, large areas of agricultural land were abandoned, facilitating the recovery of vegetation. This resulted in a decrease in CO_2 levels in the atmosphere, a phenomenon proposed as a possible indicator of the beginning of the Anthropocene owing to its clear presence in the geological record and its direct relationship to human activities. However, it should be noted that this proposal has been the subject of debate by other scholars (Trischler 2017).

This chapter proposes that the cultural concept of the Anthropocene can be established from the arrival of Europeans in Mesoamerica in 1520. The period of colonization until 1820 radically transformed both the Indigenous populations and the environment, significantly impacting the essential resource of water. This chapter contextualizes the ecological water crisis in Mesoamerica during European colonization, highlighting how this alteration transformed land use systems, exploited natural resources, and left a lasting imprint on water's existence and quality in the region. In addition, intrinsic links between colonial processes and the transformations in the society-nature relationship are explored (Castro 2021).

Colonization immediately transformed land use and the landscape. European agricultural techniques introduced export crops such as wheat and sugar cane, causing deforestation and transforming extensive forests into agricultural areas and pastures. In addition, the expansion of cattle ranching intensified these changes, directly affecting regional hydrological cycles. The reduction in the soil's capacity to retain water led to an increase in runoff and erosion, making rivers more susceptible to floods during the rainy season and to decreases in their levels during the dry season (Musset 1992: 58).

During colonization, mining, as a form of natural resource exploitation, exacerbated the water crisis in Mesoamerica. The search for precious minerals such as gold and silver led to the excavation of large-scale mines, directly impacting local aquatic ecosystems. The extraction of these materials required large quantities of water to wash and process the minerals, which depleted nearby water sources. In addition, toxic chemicals released into the surrounding rivers and streams contaminated the water supply and damaged aquatic life.

However, the pre-colonization relationship of Mesoamerican societies with their natural environment should not be idealized. It is clear that all human activities, including those of Mesoamerican societies, had environmental impacts. Although these impacts were minor compared to those caused by Spanish colonizers, they existed and should not be ignored. For example, the construction of *chinampas* (floating gardens where vegetables and flowers were grown) allowed the Indigenous people to develop intensive and highly productive agriculture. However, this practice also altered natural water bodies by transforming large lake areas into agricultural land. Similarly, dams and canals modified the natural flow of lakes and rivers, affecting aquatic and terrestrial ecosystems. Artificial river channels were also created (Musset 1992: 66). While these structures facilitated transportation and commerce, they also required constant maintenance to prevent floods.

However, these methods contrasted with the policies implemented by the Spanish, who opted for more drastic solutions such as draining lakes. The European invasion not only altered the environment but also transformed the relationship between society and nature in Mesoamerica. Land and water ownership systems were reconfigured with the arrival of the colonizers, resulting in the concentration of land and resources in the hands of European settlers and the dispossession of local Indigenous populations. This reorganization had profound implications for water access and distribution, as Indigenous populations lost control over water sources they had used for generations. In addition, colonization introduced new institutions and regulations that influenced water management and use in the region.

The Conquest and the Ecological Water Crisis

Before the conquest, various Indigenous groups such as the Mexica (central Mexico), Mixtec (Oaxaca, Mexico), Maya (southeastern Mexico, Guatemala, Belize, and parts of Honduras and El Salvador), Pipil (El Salvador), Lenca (Honduras), Nicarao (Nicaragua), Bribri (Costa Rica), and Cabecar (Costa Rica) had settlements with advanced hydraulic infrastructure. In Tenochtitlán (now Mexico City), the supply of water was crucial, with systems that included transport from sacred springs and a wooden aqueduct built between 1415 and 1427 by Chimalpopoca. The groups settled in Central America also developed small irrigation systems, using canals and *acequias* (irrigation ditches) to ensure water supply for crops such as cocoa. The Pipil, Lenca, and Nicarao implemented advanced irrigation techniques, directing water from rivers and springs to their corn and bean fields (Fowler 1989). The Bribri and Cabecar also developed irrigation systems adapted to their geographical conditions, integrating water management into their social and cultural organization and building small dams and canals for agricultural use (Bozzoli 1986).

In Tenochtitlán, however, a major human intervention occurred regarding water. In this city, water had a wide range of uses, with irrigation standing out as one of its most important applications, with use in buildings and green areas, as well as a botanical garden. In households, water played an essential role in domestic chores, human consumption, cooking, and personal hygiene (Rojas 2009). People of higher economic status received water directly to their homes through an underground distribution system that could even supply swimming pools and gardens in the central courtyards of their residences (Jiménez and Birrichaga 2012). The inhabitants of this region had developed various engineering works, such as *chinampas*, irrigation canals, *diques-calzadas* (diked canals), piers, aqueducts, and *acequias*, to manage and control the lakes. Since they experienced constant changes between wet and dry seasons, the population was forced to create ingenious techniques to adapt to and master this particular natural environment (Rojas 2009). To bring water from its source, they built aqueducts of impressive scale that tapped into springs, running along high walls made of mortar that stretched from one mountain range to the next. Canals were built in these walls to channel the water. The construction of these hydraulic works was based on the use of materials such as stone and sand mixed with grass, sod, and silt. In addition, they were lined with lime or even *tezontle* (very light porous volcanic stone), and the water conduits, known as *canoas*, were mainly made of wood.

Other communities, such as the Mixtecs who inhabited the Pacific coast, had developed a technological model that responded to the ecological changes caused by the implementation of various agricultural techniques and methods, including the construction of works to regulate river systems (Fernández, Endfield, and O'Hara 2009). Based on archaeological evidence, Indigenous historical records, conquistador chronicles, and official documents, it can be affirmed that the Indigenous communities of Mesoamerica actively took advantage of the available water resources. This chapter will discuss these aspects in more detail below.

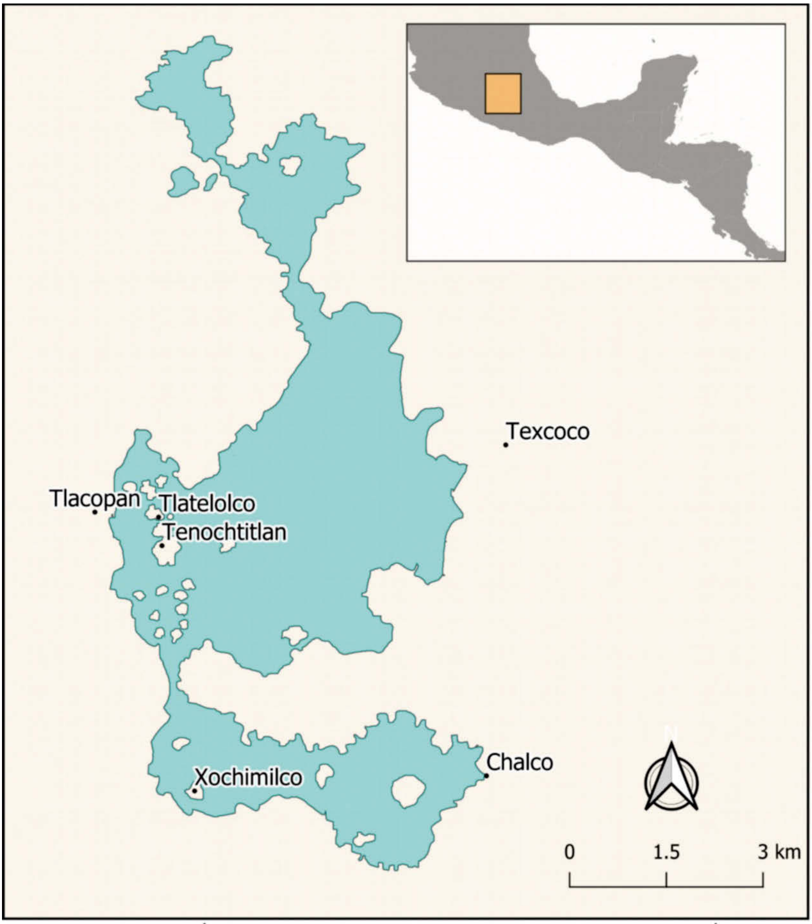
The military conquest of Mesoamerica marked a clash between two worlds with radically different social, technological, and economic perspectives on water. The conquistadors destroyed hydraulic systems as a military tactic to force the Indigenous to surrender. In 1520, Hernán Cortés, with a contingent of 800 soldiers, ordered the destruction of the aqueducts that supplied the city of Tenochtitlan (Jiménez and Birrichaga 2012).

There was interest in identifying vulnerabilities, as controlling water was necessary for the success of the conquest. Several conquistadors provided information on the functioning of the Indigenous hydraulic systems. Hernán Cortés mentioned the existence of advanced irrigation systems in the territories between the coast and the Mexica capital; he pointed out that all these territories were irrigated by carefully planned and well-maintained canal systems (Cortés 1985). An archaeological study classified the crops cultivated through irrigation or in the humid, warmer regions of Mesoamerica, identifying crops such as maize, chili, cotton, chia, and squash (Armillas 1984). However, as will be explained below, the arrival of the Spanish brought changes to the agricultural landscape as they introduced new crops, such as wheat and sugarcane.

After the defeat of the Mexica, the Spanish proceeded to restore the aqueducts using European methods. This hydraulic system consisted of three main elements: the aqueducts that transported the water from the springs, the "*cajas de agua*" in charge of distributing the water to the pipes, and the final phase that allowed the supply of water to public fountains and some markets. The Indians quickly acquired technical skills from the Spaniards to build this linear system, which involved detailed considerations of the topography of the terrain and the capacity of the conduits (Celestino, Valencia, and Medina 1985: 291–292). Meanwhile, the Spanish developed water channeling methods adapted to the characteristics of the terrain, which played a fundamental role in the design and development of these hydraulic systems. Also of note was the maintenance of the pre-Hispanic irrigation system, which was based on an efficient network of canals that were vital for the Spanish farmers. This system underwent renovation and expansion, and innovations such as *cajas repartidoras* installed in the *acequias* were introduced to improve water distribution (Gibson 1991).

Once the city of Tenochtitlán and its vassal towns had been conquered (Map 1), the military conquest of other territories began in order to establish Spanish cities. The colonizers needed to identify the operation of the hydraulic systems of the subjugated peoples. Thus, they found that Indigenous groups in Central America, particularly the Pipil-Nicarao, had hydraulic systems – albeit on a smaller scale than those of the Mexica – to ensure constant water supply to their crops, especially cacao, an agricultural product of great economic and cultural importance. Similarly, the Lenca developed irrigation techniques to maximize water use in agriculture. They used irrigation canals to direct water from rivers and springs to their fields, allowing for more efficient cultivation of corn, beans, and other agricultural products (Fowler 1989).

Map 1: Map of Vassal Towns of Tenochtitlan (Texcoco, Chalco, Xochimilco, Tlacopan, and Tlatelolco)



Source: Author's Elaboration

After the conquest, the Central American Indians were grouped into several provinces and governorships, which formed part of the Captaincy General of Guatemala and the jurisdiction of the Viceroyalty of New Spain. Unlike Tenochtitlan, the conquistadors showed little interest in dominating the lands discovered in Central America. The main reasons were the complex topography that included mountains, jungles, and rivers (Musset 1997), as well as the dispersed presence of numerous communities. These geographical conditions and the lack of a unified political system made effective control and unified administration of these territories difficult. The Spaniards who arrived there adapted the small water management systems for agricultural productivity and the sustainability of their settlements. The relationship with the environment in Central America was characterized by a more harmonious integration, respecting the pre-existing ecosystems to a certain extent.

On the other hand, in New Spain, the exploitation of natural resources was much more intensive. Water availability was a crucial factor for the Spanish colonists when choosing locations to establish their settlements in the newly conquered territory. Another was the native technological innovations for the control of this element. This was because water was an essential resource for carrying out various economic activities, such as agriculture, mining, and tanning, in addition to meeting basic domestic consumption needs.

These differential dynamics between Central America and New Spain illustrate how geographic conditions and resource availability influenced the intensity of human intervention in the environment. While Central America maintained a less aggressive relationship with nature, in New Spain, intensive exploitation and radical transformation of the environment reflect an early stage of the practices that today characterize the Anthropocene.

Initially, the Spanish recognized the water rights of the Indigenous peoples, but over time, this perspective changed as the monarch began to consider himself the owner of the resource. Through "*mercedes*" (grants) or privileges, certain families obtained control of the water of the old towns. In other words, the Spanish adopted Castilian legislation, which divided water into two categories: public and private. This change in water distribution led to the commercialization of a communal resource and generated new social problems related to its access (Birrichaga 2004). The transition in water property rights in New Spain from an Indigenous communal system to one controlled by the state and Spanish colonists exemplifies the challenges of the Anthropocene. This process not only affected water availability and management but also reflected a broader trend toward intensive exploitation and commercialization of natural resources.

Beginning in 1524, Spanish settlers began to appropriate land and water resources in the central highlands of Mexico. Initially, they mainly sought water concessions to build mills since wheat production was essential in the region (Margadant 1989). For those acquiring land, having an adequate water supply was essential, whether for agriculture or livestock. Wheat cultivation required fertile land near rivers or with efficient irrigation systems, as in Puebla. In addition, the growth of sugar production in the Cuernavaca-Cuautla Valley motivated the Spaniards to control and monopolize water resources. Spanish settlements were established near watercourses and also made use of pre-Hispanic hydraulic works (Wobeser 1981).

During the first decades of Spanish rule in New Spain, wheat production was promoted through the imposition of taxes based on this crop, which led the Indigenous population to dedicate themselves to its cultivation more intensely. This situation resulted in an increase in areas devoted to wheat cultivation and a reduction in the prices of both wheat and bread between 1529 and 1542. However, in a later period, between 1550 and 1555, there was a shortage of grain related to the decrease in the Indigenous population and the increase in the Spanish population, as well as the growing demand in the cities and mining communities for the product (Camacho Pichardo 1998).

In this context, wheat cultivation was established in the most fertile lands of the region, and corn was displaced. The introduction of this cereal boosted the expansion of Spanish-held property in the Puebla-Tlaxcala area (Mexico), particularly in the Atlixco Valley. During the second half of the sixteenth century, wheat-producing regions emerged, such as the aforementioned Puebla-Tlaxcala Valley, the Valley of Mexico, and, to a lesser extent, the Toluca Valley. Among these areas, the Valley of Tlaxcala and Puebla, which included the Valley of Atlixco, stood out as the main wheat producer. In addition, in the second half of the seventeenth century, the Puebla region was home to the largest number of mills dedicated to wheat processing in all of New Spain (Gibson 1991).

The introduction of sugarcane cultivation, a tropical plant that requires an average temperature of approximately 25 degrees Celsius for optimal growth, had a substantial impact on water use patterns. The need to irrigate sugarcane is mainly due to its root structure, which has a limited capacity to seek water at depth, leading to a strong dependence on surface water supply. The introduction of this crop led to the substitution of cotton planting, which, in turn, resulted in the degradation of the *apantles*, irrigation canals previously built by Indigenous communities for the native cotton crop. Towards the end of the sixteenth century, the landscape in the *tierra caliente* (hot land) regions was dominated by sugar and wheat production. It is essential to highlight the disparity in water requirements between wheat and sugarcane. While sugarcane cultivation required the irrigation of four *surcos* (See Table 1) for each *caballería* (a Spanish colonial agrarian measure whose extension varied according to the country), corn required two or three *surcos* (Camacho Pichardo 1998). In other words, sugarcane production requires more water than other crops.

For its part, the mining industry posed significant environmental challenges related to mine water management, and the solutions adopted had different implications in terms of environmental impact. Natural factors such as geographic location, depth of excavations, soil composition, and climatic conditions contributed to this environmental problem. In smaller-scale mines, miners used cowhides or metal containers to dispose of water, which had a limited impact on the environment. However, larger mines adopted European technology, such as inclined pits for drainage and *malacates* (a winch to move or lift objects). This drainage technique, although efficient, was costly and demanded considerable infrastructure that negatively affected the local environment, mainly due to land disturbance and pollution resulting from the construction and operation of these facilities (Trabulse 1980). Around 1575, the first report of the use of a hydraulic pump for drainage was recorded, and after this fact, numerous *mercedes* were given for mine drainage devices. Complaints about contamination from mine waste were brought to the New Spanish courts, but requests not to damage Indigenous lands and forests went unheeded (Guardián 1982).

In the context of the Anthropocene, the Spanish implemented an innovative water measurement system to exert more effective control over this resource to benefit their productive activities, which included agriculture and mining. In colonial times, water measurement involved a combination of Indigenous and Spanish measurement systems. The Indigenous communities used human references to measure, referencing body parts such as the leg or finger as one-dimensional units of measurement. When larger quantities needed to be measured, the expression "*tamaño de buey*" (size of an ox) was used. Although this method was practical in allowing each individual to have their own reference for these measurements, it lacked standardized units. Thus, the Spaniards measured water in terms of its practical applications, such as the amount needed to operate a mill or use it in milling processes. Over time, more precise measurements were developed that were understandable to all. In the sixteenth century, a two-dimensional measurement system was introduced, where the unit of water measurement called *buey* was equivalent to the amount of water flowing in a rectangular surface of 0.702 square meters or in a circular surface with a diameter of one *vara* (rod). In order to standardize these measurements, in 1567, Gaston de Peralta created a system in which each unit was equivalent to 0.038 square meters. The new measures often eliminated the Indigenous expressions that referred to water since pre-Hispanic times. This system was still in use during the twentieth century (Birrichaga 2004).

Table 1: Hydraulic Measurements Used During Colonial Times

1 buey	= 48 surcos = 144 naranjas
1 surco	= 3 naranjas = 24 reales
1 naranja	= 8 reales = 8 limones
1 naranja	= 2 dedos = 144 pajas
1 limón real o 1 limón	= 18 pajas

Source: Jiménez and Birrichaga (2012: 529).

In this early Anthropocene, the Spanish also took advantage of water as a source of energy. The presence of permanent water currents was fundamental in facilitating the construction of numerous "*ingenios hidráulicos*" (hydraulic mill complexes) throughout the Novohispanic region. The control of hydraulic power allowed the milling of wheat and, in some cases, the extraction of minerals using water wheels. These mills were capable of grinding up to 150 kilograms of wheat per hour, in contrast to the approximately seven kilograms of grain that two enslaved persons could grind using a treadmill (Gimpel 1981: 14). The adaptation of European watermill technology played a central role in the economic development of the Novo-Hispanic society, as it transformed the use of water into a source of energy capable of modifying the pre-Hispanic landscape. In later decades, both Spaniards and Indians began to request rights to use the river currents for the purpose of installing hydraulic *ingenios* and fulling mills. Hernán Cortés was one of the first to request permits to establish these *ingenios*, which were mainly for sugarcane processing and the emerging textile industry. An example of this is the Tlaltenango sugar mill, where a "grinding fulling mill and battery current" was built (Birrichaga 2004).

The rush to build watermills in New Spain was due, in part, to financial reasons. The investment in the construction of a mill promised significant short-term returns, especially since these mills could operate continuously throughout the year. In 1528, a concession was granted to Nuño de Guzmán to establish water wheels on the Tacubaya River. In subsequent years, more permits were granted for the installation of wheat mills (Garcia Acosta 1989: 50). It was common to grant permits to the *encomenderos* so that they could build mills on the lands near their property, taking advantage of suitable rivers and springs available in the area.

This transformation had a direct impact on regional hydrological cycles. Deforestation decreases the capacity of soils to retain water, increasing runoff and erosion. As a result, rivers were more prone to flooding during the rainy season and diminished flows during the dry season. The Spanish conquest can be seen as a precursor to the Anthropocene, as it was a period when human activities significantly modified the environment and altered local ecosystems. These changes had a profound impact on regional history and the interaction between humans and their environment. The conquest unleashed a socioecological crisis, reflecting a palpable manifestation of a civilizational crisis caused by the destructive interaction between European societies and native peoples. This crisis was characterized by overexploitation of resources, loss of biodiversity, pollution, and climate change – all attributable to human dynamics, especially those driven by the colonialist economic model that focused on growth and capital accumulation (Svampa 2019).

Water, Culture, and Cosmovision

The European colonists arrived in the newly conquered territory with the intention of imposing their ideas of water management but encountered a local culture that had already established its own effective management of the resource. This encounter gave rise to an exchange of practices and uses of water between Western and pre-Hispanic cultures. Although the Spaniards adopted some of the pre-Hispanic hydraulic systems, they made their own adaptations to meet new economic needs that required a more constant and efficient water supply. These adaptations ranged from diverting rivers to digging irrigation canals, as well as constructing new hydraulic infrastructures to meet those economic needs. These interventions had a profound impact on the availability and distribution of water in the colonized regions, which greatly affected the Indigenous populations that depended on access to water for their subsistence.

The existence of water was a fundamental requirement for the Spaniards when selecting a place to establish a settlement, as it was essential for economic activities, such as agriculture, mining, and tanning, and satisfying domestic consumption. All these activities depended to a large extent on access to an adequate water source, which made regulating its use one of the conquistadors' main concerns. In his second *carta-relación* (communication between Cortes and Carlos V), Hernán Cortés referred to the advanced hydraulic technologies of the pre-Hispanic peoples in central Mexico, highlighting the existence of "wells and pools of water" in the residences of the Indigenous rulers (Cortés 1985: 65). His perspective was influenced by his experience in hydraulic technology in the Iberian Peninsula, where significant advances in irrigation and water supply systems for populations and industries had been achieved between the eleventh and fifteenth centuries thanks to the contributions of the Caliphate of Córdoba, who introduced concepts such as the *acequia*, the *aljibe* (a type of cistern), the *azud, azuda*, and *noria* (various forms of waterwheels), and the *arcaduz* (water pipe). (Rojas 2009). The Iberian worldview was the opposite of that of the Indigenous people. For example, the Maya had a more magical and mythological perspective of water, related to the creation of the world and its ordering (Sotelo 1988). According to the *Popol Vuh* ("Book of the Council"), the world was created through the magical power of the word at a time when only sky and water existed. The land emerged as the waters withdrew, and geographical features such as streams, mountains, and valleys appeared.

One of the most significant changes introduced by Spanish technology in central Mexico was the creation of hydraulic infrastructures designed to divert rivers and drain lakes, with the purpose of turning Tenochtitlan into a city "on dry land." The new inhabitants did not wish to reside in a city surrounded by water. In other words, unlike the pre-Hispanic perspective that considered the valley's lakes as an invaluable economic source for the subsistence of the population, the Spaniards saw water as an obstacle to the urban development of Mexico City. The Spanish vision of turning the capital of the kingdom into a city on the mainland quickly materialized. According to Thomas Gage, the Spaniards "filled and drained" the water canals of the ancient city and built numerous mansions in their place (cited in Birrichaga 2004: 97).

In addition, the Spaniards discovered that some pre-Hispanic peoples had replaced slash-and-burn agriculture with artificial irrigation systems, using canals and irrigated terraces. To retain surface water, they promoted a pre-Hispanic technique called "*amanalli*," meaning "still water." This term referred to lagoons or ponds where rainwater could accumulate. The Spanish adopted and adapted these hydraulic techniques, which led to a rapid transformation of the landscape. Water sources were diverted to create irrigation systems. An example of this is an agreement signed in 1596 by the governor of Ixtlahuaca and local farmers to create a lagoon using spring water.

During the early years of the conquest, the term *amanalli* was replaced by *jagüey*, although it retained the same meaning for both Spaniards and Indigenous people. *Jagüey* was also used to describe cisterns or *aljibe*s. The term was derived from the Taino language of Santo Domingo. According to the chronicle of Ciudad Real, the use of *jagüeyes* was widespread in central Mexico. These reservoirs were used to retain rainwater and facilitate the irrigation of agricultural fields. In addition, in central Mexico, the Indigenous people used *aljibes* and cisterns to collect rainwater for their consumption. The 1581 geographical account of the town of Quauhquilpan describes the *jagüeyes* as ponds where rainwater accumulated in low, flat areas of the town (Birrichaga 2004; Rojas 2009).

Significant changes in water management were evidenced in places as far away as Oaxaca and Guatemala. Spanish colonists progressively took control of the primary water sources, using this resource for activities that included the operation of mills, the production of wheat and sugarcane, and the watering of livestock. This dominion over the resource also had an impact on the allocation of land through the "*mercedes*," which not only gave rights to land but also to water (Webre 1990; Fernández, Endfiel and O'Hara 2009).

This transformation in the way water is used had a significant impact on the traditional norms of water ownership and use of Indigenous communities. Initially, the Indigenous *caciques* presented *títulos primordiales*, documents that granted them ownership over and the right to sell lands and waters. However, over time, the allocation of water rights began to affect its ownership, gradually replacing pre-Hispanic principles of water control with Spanish approaches.

In the seventeenth century, a distinctive feature of the Anthropocene in Mesoamerica was the reconfiguration of the environment to adapt to new needs, marking profound changes in the management of water. In this period, human intervention began to have a noticeable impact on nature. The Spaniards prioritized the stability of the water supply for their economic activities, while for the Indigenous communities, their access to water was vital for survival and the maintenance of their agricultural methods. This divergence in perceptions and practices surrounding water became a fundamental cause for conflict during the colonial era.

During the colonial period, changes in water and land management had significant impacts on Indigenous communities. Although these communities retained much of their land, they lost control over the most fertile areas suitable for agriculture. In Oaxaca, the introduction of cultivars that did not require irrigation, such as cochineal for red dye, channeled the Indigenous labor force into activities that did not create disputes over water with the colonizers. This forced Indigenous communities to adapt their economic and labor practices to tasks that were less dependent on scarce water resources, such as cultivating species that required little water or engaging in non-agricultural trades, such as handicrafts.

Taken together, these transformations meant that Indigenous communities were obligated to adapt to new circumstances imposed by the colonizers and their demands for access to water for agriculture. The loss of access to more fertile lands and the change in economic activities had a significant impact on the lives and livelihoods of these Indigenous communities in the Valley of Oaxaca during the colonial period (Fernandez, Endfiel, and O'Hara 2009).

In this context, water regulation and distribution became critical issues. These measures reflected the growing interaction between society, represented by the Spanish Crown and the colonizers, and nature, which included the river and aquifer systems. Water control became a critical issue during the colonial period, and the Spanish Crown's issuance of ordinances and regulations evidenced its attempt to control and regulate the use of this vital resource. However, these regulations often generated disputes, as the interests of the colonizers conflicted with the rights and needs of the local Indigenous communities.

In this sense, the presence of conflicts between different groups highlights the critical issue of access to and control of water, demonstrating how water resources became a central issue and a constant source of disputes during the colonial era. To address these conflicts, legal frameworks and water distribution systems were implemented, illustrating how society was adapting to and managing changes in its environment. These developments are characteristic of the Anthropocene, a period in which humans play a major role in altering natural systems.

Tactics and Strategies of Confrontation

Mining and agriculture emerged as two of the most significant economic activities in altering water management during the colonial era. In the case of mining, substantial volumes of water were required for the extraction and processing of minerals, which led to the construction of hydraulic infrastructures such as dams and canals. These structures disturbed the natural flow patterns of the rivers and had a significant impact on the availability of water for local communities. In terms of agriculture, the colonizers introduced European crops that required different irrigation methods than those used by the Indigenous populations. This often involved the reduction of water sources and the transformation of pre-Columbian irrigation systems, which could result in the overexploitation of water resources and soil degradation.

These changes in water management have had significant environmental consequences, including the alteration of both aquatic and terrestrial ecosystems. They also influenced the cultural and economic practices of the Indigenous populations. These communities witnessed how their way of life, rooted in a balance with nature, was displaced by intensive exploitation models.

Studies by Wobeser (1981), Lipsett (1987), and Camacho Pichardo (1998) have addressed the issue of water conflicts. The aforementioned authors agree that the clashes over the resource intensified notably during the last decades of the seventeenth and throughout the eighteenth centuries. This significant increase in conflicts can be attributed to two main causes. First, the increase in the Indigenous population in the region played a crucial role in this dynamic. Secondly, land appropriation by Spanish *hacendados* became a determining factor that generated intense competition for water resources, given that the available water sources were not sufficient to meet the growing irrigation needs of their crops (Camacho Pichardo 2010).

In the first decade of the seventeenth century, controversies arose between the Indians and the Spaniards regarding the use of water resources. The conflicts originated from poorly defined policies and practices regarding the allocation of water rights during the first decades of the colonial period. Due to the lack of a precise specification of the amount of water that both the Spaniards and the Indigenous communities were allowed to receive, misappropriations occurred, generating tensions among the beneficiaries. This situation culminated in clashes, such as that which occurred in 1605 between the Spaniards and the community of Huiluco over the use of the waters for an irrigation ditch. The natives argued that they had been using these waters since before the arrival of the Spaniards and even had the viceroyalty's authorization for its use. In response to these conflicts, the authorities dictated that the inhabitants of the towns share access to water with the Spaniards (Camacho Pichardo 1998).

During this period, there was a significant change in the perception of water, which came to be seen as a marketable resource. In *repartimientos*, a rule was established that each Spanish beneficiary had to make a payment to the Spanish Crown in exchange for water access rights. This process was conceived as an effective mechanism to grant property titles, since it could be interpreted as a purchase and sale agreement. Consequently, the Crown handed over the right to and ownership of the water in exchange for the corresponding payment, which led the Spaniards to begin to perceive themselves as owners of the resource, often ignoring property titles held by Indigenous peoples. On numerous occasions, legal disputes arose between landowners and Indigenous communities over water access rights. In most cases, the resolution of these disputes was characterized by prevalent violence.

The Indigenous people often complained about the inadequate distribution of water to irrigate their fields. They argued that numerous haciendas dedicated to wheat and sugarcane cultivation had been established in many valleys, as well as *ingenios* and mills. Therefore, they argued that they could not adequately cultivate their plots of corn, cotton, garbanzos, peas, and other seeds, causing them a variety of difficulties and losses. In the seventeenth century, in the midst of water-related conflicts, priority was given to the needs of the *hacendados*, dismissing the claims of the Indigenous communities and their legitimate right to use water resources. There was a clear interest in emphasizing the supposed inability of the Indigenous people to manage their own resources, which resulted in most of the water allocations being oriented mainly for the benefit of the *hacendados*.

In addition, it is essential to consider how other factors, such as the presence of livestock, deforestation, and extensive plowing, contributed significantly to soil erosion and reduced water availability. These elements further aggravated the competition for water resources, as they reduced the soil's capacity to retain water and, at the same time, increased the demand for irrigation. This complex interplay of factors made water management and access to water key issues in this historic region.

Disputes and tensions between the Spanish and Indigenous communities over access to water reflected the growing interaction between diverse human groups and their natural environment – a characteristic aspect of the Anthropocene. In the eighteenth century, infrastructure projects such as dams, canals, and reservoirs and the diversion of key rivers for agricultural irrigation and urban supply were already visible in the landscape. However, in drought-prone regions, water scarcity and conflicts related to access became common. Although some communities collaborated in the creation of water distribution systems to cope with shortages during times of drought or late rains, competition for the resource and legal disagreements over rights and access were frequent, often exacerbated by human intervention in water management and inequalities in its distribution (Endfield, Fernandez and O'Hara 2004).

In this context, it is evident that humans have had a significant impact on nature and local water systems. The prioritization of the *hacendados*' needs over those of the Indigenous communities can also be interpreted as an example of how colonial society was adapting to and managing changes in its environment during the Anthropocene.

Final Discussion

The study of water management in Mesoamerica, contextualized within the framework of the Anthropocene, reveals how human intervention has left an indelible mark on the environment and social structures of the region. Water resource management practices by Mesoamerican civilizations, although sophisticated and adapted to their environments, were radically altered by the arrival of European colonizers. This chapter revealed that intervention had a greater impact in New Spain, while in Central America, the impact was limited to the use of Indigenous hydraulic systems without altering nature to a large extent.

But in central and northern Mexico, the introduction of new agricultural practices, the intensive exploitation of natural resources and the reconfiguration of land and water ownership systems marked the beginning of an ecological and social crisis. Deforestation, mining, and the implementation of European hydraulic infrastructure not only changed the landscape but also profoundly affected hydrological cycles and water availability in the region.

Thus, it can be affirmed that the Anthropocene, triggered by European colonization, represents an era of profound ecological and social alterations. This period not only transformed natural systems and the availability of water resources but also redefined human interactions with the environment, leaving a lasting legacy that continues to influence water management and distribution in the region today.

Finally, recognizing the role of the Anthropocene as an era of significant human intervention in nature forces us to reflect on our current actions and responsibilities. The legacy of colonization in Mesoamerica reminds us that our decisions and policies must be informed by a deep understanding of history and a long-term vision prioritizing sustainability and social justice. Therefore, it is crucial to consider this historical background if we are to develop water resource management strategies that are sustainable and equitable in the contemporary context.

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Water in the Caribbean in the Colonial Period

Caribbean Waterways and Colonial Regimes in the Anthropocene

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Colonizing new lands was rarely abrupt. The expropriation of Indigenous lands by European empires was often preceded by moments of evaluation of the natural world. In the early colonial period, land and its affordances were a means to expand trade opportunities and strengthen one's political position. Water, along with what it allowed colonizers to achieve within a landscape, was often viewed through registers of private property and management. The process of land transformation necessitated the invention of a value system that became more entrenched as the plantation economy developed. Accounts of land transformation on various Caribbean islands are a reminder that this way of viewing the landscape resulted in patterns that elevated a combination of features such as access to water sources, flat cultivable land, and ease of transport to ports and urban markets. In this way, land transformation under colonial rule was always hierarchical, with water access and the technologies needed to control its use as one of the ways that, even among the white planter class, differences were instituted.

One of the features of the Anthropocene is the way its impact is felt unequally in a global sense. As other scholars have argued, one could trace this pattern historically to the colonial era and the expansion of European influence in the Atlantic World. In the present, water crises stemming from its privatization are only possible because the working class has historically been excluded from the infrastructure that disseminates this resource, such as cisterns and wells. Under slavery and colonialism, water quality and ease of access varied and highlighted differences that mapped onto colonial hierarchies. One way of apprehending these differences involves calculating distances from freshwater sources. Another way is to explore how the enslaved and later free people were able to store water for everyday use. Archaeological explorations of everyday life reveal that water access and storage were a central concern for the enslaved and later free people. The differences between enslavers and the enslaved that emerge show how people struggled and adapted to constantly changing conditions surrounding water, but working-class efforts were more time-consuming and only one element in wider dehumanizing practices. Within enslaved domestic spaces, it meant repurposing wine and beer bottles or utilizing yard space to ensure water catchment during rain spells. Materially, there is a convincing body of evidence that shows that the laboring classes, especially in rural plantation settings, have a highly developed set of practices around water that is characterized not only by insecurity but also by a material exclusion from systems meant to ensure water access during periods of crisis or disruption. What has been recast as resilient practices in the present were borne out of the social inequalities typical of plantation societies in the past.

This chapter puts into conversation the work of scholars who question the premises of capitalism and its workings in the environment, historians concerned with the role of slavery and governance in colonial settings, and archaeologists engaged with spatial relationships inscribed into plantation economies. While contributing to a long-term conversation in which Caribbean scholars have centered these ecological relations in the making of social lives, it is the watery conditions of intense social inequality that show how environmental data can contribute to broader conversations about nature, culture, and place (Fanon 1963; McKittrick 2013; Wynter 1971). Caribbean historiography of the eighteenth century is useful when framed as a discourse between two priorities (DeLoughrey 2011; McKittrick 2013). One priority, that of the plantation fields, was framed in the idiom of property and improvement. Colonization was a process of alienation where humans were transformed into labor "and nature to land." Here, the enslaved were dually alienated. The process of colonization was a physical alienation by which people racialized as Black were held captive in the Americas. It was also a political alienation of the relationship between those people and the earth, which reshaped the social fields in which they operated. A second priority frames Caribbean history through idioms of reunion and cultivation. Within provision grounds, Africans reunited with the earth through growing food. In so doing, they cultivated relationships on "the plot of folk culture," which became another basis of social order (Wynter 1971: 99).

Rather than focusing on different island nations (Barbados, Cuba, or Haiti) or colonial regimes (French, Spanish, English, Danish, or Dutch), this chapter will be organized around the varied geographies of the insular Caribbean. As an assemblage of land masses with an equivalent area of the United Kingdom spread over an area approximately the size of Western Europe, the region contains enormous physical and cultural diversity in water availability and resources. Additionally, while the channels between islands have historically been used to define political boundaries between nations and imperial regimes, in the course of everyday practice, such channels are better viewed as conduits of ideas, things, and practices. That being said, the region can be usefully divided into four geographic regions: The Greater Antilles, including Cuba, Jamaica, Hispaniola, and Puerto Rio; The Eastern Caribbean; The Bahamas; and the Southern Caribbean. Importantly, each of these regions is a multilinguistic space in which a combination of historical and geographic features creates a set of affordances that shape engagements with water.

Fluid Sources

Scholars examining the question of changing environmental engagements with water in colonial societies rely on a variety of sources that are not necessarily about water itself. As anthropologist Andrea Ballestero (2019) notes, "water's significance for the sustenance of life makes its symbolic meaning multiple," and these meanings emerge out of interactions with human and non-human actors (20). A review of the literature reveals that water concerns are often not about water itself, but about how water allows for the reproduction of life and the political systems that define legitimate forms of it. The work of the scholar is to trace the role of water in the transformation of land and people into "the colonized." This scholarly tracing unveils changing attitudes towards water as a resource that fully characterizes what has come to be called the Anthropocene. If this new geological epoch is characterized by an unpredictable yet complete dependence on water, then the early colonial period illuminates the attitudes, preoccupations, and predicaments that shape present vulnerabilities. The sources that allow scholars to trace the role of water in both sustaining and ordering colonial societies are varied and require an interrogatory comportment that goes beyond simply chronicling water access and use, to showing how power was wielded through water.

Water access has long been a site of power struggles, especially in the colonial period. Morgan et al. (2022) in *An Environmental History of the Caribbean*, for example, narrate almost two centuries of environmental transformation as the outcome of changing economic structures and power relations. In their account, the environment and the waters that flow through it constantly change meaning. The authors show how the biophysical transformation of the Caribbean happened alongside empire-making in the early Atlantic. They also show that the business of empire-making was neither uniform nor careful, but at the core, at least partially about how to shape environments. In the book, German naturalist Alexander von Humboldt appears frequently as an observer, a conservator, and part oracle. Von Humboldt makes no specific mention of water, its quality, or how to hoard it, but the excerpts of his descriptions that the authors use speak to the potential for its management and containment. For either of those things to happen, those in power had to have assumed the right to define both legitimate and dangerous waters.

One critical source for understanding water during the Anthropocene is archaeology. For the most part, archaeologists focus on water as a medium through which to explore politics, ritual, land use, settlement patterns, and responses to and possible origins of change. These studies can be usefully summarized into three common themes. Water is a medium through which to explore human-environment interactions. The changes in patterns of precipitation, sea levels, and rivers create contexts through which to explore human settlement patterns, adaptation, and sustainability (Cooper and Peros 2010). Water is an element of the landscape that becomes overtly subject to human manipulation. Landscape features, infrastructures, and terrain modification are venues to explore food production, social lives, and the polities that employ them. Water is a tool of "management" linked to nation-states and a consolidation of power. Implicated in these very issues are the roles of infrastructure, the making of surplus, or modes of agricultural production (Wells et al. 2017). Since Wittfogel (1957), water "management" has long been a concern of archaeologists studying the flow of power. Commonly, archaeologists employing water tend to focus on regional landscapes – both in their interpretive goals and their scale of analysis. The tendency towards a regional analysis of water is unfortunate because it fails to take advantage of water's most important qualities – its immediacy in everyday life.

Landscape Transformations

Of the many epochs identified by Earth scientists, only one takes its name from a particular agent behind its cause. This is the Anthropocene, a coagulate of effects located in the twentieth century with far-reaching implications for the Caribbean that originate between the sixteenth and nineteenth centuries. Unlike more broadly based epochs typical of Earth histories (e.g., the Holocene or the Pleistocene), during which humans migrated to and developed a range of social forms, economies, and environmental engagements in the Americas, the Anthropocene points to the transformative power of a single species, resulting in what some soil scientists and archaeologists have identified as an *event*. An Anthropocene event would 1) cover a heterogenous array of cultural and environmental processes contributing to climate change; 2) allow for stratigraphic recognition of seemingly abrupt changes in the presence and density of synthetic materials, elements, and isotopes (sometimes called the Archaeosphere); and 3) acknowledge a "pre-history" to such interfaces that need to be studied through a variety of disciplinary practices (Bauer and Bhan 2018; Edgeworth 2018; Gibbard et al. 2022). At the same time, others have acknowledged that terms such as the Anthropocene lend themselves to an uneven framing of modernity, and have instead opted for terms such as Plantationocene, Capitalocene, and/or Cthulhucene to describe a very real spatial and temporal heterogeneity in terms of the Anthropocene's origins and impacts (Haraway 2015; Moore 2017; Wolford 2021). In the case of the Caribbean, the heterogeneous environmental and cultural processes surrounding water can be traced to the colonial period, where a suite of agrarian and governmental technologies fundamentally transformed human relationships with water (Hauser 2021).

Most would acknowledge that the Anthropocene did not begin in the twentieth century, nor are its roots always evident in the facts presented in the archives. Michel-Rolph Trouillot (2002) famously noted that even though today's global flows have a genealogy that can be traced back to the fifteenth century, one of modernity's conceits has been an elaboration of its exceptionality through a silencing of the past. To fully understand the landscape transformations that have occurred in the Caribbean, one must begin with the environmental affordances of the land and how those who first arrived in the Caribbean operated within them (Newsom and Wing 2004; Wilson 2007).

The sea contains several island chains that are typically separated into four major groups – the Greater Antilles, Lesser Antilles, Bahamas, and those adjacent to the South American mainland, including Trinidad, Margarita, Curacao, Bonaire, and Aruba. The 115 islands (not counting islets or cays) comprise a total area of approximately 240,000 km^2. Most of that landmass (95 percent) makes up the Greater Antilles. Cuba, Jamaica, Hispaniola, and Puerto Rico have large interiors, long rivers with wide valleys, and diverse landscapes that approximate those on the continents that surround the sea (Lugo et al. 2012; Rodriguez-Silva and Schlupp 2021). Throughout history, these islands have been home to larger populations, which are supported, though not exclusively, by terrestrial resources (Rivera-Collazo 2022; Rosen and Rivera-Collazo 2012). The Lesser Antilles are smaller with a total land mass just under half the size of Hispaniola. These islands contain far less diverse landscapes compared to the Greater Antilles, though they can look quite different from one another.

In this tectonically active region, earthquakes and volcanic eruptions can dramatically change the amount of land, its relief, and the resources that it affords. Geologically, islands in the Caribbean can be broken down into fault block, carbonate, volcanic, and mixed. In the Greater Antilles, mountains forming Cuba's Sierra Maestra, as well as the central spines of Jamaica, Hispaniola, and Puerto Rico, are extensions of mountains also found in Belize and Guatemala. This chain was formed from the vertical displacement of land at the fault line of the Caribbean and North American plates. As such many of these fault block islands are prone to earthquakes. The majority of the lesser Antilles belong to one of two overlapping and parallel island arcs. These arcs were formed from the subduction of the Atlantic plate underneath the Caribbean Plate. The older, outer arc begins with Anguilla and St. Martin and extends in an irregular shape through to Grand Terre and Marie Galante in Guadeloupe. These islands are characterized by low relief and carbonate bedrock formed from marine reef deposits on sunken islands uplifted or left stranded by receding sea levels (Schubert and Szabo 1978). The younger inner arc begins in Saba and continues through Basse-Terre, Guadeloupe, and Grenada. These islands contain steep mountains, narrow valleys, and much less in the way of flat land.

This geological history is important because it informs, indirectly, the amount and kind of precipitation as well as the amount and volume of ground water. Not all islands offer the same relief, and this topography affects the intensity and location of rainfall. Climate specialists generally talk about three kinds of precipitation: convectional, orthographic, and cyclonic. Cyclonic precipitation results from high-energy events, including tropical waves, tropical storms, and hurricanes. This typically heavy rainfall is accompanied by high winds. People living in Dominica, for example, encounter hurricanes more frequently than islands to the south and less frequently than those to the north. Convective precipitation falls when moist air is warmer than its surroundings. Relatively short in duration, intensity varies depending on the speed of the wind, the differences in air temperature, and the moisture content of the atmosphere. On the Windwards Islands, at times, convective rainfall can happen with some regularity, though its intensity changes depending on the season. This is the wet season. At other points in the year, precipitation can be quite negligible. This is the dry season. Orthographic rainfall occurs when moist air near the surface is forced upwards into cooler layers of the atmosphere when prevailing winds reach tall mountains. Moisture in the atmosphere is released. The regularity and intensity of rainfall have changed since humans first arrived on the island.

This precipitation also informs both surface and groundwater availability. Groundwater that permeates into the soil and porous rock varies considerably. Layers of the soil that are saturated with water are the land's aquifer. The barrier formed between saturated rock and the non-saturated rock above is the water table. These water tables are rarely horizontal and often reflect the topography of the underlying geology. Different geologies have different levels of porosity and permeability, which means that water does not move around the same way, nor is it captured to the same degree. Carbonate bedrock, found in the islands of the outer arc and Barbados, is both permeable and porous leading to significant aquifers that feed springs or can be reached by digging wells. Weakly cemented volcanic ash, which underlies many of the dispersed soils in the younger inner arc islands, is permeable but has low porosity. This means that it drains well but cannot capture the water. "Perched" water tables can form but only when the underlying rock is impermeable, creating subterranean basins. The water generally drains laterally from these basins into springs (Hauser 2021: 51). In some cases, these interfaces are near active volcanic zones creating hot springs. Aquifers are recharged through precipitation. Therefore, the depth of the water table can lower during dry seasons or droughts, or if more water is being removed from the aquifer through wells than can be recharged by rainfall (Hauser 2021: 38).

Indigenous Waterways in the Colonial Caribbean

The advent of European colonialism did not completely annihilate Indigenous peoples in the region. As such, we have some idea about the centrality of water in everyday life for the Indigenous inhabitants. For example, in Dominica, Raymond Breton, in his *Dictionnaire caraïbe-français* , documented that the Indigenous Kalinago had a highly complex taxonomy of water. The relationships with water in this document parallel some taxonomies found in French but with a few significant differences (Breton 1999[1665]). Breton explains that the Kalinago word *Tona* could be used interchangeably for both river and water (Breton 1999[1665]: 121). As a liquid, this term could be contrasted with *Arágoni* (urine), *Araógane* (sweat), *conóboüI* (rain), *Inhali* (manioc juice), *Ira* (juice or liquor), among others. As an element of the Indigenous landscape, it could be contrasted with *Acoúllou* (pond, pit, or abyss), *Balánna* (sea), and *Icópoui* (brackish pond). Water, as a substance, could also be qualified. It could be a fishy river, *Káricheti tona*. But the word could also be combined to create something different than the sum of its parts. The word *Amoyen* means cold, but when used in combination with *Tona*, means fresh water. The prefix *Bácha* signifies heat, but when combined, *Báchuetitona* means both stomach fluids and/or brackish water. *Inchiali* means to smell bad, but *Inchiénli tona* means salt water or troubled water. Such terms are useful in reconstructing some of the taxonomies that might have been salient for the Indigenous people during the seventeenth and eighteenth centuries.

For Indigenous peoples, water could purify. According to this taxonomy, water is defined narrowly. Liquids holding these latent qualities must come from the river. The act of bathing, *Nicobi niabou*, was a way for water to wash away other kinds of liquids (Breton 1999[1665]: 223). Breton comments that every morning, Kalinago men "go to wash at the river (women and children go there at another time)," especially in the places where the river is "heated" from sulfur springs. He goes on to say, "If they are wet with seawater, rain, or if they are dirty, or if they are too hot from some work, they return to wash" (Breton 1999[1665]: 191). From this description, one can surmise that different qualities of water mattered for the Kalinago, though it cannot be assumed that baths were required for the same reasons, as Breton describes these qualities in relation to health. Work brought about *Araógane* (sweat). Sea water carried with it a connotation of dirt. Rain was thought to chill the body too much.

Water carried with it important symbolic significance for Indigenous peoples. For example, children called the wife of their father who was not their mother their *Noucouchoutonarou*. This roughly translates to "my mother by water" (Breton 1999[1665]: 243). This presumably references two aspects of Kalinago kinship. First, that consanguinity, relatedness by blood, did dictate some of the terms under which family was constructed. Second, that family structure was polygamous. Finally, that many of the members of the family were brought in from other places by canoe.

Objects in a landscape are important elements in understanding such taxonomies. A clue to the ritual significance of water and precipitations in early and late ceramic ages are etched into portable objects and stationary rock surfaces. *Atabey*, the frog lady, for example, is one avatar of the apical female deity of Taino cosmology. She is also the mistress of the wind and the destructive force of hurricanes. The location and alignment of petroglyphs reveal that their carving was a largely political act, aligning living descendants with ancient ancestors of a particular deceased *cacique* or *caciques* (Oliver 2009). Rock art, depicting frogs, has been found throughout the Windwards including Grenada (6), St. Vincent (13), St. Lucia (5), Martinique (3), and Guadeloupe (12). The presence and frequency of rock art could be an indication of the anxiety over water security and an attempt to control it through spiritual means (Petitjean Roget 2008).

This art's recurrent themes – the fruit eating bat and the tree frog – reflect Kalinago concerns about the annual cycles of precipitation and its ritual management. The Coki, or tree frog, "comes from beneath the surface of the water," and is linked to the destructive hurricane season. The fruit eating bat "lives out of the water [...] and is a dry animal" linked to the equally destructive dry season when many islands can best be described as a green desert (Petitjean Roget 1997: 105). Petijean Roget argues that these two motifs reflect attempts on the part of ritual specialists to influence the regularity and intensity of dry and wet seasons. He argues the rock art is present in areas where people would want to ensure the safety and security of water sources. On dry islands, like Anguilla, petroglyphs are located near the few water sources on the island. In the Windwards, petroglyphs tend to be located on boulders in riverbeds where annual cycles of wet and dry seasons affect the safety and security of the water.

The quantity of water available was affected not only by the annual cycles of wet and dry seasons, but so also by the quality of water. Perhaps those events most linked with the wet season were hurricanes (Ortiz 1947). Stuart Schwartz, in his discussion of the impact of these storms in shaping circum-Caribbean societies, notes that the storms were an ever-present fact of everyday life (Schwartz 2015). Specifically, during a hurricane, water sources might often become contaminated, making them unsafe to drink and potential carriers of disease. Coastal storm surges and rising rivers mix with brackish water, rendering it unfit for consumption. Stagnant floodwaters and standing pools provide breeding grounds for mosquitoes, which spread mosquito borne diseases (McNeill 2010). In Puerto Rico's historical hurricanes, the deterioration of water quality led to outbreaks of deadly illnesses such as measles, smallpox, and typhus, worsening the already dire conditions of hunger and sickness among the affected populations (Schwartz 2015: 41). That being said, eighteenth-century observers had come to think of hurricanes as part of a larger ecology that had a positive effect on the land (Ortiz 1947: 6), fertilizing "the earth and purg[ing] the atmosphere from the lent vapors and bring[ing] with them a healthy season" (Long

1774: 22). Writing at the century's end, the French jurist Moreau de Saint-Méry, however, remarked that those directly affected by hurricanes found it hard to see them as contributing to the universe's admirable order. Indeed only a few decades earlier, it was widely reported that hurricanes experienced in Jamaica and Barbados led to civil unrest where victims were "simply trying to survive the lack of food, shelter, and water" (Schwartz 2015: 103).

The vegetation present can also affect the amount of groundwater. A combination of plants with shallow root systems and intensified precipitation cycles can lead to soil erosion destabilizing permeable layers of soil that contain water. Mono-culturing plants in areas where aquifers need constant rainfall to recharge can have the effect of lowering the water table, putting plants and animals in competition for the same resource. Plants are not agnostic when it comes to aquifers, for example, cotton, which prefers "dry feet." That is, the plant prefers to grow in areas with well-drained soil where the aquifer is relatively deep (Nijland and El Guindi 1984). Other plants are more tolerant. Rice yields do not suffer as much from having waterlogged soils (Armstrong 1978). Sugarcane is somewhere between the two. Yields increase significantly when the water table is deeper than sixty centimeters (Rudd and Chardon 1977). It is thus no surprise that sugarcane can affect the amount of groundwater present in perched landscapes.

Geographer David Watts' study of how environments and landscapes were altered in the wake of European colonization demonstrates that deforestation and dramatic erosion occurred in the wake of the establishment of plantations, leading to a notable ecological break (Watts 1966; Watts 1990). Atwood insisted that "to render Dominica a good sugar country [...] extensive forests had to be cleared" (Atwood 1791: 81). Atwood, who admired the "uncommon" size of the trees of Dominica argued the forests they populated were responsible for the excessive fog and rainfall on the island which rotted canes and created pools of standing water on the "stiff clay" which in turn would "chill the soil" (Atwood 1791: 80). Mangroves, a predominant tree taxon in the north of the island, were seen as detrimental to sugar colonies. Thomas Jefferys' *The natural and civil history of the French dominions* (1761) provides some insight about how land might be improved. In this account, Jefferys describes Guadeloupe, which "abounds in great quantities of mangroves and palmettoes, by which the free course of the air being interrupted [...] generates tedious and often fatal disorders." He argued that if the mangroves and palmettoes were cut, "the air would be much more wholesome, and the inconveniences arising to the people from the number of trees would be removed by a constant supply of fresh air" (Jefferys 1761: 80).

At the same time, Jefferys recognized drawbacks to deforestation. Later in the treatise, he describes the commune Vieux-Habitants, which at the time of his visit was characterized by sandy soil. This parish that once, "appeared as beautiful as any other part of Basse-Terre," was subject to frequent floods and landslides precipitated by "cutting trees that consolidated [the] banks" of the River de Plessis (Jefferys

1761: 83). Soil that was "taxed" or "worn out" could also be employed to grow cotton, manioc, maize, and potatoes [most likely yams] (Jefferys 1761: 83). Add to that, many observers began to draw connections between deforestation and water availability. They speculated that two severe droughts earlier in the eighteenth century were made especially harsh by the lack of foliage on Antigua and Barbados. So, while clearing the land was important, it had to be done with great care. The effect of early settlement on water supplies was dramatic. Watts noted that as early as the seventeenth century on St. Kitts and Barbados, the two English islands first to be transformed to sugar cultivation, settlers began to rely on rain after tanks and cisterns, because springs had been quickly contaminated (Watts 1990: 166). By 1650, these cisterns and tanks could not be relied on to supply the much-increased populations on both islands. In Barbados, wells were sunk to supply water for plantations residents and dew ponds, or clay lined ponds, were dug to capture rainwater for plantation livestock (Watts 1990: 196).

For Watts, European settlement and its impact on biodiversity could not be uncoupled from the very crops to which the land was put to task (Watts 1990). While Europeans were engaged in a number of agricultural activities concerning commercial crops, including tobacco, cotton, and indigo, the two crops which caused the greatest amount of alteration to the landscape were coffee and sugar (Morgan et al. 2022). Both coffee and sugar have specific water demands that require intense dry periods followed by consistent irrigation. The role of water in the development and yield of the coffee crop (*Coffea arabica L.*) is critical. A period of water stress, induced either by dry soil or air, is needed to prepare flower buds for their blossoming, which is later stimulated by rain or irrigation (Carr 2001). Sugar itself is a thirsty crop, requiring a large amount of water (1,250 mm per year as a minimum) for its main growth period, and then a dry, sunny season to encourage the relatively slow natural process of cane sweetening. The World Wildlife Fund identified sugarcane, along with cotton, rice, and wheat, as among the world's thirstiest monocultures. In a study documenting water usage in the Niger and Chad basins, researchers found that one hectare of sugarcane required 55,000 m^3 of water as opposed to rice, (31,000 m^3), wheat (21,000 m^3), and vegetables (18,000 m^3) (Davis 2003). Indeed, contemporary histories and treatise speak to the centrality of water in both the settlement and operation of sugar estates (Belgrove and Drax 1755; Diderot 1762; Leslie 1740; Ligon 1657; Moreton 1793; Trapham 1679; Young 1764).

Historian Barry Higman (2000), a pioneer of the spatial-relations-of-colonies approach and slavery and plantation studies, defined the sugar revolution in a way that encompassed these concerns, i.e., as an ecological-socio-spatial process of agricultural extensification and intensification. In a systematic comparison of plats drawn depicting sugar and coffee estates in eighteenth and nineteenth century Jamaica, Higman noted that proximity to water was key in settlement patterns and organization of sugar estates and coffee estates in Jamaica (Higman 1986; Higman 1987; Higman 1988). Coffee requires water for processing when using the wet method. First, ripe coffee cherries are hand-picked and then sorted and cleaned. Next, a pulping mill driven by a mule removes the outer skin and pulp. The beans, still covered in mucilage, are then soaked in water for fermentation, which breaks this substance down. After fermentation, the beans are thoroughly rinsed to remove any of the remaining mucilage. They are then spread on drying tables or patios to dry until they reach the desired moisture content. Once dried, the parchment layer is removed from the beans through hulling (Ellis 1774). Sugarcane, on the other hand, needed more water to process the grass into syrup, molasses, sugar, and rum (Deerr 1905). The amount depended on the method of juice extraction, crystallization, and distillation employed. For example, approximately 180 liters of water were required daily just in the boiling process to clean and season the cauldron used to concentrate cane juice (Browne and Blouin 1907: 276). Distillation of molasses into rum required additional water to cool the evaporate into rum (Porter 1830: 252).

It is important to distinguish, as Guy Lasserre (1978) does, between the different relationships through which capital was deployed to cultivate, transport, and process sugarcane between the seventeenth and nineteenth centuries. For Laserre, such environmental relations can be broken down to the kinds of engagements described by Higman above in the seventeenth and eighteenth centuries and those that accompanied the steam engine and novel modes of production in the nineteenth century. The introduction of the steam mill revolutionized the production of sugar in two ways. It powered mills that no longer relied on cattle, flowing water or consistent prevailing wind. It also enabled greater distances to be negotiated after the cutting of cane (See also Engerman 1983). The effect was a change in settlement patterns where independent boiling houses attached to different properties were absorbed by *les centrales* (centralized sugar factories fed by a combination of canals and railroads) (Buffon 1987). Importantly, the demands that sugar had on ground and surface water did not disappear with these novel technologies, rather they both intensified and became more unevenly distributed across the landscape.

Perhaps the landscape where these two revolutions (sugar and industrial) and their implication of water are best exemplified is in Cuba, where the growth of sugar exports in the seventeenth century led to widespread deforestation on coastal plains as planters cleared land for cane fields and used wood in the *ingenios* (water-powered mills) (Funes Monzote 2009: 31). Importantly during this early colonial regime, the transformation of the landscape did not encroach on heavily forested interiors. Timber was a resource, but one that could be managed. Political conflict over forests erupted in 1748 when the Spanish navy established a shipyard in Havana, prompting regulations to conserve timber, much to the dismay of sugar planters. Cuban timber created ships that lasted twice as long as those made in Europe because of its quality. After the Haitian revolution in the nineteenth century, Cuba became the world's top sugar exporter (Funes Monzote 2009: 35), leading Spanish authorities to issue decrees in the 1810s granting them authority over private property, including forests. The advent of steam engines in the same period increased the demand for wood, enabling unprecedented scale in sugar processing and transport (Funes Monzote 2009: 267). According to one planter, unabated deforestation stemming from clearing for cane fields would lead to a double calamity "of shortages of fuel and scarcity of water" (Funes Monzote 2009: 151). Funes Monzote notes that twentieth-century engineers observed that nineteenth-century deforestation had not only immediate impacts but also long-term consequences for watersheds and aquifers, causing upstream flooding and riverbank erosion (Funes Monzote 2009: 152).

The predicaments of plantation slavery and imperialism impacted all parts of colonial societies, although the impact of water disruptions was felt unequally. Reports of droughts or disruptions caused by earthquakes and hurricanes often detailed how disastrous the effects were, especially for the enslaved population who already lived with water scarcity. Smaller islands struggled even more than their neighbors because the needs of plantations were always privileged, even during disasters. This resulted in landscapes that were vulnerable and characterized by long-term water insecurity. Droughts were especially prevalent where there was excessive deforestation. Research shows that during droughts, the enslaved population suffered even more than the white populations in the Caribbean. Floodings after hurricanes also reinforced the racialized distinction in water access. The lack of potable water in the aftermath of devastating weather events meant that the mortality rate of the enslaved shot up during these disasters. The resulting pattern was the normalization of water insecurity among the enslaved population.

Politics of Everyday Water Usage

Colonial regimes in the insular Caribbean had major impacts on landscapes and their affordances for precipitation, surface water, and groundwater. The effects of changes to the land in the region, including deforestation, soil erosion, and the amount and quality of ground and surface water, unfolded slowly and without spectacle. They may have been glossed over as a consequence of intense wet seasons, harsh dry seasons, and unpredictable weather events like hurricanes. Similarly, the population explosion, while sudden, would have been difficult to see in its entirety from the perspective of any one place. Ultimately, few people on Dominica would have lived long enough to see the development of the sugar revolution and feel its effects. Instead, the slow violence was embodied in the changing quality of water and the greater distances people had to travel to get it. These changes would have affected those who were bound to the land through enslavement more severely than those who they labored for.

Scholars who have interrogated slave life have argued that it is intellectually short-sighted to ignore differences between slave-holder ideology and the everyday lives of people categorized as slaves (Brown 2009). The sugar and industrial revolutions marked the intensification of exclusionary relations of markets, regulation, force, and legitimation. These relations were assembled in the socio-ecological form of the sugar plantation (Mintz 1985). On these plantations, enslaved people racialized as Black lived in denser settlements and struggled in fields devoted to monocultural output for higher capital gain for owners. Concomitant with this emerging socio-ecological form was a transformation of the landscape that impacted the availability of water for those living under the condition of slavery (Hauser 2017). Waterways were not free of charge.

Hauser's (2021) study of slavery on the island of Dominica shows that the region was exceptional for its late engagement in the plantation economy and the continued presence of an Indigenous population. Hauser investigates how space mediated social and political relationships, water being central to the ways in which power and nature came to constitute each other through the predicament of slavery. Plantation agriculture made water – in one of the Caribbean's wettest islands – scarce, forcing people to compete with industry over this abundant resource. More ordinary day-to-day uses of waterways were the norm, actions to meet basic needs but also to develop commensal relations in unexpected ways. Overall, environmental health, water's moral and cultural centrality, and enslaved laborers' situated knowledge were at the core of strategies for survival and resilience.

Indeed, landscape transformations brought about to cultivate sugar and coffee were just one of the many interactions shaping water and its uses. The plantation indexes just one of many relationships between humans and water in the Caribbean. Africans brought to Dominica would have had equally complex ways of managing water to promote cultivation. Intercropping and enhancing landscape features would have been strategies practiced by African farmers thrust into slavery. Though sometimes depicted as a state of "permanent cultivation" that is less elaborate than hydraulic systems, which support monoculture, intercropping can support large urban centers, cohorts of artisans and merchants, as well as long-distance trade (McIntosh 2005). The retreating waters exposed clayey soils that trapped water in back swamps and ponds. Farmers sowed more land with plants in close proximity that had different water tolerances, including rice and sorghum. To create high yields, these farmers also enhanced banks to create terraces that would hold water through the dry season. They also became adept at judging which crops would be suitable for their respective locales.

Judith Carney, for example, documented three different water regimes associated with rice cultivation in twentieth-century Guinea (Carney 2001: 57). The first, used in drier climates, was a rain-fed system. The second, used in inland swampy areas, relied on groundwater collected from artesian wells, freshwater springs, and wells dug into perched water tables. The final water regime, used on tidal waterways and floodplains, had to retain freshwater and keep brackish and saline water from entering fields. The floodplain system of growing rice required thorough manipulation of water flow through floodgates, canals, and ditches. These strategies involve planning that would consider the investment of time and labor, accounting for variations in wetness and dryness of soil over the year. Those who were thrust into slavery were unable to bring a water regime with them to the Caribbean.

Raised fields would have been another technique available to manage water for farmers in the Caribbean during the centuries before Columbus (Rostain 2016). Wetlands in the tropical Americas were, on the one hand, rich in fertile soils; on the other, these soils could be waterlogged (Rostain 2008). In an environment that experiences both drought and flooding, growing maize (which prefers drier soils) and manioc (which prefers wetter soils) presented a particular challenge. Farmers on the Caribbean's South American coastline created raised fields to regulate water during annual heavy rains and dry spells. Farmers there constructed small agricultural mounds with wooden tools (McKey et al. 2010). These raised fields provided better drainage, soil aeration, and moisture retention. They also benefited from increased fertility from the muck continually scraped from the flooded basin and deposited on the mounds. The farmers limited flows, preserving soil structure and conserving soil nutrients and organic matter. While there have been no documented archaeological examples in the insular Caribbean, such techniques have been documented in contemporary Puerto Rico (Pagán-Jiménez 2013). Given this and their use in deep history, it is not unreasonable to argue that raised fields were a strategy farmers used to manage water.

In contrast to the massive irrigation works employed by Europeans to make land suitable for crops such as sugar, the modifications the Indigenous peoples and Africans employed may have seemed humbler. They were, however, no less complex. These strategies involved a level of planning that would consider the investment of time and labor, accounting for variations in soil moisture throughout the year. These strategies entailed calculations of risk about the possible catastrophic consequences. Investment of time, matter, and energy did not always yield in ways that the farmers had intended. Finally, these strategies required communal labor to create the earthworks responsible for retaining or draining fields. This would include earthen ditches and embankments to drain water from fields, ponds that would capture fresh water in the wet season and retain it during the dry season, alignments of stone that might have acted as dikes, and terraces with stone retaining walls that could capture or slow the movement of water downhill. These are the archaeologically visible features that reflect strategies of substance where water is concerned.

The increased dependence of island denizens on captured water for everyday water uses introduced a predicament for the health of some. Human waste, drowned animals, and even everyday activities such as bathing contaminated the water supply and made slaves vulnerable to waterborne diseases (Handler 2006). Fouled water was, in many places, the only water available to slaves (Kiple 1984: 145). Waterborne illnesses such as typhoid and dysentery stressed organs and often resulted in death (45). By 1750, a combination of town planning that included paving streets, building stone and brick housing, and the passing of a number of local statutes related to drainage, rubbish removal, the provision of water, and new hospitals had shown a decreased death rate in in England (Buer 2013: 35). Abolitionist Robert Nikolls invoked pond water to make the point that slavery deprived people of basic needs. As such people had to develop ways to make water potable (Nickolls 1788: 17). In the last quarter of the eighteenth century, there was a decline in mortality associated with the slave trade. Robin Hayes and Ralph Schlomowitz link this to the greater attention on public hygiene in the Atlantic world, where "the life-saving effectiveness of adequate accommodation including isolation of the sick, improved hygiene, sanitation, clean water, and diet, was demonstrated long before the germ theory of disease" (Haines and Shlomowitz 2000: 285). As such, by the last quarter of the eighteenth century, naval and civilian physicians began to pay careful attention to hygiene and fresh potable water (272).

The importance of safe and clean drinking water was at least a part of town administrators' calculations. Belisario describes the attempt of Falmouth, a town on the north coast of Jamaica, to build main and service pipes as in "those adopted in the Mother Country." Likewise, colonial administrators in Point-a-Pitre and Basse Terre, Guadeloupe, would provide safe water for town residents (Arcangeli 2012: 190–200). Belisario continues with a detailed description of Kingston's water supply: "there are pumps in every street and wells in almost every yard, but so strongly are their waters impregnated with salt [with few exceptions], as to be totally unfit for culinary uses" (Ranston 2008: 264). The jars, according to Belisario, would be used to carry water in water carts on the tops of the heads of the servants that "traversed the city." Belisario goes on to describe how homes should have a "water pantry, in which jars of large dimensions, serving as reservoirs, are deposited." There, a "trusted" slave would clean and resupply the vessels. It appears, therefore, that such vessels were important for transporting and storing water.

There were additive methods that made water palatable. Archaeological evidence exists of some of the crafted beverages they might have drunk, including water flavored with fennel and coffee (Oas and Hauser 2017). Slave apologist Thomas Atwood states that a daily ration in the rainy season would be a "pint of rum and water, sweetened with molasses" (Atwood 1791: 257). This method was not unique to the Caribbean or to slavery. While today grog is considered a type of alcoholic drink, in the eighteenth-century Caribbean, it was more associated with water. Rum was a way to make fetid water stored in barrels palatable on long naval voyages. In many West Indian islands, water for grog came from ponds, which were easily polluted.

During the decades when the plantations in the Caribbean proliferated, colonial governance expanded its reach. In addition to acquiring territories and transforming them into productive colonies, European powers were doubly committed to creating and maintaining the socio-political conditions that would be conducive to and supportive of slave-based plantation agriculture. This meant reinforcing racial differences in all facets of colonial life, especially in the use of space. In this moment of expansion, landscapes were deforested, boundaries were invented, and monuments to plantation agriculture dotted the landscape. On plantations where water access proved a challenge, water infrastructure prevailed. Mills, reservoirs, dams, and duck ponds became prominent features of plantations. Their presence in the landscape narrates a story about legitimate uses of water in a society driven by slave-based plantation agriculture. Water access and storage for enslaved laborers were rarely priorities for colonial authorities. The outcome of these patterns casts the Caribbean as a space where water was a tool of violence that created frequent conflicts over resources. Ryan Fontanilla's Waters of Liberation (2023) shows us how white Jamaicans especially used the law to dispossess Black farmers in the post-emancipation period. He cites the *Public Water Supply Law* of 1889 that enabled the state to seize any fresh water supply it deemed necessary for the establishment of water and irrigation companies in the future anywhere in the colony as emblematic of the overreach of colonial governance as it regards water (346).

Water as a Medium of Movement

In the face of widespread privatization of water and waterways, the laboring classes in colonial societies have used the centrality of water and its affordances as a way to create possibilities away from the plantation and provide alternatives to imported food. With dependency on imported goods, a marked feature of Caribbean colonialism, there were efforts to increase food supply from marine resources to support their resiliency in a global system that has only ever sought to extract. Both freshwater and deep-sea fishing have been important subsistence practices among the laboring classes. Studies of fishing villages or communities that have access to terrestrial ecosystems like rivers and ponds have shown how reliant the laboring classes are on these food sources, their proximity becoming, over time, a core part of community identity. Access to resources that were outside of the purview of the plantation meant that despite efforts to police water access, there were moments when water and a political will to transgress became central to liberation efforts and challenging the reach of colonial officials. Studies of this kind reveal that when water access was not impeded, the laboring classes would find ways to use it to aid in liberation.

Water was not just a concern for rural communities. In urban spaces, an entire industry sprang up around sourcing water for the residents of major towns. Water carriers were key to water supply in places like Spanish Town and Kingston in Jamaica. They would sometimes travel long distances over impractical terrain to sell water to an ever-available market. As Fontanilla's research shows, "independent enslaved water-gatherers could turn immense profits" (Fontanilla 2023: 243), especially in drier towns with fewer freshwater sources. During the dry period or in times of drought water prices would skyrocket in urban contexts. Much of that was because the labor of water gatherers was both physically taxing and time-consuming (245). The prevalence of water gatherers was so pronounced that it facilitated the rise of what Fontanilla calls "swamp suburbs," communities that existed on the fringes of dryland so that Black Jamaicans could be close to work opportunities. While these dense wetlands sometimes served as a deterrent to white surveillance in post-emancipation Jamaica, they also exacerbated the need for freshwater that only an industry of water-gatherers could supply.

Waterways, as a means of travel, have a long history in the Caribbean. The islands in the Caribbean were first inhabited by seafarers who had perfected long-distance travel by canoes. The various groups who settled in the region both maintained and challenged political and economic relationships via these watery networks. In the colonial period, both oceanic and inland waterways were conscripted in the efforts of empires that sought mainly to extract. Most notably, the Atlantic Ocean and the Caribbean Sea were crucial for trafficking enslaved Africans and expanding European political power. Inland waterways were no less important as they offered more direct routes into difficult-to-access landscapes and, particularly in South America, opened up access to peoples who had better experience living in these watery landscapes. Natural waterways in Caribbean landscapes were imbued with layers of meaning. While these resources were conscripted into the slow violence of colonial life, they also provided pragmatic solutions to the predicaments of life in the Caribbean.

Vikram Tamboli's "Black Water Politics" (2024), for example, explores how the Pomeroon River in Guyana fomented an ethno-racial politics. The Pomeroon River is the deepest in the country, with a glossy black surface that hides what lies beneath. Because of its location and depth, the riverine communities that emerged in the colonial period were caught up in centuries of geopolitical conflict that brought together Indigenous groups, enslaved Africans, maroons, indentured laborers, and Europeans. Tamboli's works show that "waterways provided freedom – power through access, ability, and mobility – for distinct people at distinct moments in time" (302). The Pomeroon here, like other waterways, are not simply canvases for history to play out. Instead, rivers and the like are crucial to the creation of a sense of community and are thus part of the creation of a Caribbean political consciousness that remains fluid. Tamboli reminds us that these waterways "allowed people to transform lineages, and in turn, the socio-cultural history of the Guyanese northwest" (302).

These natural waterways were not only places of travel, but also spaces of extraction. The Pomeroon facilitated industries like logging and gold mining that were fundamentally export oriented. The actors involved in these endeavors, however, would change over the course of the eighteenth and nineteenth centuries. Tamboli reminds us that while in the eighteenth century, the Pomeroon riverine landscape fugitive peoples were hunted as they sought freedom, in the nineteenth century, the formerly enslaved found moderate success in small-scale mineral mining that was able to sustain life in the free villages of coastland Guyana (302).

One obvious use of natural waterways in the colonial period was to facilitate inter- and intra-island travel. Especially in the eastern Caribbean, where smaller islands could be separated by as little as twenty miles, mobility was far less constrained than it is in the present. Travelling south against the current was often challenging but experienced sailors knew to hug coastlines on the windward side of the islands. How individuals traveled by water depended on their relative position in colonial society. In the Eastern Caribbean, both enslaved and free Afro-Caribbeans regularly traveled between the colonies for a variety of reasons. The relationship between Martinique and its neighbors in the eighteenth century serves as an example. In Martinique, it was common for smallholders to abandon attempts to transform peripheral parcels of land where it was difficult to grow food or source wood, instead focusing on more fertile lands freely available on nearby Dominica and St. Lucia. In Dominica, smaller plantations in the southernmost enclave of Soufriere, like Morne Patate, grew provisions that were transported by water to larger estates in Martinique. This facilitated the creation of social and economic ties across colonial society that deepened over time. In the Creole Archipelago, historian Tessa Murphy writes, "in addition to selling their ware in Martinique, residents of St. Lucia regularly traveled to the colony's southwest to partake in religious celebrations" (2016: 37). Murphy's research underscores the centrality of water travel not just for the transportation of goods like food and water, but also for creating and maintaining social ties. Contrary to its post-independence portrayal as a barrier between nation-states, the Caribbean Sea has long been a conduit for the region's formation.

Grace Turner's (2006) work on ship graffiti in the Bahamas offers some archaeological insight into the ways humans took advantage of waterways and how such practices were incorporated into everyday life. At the time of Turner's research, nearly one hundred incised drawings of ships had been identified. Their repeated occurrence highlights the economic importance of seafaring and shipping to the island and the region. Turner rightly contends that these drawings ought to be understood as part of a larger landscape that incorporates both land and sea. Earlier studies show that about 16 percent of enslaved males in the Bahamas were employed in shipping – the highest in the region.

While shipping and seafaring in service of the plantation economy and British imperial interests dominated the accepted uses of natural waterways, these practices were also used to enact maritime marronage. As Singleton and Landers (2021) note, liberating oneself from slavery by escaping on the water was no easy feat and involved much planning in order to decrease the likelihood of capture. Maritime marronage carried a greater risk of being captured on the open sea or getting shipwrecked. Still, it was one of several ways that the enslaved were able to escape captivity. Knowledge of the practices and networks necessary for success were intentionally kept hidden and are still only accessible through brief mentions in historical records and, more commonly, through oral traditions. More recently, archaeologists working on St. Croix using ocean current modeling have pointed to ways in which those escaping enslavement would have relied on both an intimate knowledge of weather patterns and clandestine networks to successfully reach Puerto Rico.

It is tempting to view natural waterways in a purely pragmatic sense, as resources that were molded into a preexisting colonial agenda. This chapter cautions against such a position. Determining how various waterways were used is but one part of the equation. Borrowing mostly from anthropological studies that conceive of water as always more than itself (Ballesteros 2019), a consideration of how waterways could have been used in the colonial period is an invitation to consider the semiotic, historic, political, and material underpinnings of their use. This section considered how specific waterways were relationally understood. Ballesteros urges – even challenges – scholars to extend their inquiry beyond the liquid form. In the colonial Caribbean, this involves considering how water bodies were drawn into the broader process of colonization and, beyond that, the limits of its conscription.

Conclusion

Taken together, this survey of water and its uses during the colonial period in the Caribbean suggests that not all appropriations of the same matter harness the same strategies of explanation. One of the oft-repeated critiques of the Anthropocene is the extent to which the term collapses overlapping and concurrent themes and enacts a form of conceptual violence to a far more nuanced argument. What this chapter has shown is that individuals in colonial societies, differently positioned based on race, class, or gender for example, engaged with the substance differently and so valued its possibilities differently. The persistence and universality of the gap between wealth extracted through commercial agriculture and mining in the Caribbean and the reality of increased water insecurity for many of its denizens demands that the validity of any approach that fails to consider the historical particularities that have given rise to the Anthropocene be questioned.

There are three overarching messages in this chapter. First, scholars should make more of an attempt to familiarize themselves with work in the field of environmental studies and science that is being done in and on the pan-Caribbean region beyond the past colonial points of reference. More recent work done by soil scientists, archaeologists, and other biophysical scientists has made the theoretical leap to consider the highly extractive nature of the colonial period in the context of a longer-term environmental history. This is important because, as learned from the field of archaeology on the pre-colonial past, the Amerindian deeper histories continue to inform the present. Second, it is important to consider scholarship beyond the particular insularity of the places studied and view the challenges of the Anthropocene as regional in scope. Research from the Anglophone world often dominates these intellectual explorations, and at the same time, if scholarly work finds its way into translation, it is often into English. Despite this, the field at large would be best served by incorporating insightful work printed in French and Spanish that have carried on much longer engagements with topics such as physical geography, history, and its impact on the present. Third is that the scope, complexity, and novelty of an interdisciplinary approach to Caribbean environmental history are such that scholars must remain committed to thinking beyond the confines of their disciplinary allegiances. The attempt to apply a historical analysis of water to the Caribbean by various fields, such as anthropology, sociology, political science, and literature, has been an added strength, introducing novel questions that the field might not have thought to ask before. This commitment has produced innovative, well-documented, and thought-provoking works that historians would do well to take note of. To advance beyond broad generalizations and a slippery conflation of environment ecology and landscape, all of which are commonplace and contradictory, there remains the need for a body of scholarship that is not only sensitive to the theory of the environment, ecology, and the past but also grounded in the limits and constraints of the sources studied.

On balance, all such interventions represent a welcome response to the predicaments represented by rematerialized histories and archaeologies. While questions remain about what the Anthropocene is, when it began, and the degree to which it can be associated with particular technological interventions, a focus on the predicaments associated with everyday water and its uses provides a pragmatic and future-oriented lens from which to clarify the term.

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From the Mid-Nineteenth Century to 1950

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

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If the eighteenth century can be recognized as the century of the Enlightenment, the nineteenth century must be seen as when Europe materialized the ideas of the project of modernity into practices that visibly transformed the paradigm of the society-nature relationship. Raymond Williams gives an account of the many ideas around nature that have arisen from the fact that human beings think of themselves as entities that can observe and know nature; while presuming they are not a part of it (Williams 1980). Discursively, there were still no references to the "environment" as it is now perceived during this period, but instead, to the natural surroundings: "nature" was dissociated from the human and conceived as an external set of possibilities and resources.

Nature – cleaved into one of the living and one of the phenomena of the surroundings (Foucault 2010) – was thought of as both a supplier of resources and a threat, and what was known about it through the nascent modern sciences demonstrated both an ability and a need to control and subdue it. Technological development, industry, incipient urbanization, and population growth – stemming, among other factors, from scientific advances in medicine – increased the demand for food, water, energy, and materials, creating conditions for the extreme exploitation of natural goods that would result in multiple imbalances and stresses on the Earth System in the twentieth century (Steffen et al. 2005). The period from the second half of the nineteenth to the first half of the twentieth centuries was a space of dizzying change in the relationship with the environment and the conceptualization and imaginaries about nature and water. It was also a period in which, due to the symbolic separation of human beings and nature, the conditions for the great global crises of the late twentieth and early twenty-first centuries were fermented and brewed.

The emergence and consolidation of modernity in Europe had its correlate in the world-colonial system, that is, the world-system that originated with the conquest of America and gave rise to a colonial/modern and Eurocentric capitalism, with a racialized pattern of power (Quijano 2019) based in particular on the coloniality of nature in Latin America and the Caribbean. In the nineteenth century, within the context of the dominant European nations and the ascendant power of the United States, an international division of nature began to take shape that would result by the turn of the century in the natural world's commodification, inequitable and unequal, inherent in the forms of capitalist relations. The transformation processes of the human-nature relationship were simultaneous with the unequal integration of Latin American societies into the international economic system between the end of the nineteenth and the beginning of the twentieth centuries.

The region of Latin America and the Caribbean – with its newly configured nations that derived from European colonies being still oppressed and inevitably economically dependent due to what Aníbal Quijano has called the coloniality of power and knowledge (Quijano 2019) – was placed in this international division of labor and nature as a supplier of primary goods. Vast stretches of native forests, lush jungles, and other biomes were transformed into plantations or pastures, resulting in a radical modification of ecosystems and the imposition of ways of relating to nature alien to the various groups inhabiting the region.

In this context of reconfiguring territories and changing practices, the perception and conceptualization of water underwent radical transformations. These ways of thinking about and referring to water in the context of nature's scientification have been integrated into the concept of modern water proposed by Linton (2010), which suggests that science allows one to think of water as an object of study and as a quantifiable entity, with characteristics and properties that are independent of the social and cultural relations of human groups and the natural and ecological surroundings in which waterways and bodies are located.

This process of water scientification, within the framework of the consolidation of an international division of nature, led to projects of control and domination in Latin America and the Caribbean, both of the water and the population. This moment constituted the first steps toward a trend of privatizing and regulating water. It would gradually acquire the character of an indispensable resource to sustain the growing production of export agriculture and the demands of urban life that, in the capitals, were increasingly more densely populated. Science and technology became the ways to transform the immense amount of water in the region into a useful and manageable good. During the second half of the nineteenth century, in the nascent liberal Latin American nations, these processes materialized in the construction of dams for water harvesting and later for hydroelectric power generation, the desiccation and modification of river channels for agriculture, the creation of irrigation systems in the countryside, the use of rivers for transportation, and the establishment of distribution and sanitation networks in cities. An extreme case of environmental transformation due to technological intervention was the construction of the Panama Canal, epitomizing the capacity to control nature and displace and force human groups into submission for the sake of progress. These processes are also associated with uprooting local sociocultural contexts and erasing or making invisible other practices and visions of water relations originating from the Indigenous populations.

Together with this vision, the conception of the natural territory of the continent as wild lands of swamps and unhealthy waters populated by disease-carrying Indigenous peoples and Afro-descendants persisted. The ideas stemming from European hygienism led to the modification of domestic and urban practices and the search for regulatory frameworks that would result in the enactment of water laws that, on the one hand, aimed at guaranteeing access to water resources for agricultural producers, fledgling industries, and city dwellers and, on the other hand, sought to regulate both the supply and eviction of waste in urban areas. Inequality and inequity in extractive and consumption processes, access to good quality water, and healthy territories were made real in norms and laws that were, in turn, based on the discourse of progress.

In the interwar period of the 1920s and 1930s and the context of the

> widespread social disenchantment after the First World War and the international socioeconomic crisis [...] such essential foundations as universal progress – economic, intellectual, social– that had been established during the nineteenth century in free trade and scientific-technological development [were] called into question. [...] The role of science [was] now a condition of possibility for a massive and standardized mode of production, dependent on the instrumentation of knowledge using technology. (Herrera-Lima 2018: 153–154).

It was during this period that the scientific and technical foundations for what would later be the polymer industry developed in Europe and the United States, resulting in the mass production of plastics in different forms and manifestations (Watson 2007). During this same period, there were also advances in industrial applications of chemical processes that would result in the ability to produce highly toxic insecticides, pesticides, and fertilizers. The automobile's integration into urban areas as an essential means of transport was also introduced. These advances in science and technique were shown at the 1939 New York World's Fair with spectacular displays and speeches that heralded the possibility of mastery and control; above all, however, was the idea of going "beyond nature": of emulating, designing, and challenging it by producing elements that had not previously existed in the natural surroundings (Herrera-Lima 2018; Rydell 1993). In this way, the massive production of non-biodegradable waste and pollutants began, which would lead, in the medium term, to large-scale pollution and degradation of air, land, and bodies of water, from oceans to groundwater. Also, fossil fuel use for transportation and production became more widespread and normalized towards the first half of the twentieth century, which resulted in acute atmospheric CO_2 pollution in the decades since.

The consequences of these actions were inequitably distributed globally, the greatest manifestation of their damages occurring in Latin America and the Caribbean – along with Africa and Asia – which, in the race to development, would later offer favorable conditions for transnational corporations to produce with cheap labor without environmental restrictions in general or regulations for water quality and availability in particular. Monumental sums of plastic and toxic wastes were now arriving by land and water to the most disadvantaged regions of Latin America and the Caribbean without national or international regulatory frameworks to address the problem, thus disrupting the balance of ecosystems and radically changing the practices and ways of life of Indigenous and Afro-descendant population. The vast majority of water bodies in the region now have high pollution levels from agrotoxic and industrial waste (Garcés Ordoñez et al. 2021).

The second part of the nineteenth and the first half of the twentieth centuries were times of development and configuration of a new paradigm in the relation of human societies with nature in general and with water in particular, leading to the critical conditions that characterize the Anthropocene today. In these dependent regions – being economically subordinate suppliers of primary goods and subject to predatory and extractive practices – socio-water crises resulting from the articulation of multiple factors that constitute the modern water paradigm were exacerbated. Many resistances, social movements, conflicts, material struggles, and symbolic disputes over water also took shape. While modernity and Anthropocene are not synonymous, they are indeed of the same substance.

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Water in the Southern Cone from the Mid-Nineteenth Century to 1950

A Rereading of Water and Sanitation Networks from the Perspective of the Anthropocene

Ricardo A. Gutiérrez and Patricio Besana

Scientific terms sometimes echo outside their fields and are appropriated by a wider public. While such diffusion does not imply complete agreement on what they designate, such terms often manage to express a number of widely shared concerns (Snow 1959). Anthropocene seems to be one such term (Trischler 2017). Coined to designate a new geological epoch in which humans are agents of planetary change (Crutzen and Stoermer 2000), it has sparked debates among geologists and scientists from other disciplines, but has also channeled concerns shared by a wider public regarding climate change and the global environmental crisis (Zalasiewicz et al. 2015).

Among the debates that the term has awakened in the scientific community, the discussions over the moment that marks the beginning of the Anthropocene and whether the human species itself is an agent of global change have stood out. In the first debate, the year of the nuclear bomb detonations (1945), also known as the beginning of the Great Acceleration, seems to be gaining more adherence over other dating (Waters et al. 2016). In the second discussion, the idea of the Anthropocene is questioned for obscuring the responsibilities of those who led the development of capital – or other processes associated with the change of geological epoch – and imposed the project of modernity as the only horizon (eg., Moore 2016).

The following chapter assumes its own perspective on these debates. Regarding the first, the impact of human action on the planet is understood as a process rather than linked to a specific starting date for a new geological epoch. Regarding the second debate, the analytical perspective assumed emphasizes the contribution and effects suffered by the Southern Cone and Brazil in the context of their incorporation into the international division of labor. In other words, the perspective offered here emphasizes regional aspects without ignoring the global change expressed by the Anthropocene.

The study of the expansion of water and sanitation networks in Latin America is not a very common topic in discussions on the Anthropocene, and even less so in the period between the independence revolutions of the nineteenth century and the Great Acceleration in the middle of the twentieth. Information with distinct characteristics from different periods can be found on cities in Brazil (Rückert 2018; F. A. dos Santos 2013; Campos 2005; Poettering 2018) and Mexico (Aboites-Aguilar 1998); a more limited amount of information on the capitals of Argentina, Colombia, and Cuba (Casas-Orrego 2000; García-Blanco 1986; Lanciotti and Regalsky 2014); less data on Chile (Sánchez Andaur and Simón Ruiz 2014); few but detailed studies on Uruguay (Cooperativa de Trabajo Comuna and Federación de Funcionarios de la OSE 2020); and almost no knowledge on Paraguay, as well as very few comparisons between two or more countries during this period (e.g., Castro and Heller 2007).

In this context, this chapter periodizes the expansion of water and sanitation networks in Southern Cone countries (Argentina, Chile, and Uruguay) and Brazil between 1800 and 1950. To this end, it asks: How were water and sanitation networks expanded during the period studied? What phenomena are related to the ways in which such expansion developed?

In response to the first question, it is argued that the expansion of water and sanitation networks in the Southern Cone and Brazil between 1800 and 1950 developed in three major stages that, however, each country and city went through at different times and levels of intensity. In response to the second question, it is argued that this expansion is related to the specialization in the production of primary goods with which the region joined the international division of labor and the development models pursued in response to changes in the global economy.

In line with classic (e.g., Cardoso and Faletto 2004) and other more recent works (e.g., Svampa 2019) that have sufficiently shown that dependence and development are related phenomena, this chapter demonstrates how the general features of each stage of water and sanitation network expansion in the countries analyzed are related to the subordinate role that Latin America occupied in the global order. On a symbolic level, it illustrates how water network expansion was linked to a certain notion of modernity associated with Europe and the United States and the idea of development pursued by two models. At the material level, it shows how water and sanitation network expansion, regardless of the development models pursued, depended on primary goods export for financing. The end of the chapter suggests that such dependence-imposed limits to the universalization of services contribute to the degradation of the environment and the process of geological epochal change.

The lack of information on water and sanitation networks at the aggregate level until very late in the twentieth century sets a limitation on answering the questions posed. In order to mitigate this limitation, available information on subnational territories in the countries analyzed was systematized. In this regard, information was gathered on Buenos Aires, Rosario, and Córdoba (Argentina); Alagoas, Bahía, Belém, Campinas, Maranhão, Mina Gerais, Pelotas, Pernambuco, Porto Alegre, Recife, Rio de Janeiro, Rio Grande do Sul, Salvador, Santos, São Luis, and São Paulo (Brazil);

Iquique, Santiago de Chile, Talca and Valparaíso (Chile); Maldonado and Montevideo (Uruguay). The following accounts relate significant comparisons and facts to obtain an overview of water and sanitation network expansion during the period under analysis. The research design was complemented by reviewing historiographic sources on demographics, urban population, and exports, among other national indicators.

Before moving on to the description of each stage, there follows a conceptual framework of the Anthropocene, Latin America's place in the changing geological era, and its relationship to water and sanitation. The chapter ends with a section devoted to conclusions.

Anthropocene, Development, and Water and Sanitation

That the Holocene ushered in a new geological era seems to be an idea that is gaining more and more adherents every day (Zalasiewicz et al. 2015). Recently, a group of experts indicated that the "Anthropocene [has been] functionally and stratigraphically distinct from the Holocene" since the first nuclear detonations occurred in 1945 (Waters et al. 2016). This would relegate other hypotheses about the change of geological epoch, including the initial thesis that attributes the beginning of the Anthropocene to the Industrial Revolution (Crutzen and Stoermer 2000).

Just as the first nuclear detonations were the work of a small group of people, the Industrial Revolution can also be attributed to a specific place. Issues such as those mentioned above led to a discussion on the relevance of the category ánthrōpos, as it refers to humanity as a whole. Various aspects associated with the change in geological epoch are highlighted by alternative designations. Oliganthropocene, Chthulucene, Plantaciocene, and Urbanocene are some of these designations (Haraway 2016; Mendieta 2019). Capitalocene is another (Moore 2016) and possibly the denomination that has gained the most supporters in Latin America (Ulloa 2017). However, as shown in the following sections, the change of geological epoch cannot be explained by capital's advance or the factors stressed in the other denominations that dispute the meaning of the Anthropocene.

With few exceptions (Shellenberger and Nordhaus 2015), the narratives around the Anthropocene question the culture-nature dichotomy (Mauelshagen 2017). In doing so, they join the perspectives questioning the modern ethnocentrism that placed the West at the top of a civilizational continuum and justified its dominance over other beings, communities, and the natural realm (Cuche 1999). In Latin America, such narratives enjoy a unique acceptance (e.g., Svampa 2019). The questioning of the culture-nature dichotomy has led to a certain elective affinity between Anthropocene narratives and positions that rescued the ontologies of native peoples as an alternative to the way in which Western culture thinks of its relationship with the world (Descola 2005; Escobar 2005; Viveiros De Castro 2008; Mantiñán 2022). A certain affinity can also be observed between the Anthropocene narratives and several studies that criticize the role of primary goods producers assumed by the region's states in the international division of labor between the end of the nineteenth century and the beginning of the twentieth century (e.g., Alimonda 2017).

These studies are heirs to a line of thought that emerged with ECLAC. It identified problems for the region's development along the paths followed or proposed by early industrializing countries and proposed to develop its own paths, linked to import substitution industrialization (Furtado 1993; Prebisch 1992). Subsequently, the questioning included the very notion of development in order to think of alternatives to it (Svampa and Viale 2020; Gudynas 2010).

The following sections show how development models and drinking water and sanitation network expansion in the Southern Cone and Brazil are linked beginning in the period of the independence revolutions until the Great Acceleration. Newly incorporated into the international division of labor as independent states, local elites accepted the role or specialization of their nations as primary goods producers (Bértola and Ocampo 2010). In a context of free movement of capital, products, and labor, the new states benefited from the expansion and consolidation of their borders and the incorporation of new arable land (Pinilla and Aparicio 2015). In parallel, an accelerated urbanization process affected the cities best connected to the flow of international capital (Castro and Heller 2007; Mendieta 2019). Faced with the emergence of epidemics and the need to attend to a growing population, a substantial part of the income obtained from primary goods exports was earmarked for the modernization of these cities (Paiva 2000; Melosi 2020). In this context, the aim was to replace colonial forms of water access and sanitation strategies with infrastructure and service networks similar to those developed in Europe and the United States (e.g., Lanciotti and Regalsky 2014).

The effects of World War I (1914–1918), the international crisis of the 1930s, and World War II (1939–1945) changed the international stage and, with it, the aspirations and development models pursued in the region (Halperin Donghi 2005). Liberal states gave way to entrepreneurial states that more decisively took on the task of modernizing their social structures, betting on the development of industry and the universal provision of services, such as drinking water and sanitation (Bulmer-Thomas 2003). In a more unfavorable international context, the lack of alternative financing sources to the foreign currency obtained from primary goods exports and the political instability itself presented difficulties for these projects (Castro and Heller 2007).

Within this framework, three stages of access to water and sanitation networks are identified below. The first stage was characterized by the "backwardness" of the systems inherited from the colonial period and by the aspiration to achieve "modern" networks to prevent problems such as epidemics, at least in territories directly linked to international trade. The second stage was characterized by the expansion of the first network sections in the face of numerous drawbacks by means of concessions to private companies whose main feature – unlike those in Western Europe and the United States (e.g., Matés-Barco 2013) – is their foreign origin. Finally, the problems experienced during this stage and the lack of infrastructure, especially in the context of economic recession or exchange rate instability, gave way to the third stage, characterized by a process of centralization in the hands of nation-states with the intention of universalizing and improving water and sanitation services.

As will be seen in the following and all subsequent stages, despite having common features that are theoretically significant, each territory traversed these with a different manner, frequency, and intensity.

Stage I: Colonial Backwardness and Modern Networks as Aspiration

The Southern Cone countries and Brazil joined the international market as sovereign nations during the first decades of the twentieth century (Halperin Donghi 2005). Their participation in an international context of free movement of products, capital, and labor was characterized by primary goods exports (Bértola and Ocampo 2010). The expansion of national borders and the incorporation of arable land favored such participation through military campaigns. In general, these campaigns were to the detriment of Indigenous peoples, such as the Aymara population in Tarapacá (Chile) (Gentes 2001), and other states in the region.

Exported goods varied between countries and from year to year. Livestock products predominated in Argentina and Uruguay until the end of the nineteenth century, later giving way to agricultural production (Rayes 2015). The nitrate obtained in saltpeter territories notably increased Chilean coffers after its victory in the War of the Pacific of 1879–1884 (Fernández Domingo 2015). The sugar trade, cotton exploitation, and gold and diamond mining receded in the face of the coffee boom in Brazil around the middle of the nineteenth century (Murtha, Castro, and Heller 2015). The livestock sector was also consolidated in the territories between São Paulo and Rio Grande do Sul.

Foreign exchange earned from trade in primary goods, labor, and international financing was not evenly distributed within each country (Rückert 2018). The territories that captured most of the resources experienced strong transformations in infrastructure and demographics (Bulmer-Thomas 2003). New ports were added to those inherited from colonial times (Castro and Heller 2007). Large works were built with the purpose of favoring the exploitation and commercialization of the aforementioned resources (ibid.). Works such as channeling the waters of the Carioca River (1750) and constructing an aqueduct of the same name also served to meet the water demand of a growing population through public sources (Murtha, Castro, and Heller 2015).

By the outbreak of World War I (1914), the urban population had increased exponentially. In Uruguay, it had reached 79.1 percent of the total population, and in Argentina, 52.7 percent (MOxLAD 2022). In the first case, the population was concentrated mainly in Montevideo. In the second case, it was mainly distributed between Buenos Aires and Rosario. The Brazilian states of Rio Grande Do Sul, Pernambuco, and São Paulo reached exorbitant demographic figures for the time (Rückert 2018). Santiago de Chile, Valparaíso, Talca, and Iquique also experienced significant growth (Fernández Domingo 2015).

The poor living conditions offered to subaltern sectors, whether newly arrived migrants or ethnic groups with a long history in the territory, contributed to the emergence of epidemics (Paiva 2000). In spite of this, most of the population continued to obtain water and dispose of their feces using methods and means inherited from the colonial period (Murtha, Castro, and Heller 2015).

Several records indicate that well water was common among the better-off, and rainwater storage was common among the less-so (Jacob 2011). Public fountains and watering places were used by many people to supply themselves with water by means of pots or buckets that they transported to their residences (Castillo Fernández 2017). Purchases from water carriers who distributed the resource to areas with difficult access were also common in the Southern Cone (Castro and Heller 2007). Enslaved individuals performed similar work – before the practice's abolishment in 1888 – for wealthy families in Brazil (Murtha, Castro, and Heller 2015). Direct extraction from rivers, streams, and other watercourses was common wherever possible (OSN 1993). Popular sectors collected water from irrigation ditches as another method of consumption in Santiago de Chile (Muñoz 2019). Spread over the layout of the Chilean colonial city, these ditches were also used to evacuate excreta. This system was cleaned with buckets that were then deposited on public roads, removed with carts, and dumped in drains near the city.

"Cesspools" were another mechanism usually used to dispose of waste (Besana 2018). More common than the previous methods was the dumping of sewage directly in public roads. In Brazil, the same slaves who carried water to drink traveled great distances to dispose of wealthy families' sewage (Murtha, Castro, and Heller 2015).

Generally speaking, the poorest sectors had access to more unfavorable sanitation methods, as well as water of lower quantity and quality (Castro Castro and Simón Ruiz 2020). Their "moral backwardness," together with the "material backwardness" of the cities, was conceived as the cause of the epidemics by the local elites under the influence of the miasma theory and hygienist thinking (Fernández Domingo 2015). "The solemnly poor, whose lack of hygiene habits and whose half-savage way of living hasten the death of their children" (Murillo 1875 cited in Fernández Domingo 2015: 15) became the focus of the "social question." Their deaths, "numbering in the thousands" (17), constituted a threat to the health of the local elites.

In Buenos Aires, Montevideo, Santiago de Chile, and Porto Alegre, among other cities, committees or commissions of notables were formed to evaluate the actions to be taken (Lanciotti and Regalsky 2014; Bertino et al. 2012; Castillo Fernández 2017). Along with the education of the poorest in hygiene habits, improvements were promoted for the main popular housing strategies of the time (Fernández Domingo 2015). Measures were also enacted that simply sought to displace numerous sectors to the urban peripheries (Murtha, Castro, and Heller 2015; Besana 2018). Faced with the "moral" and "material backwardness" inherited from the colonial era, the solution to epidemics was thought to lie in the expansion of "modern" water and sanitation networks, such as those in cities in Europe and the United States (Paiva 2000). The occurrence of droughts that affected cities such as Montevideo (1867–1869) and territories in Chile and Brazil led to decisions along these lines (Cooperativa de Trabajo Comunal and Federación de Funcionarios de la OSE 2020). The replacement of methods inherited from the colonial period, however, did not occur automatically, nor was it carried out uniformly in all cities.

The consolidation process of an impersonal state structure – still in its infancy – the separation of powers and competencies between national and regional states and regime changes brought with them numerous delays and inconveniences (Murtha, Castro, and Heller 2015). In Buenos Aires, for example, in 1867, a Comisión de Aguas Corrientes (Running Water Commission) was constituted to promptly initiate water and sanitation works (Lanciotti and Regalsky 2014). However, conflicts between regional elites led to the federalization of the city (1880), delaying the process and transferring responsibilities to the Comisión de Obras de Salubridad (Commission of Health Works) under the Ministerio del Interior de la Nación (Ministry of the Nation's Interior).

The usufruct of saltpeter exploitation allowed the Chilean state to structure its administration towards the end of the 1890s (Sánchez Andaur and Simón Ruiz 2014). It was then that the state gained relative autonomy from sectors of the Santiago elite and took on urban infrastructure projects in a different way. Even so, the "excessive cost" of the sewage works was one of the reasons given for rejecting a national loan in a session of the Chilean Senate in 1896 (Muñoz 2019).

The Brazilian empire, on the other hand, managed to build administrative structures only after the collapse of the customs agreement that united it with Great Britain (1842) (Murtha, Castro, and Heller 2015). Cities such as Pelotas and Rio Grande, however, saw four projects pass, but these took twenty years (1851–1871) to raise the necessary capital and successfully initiate the first waterworks (Rückert 2018). Financing was also a source of problems in Buenos Aires (Lanciotti and Regalsky 2014). The first concession was halted less than a year after beginning due to the bankruptcy of the company's main financier (OSN 1993).

In short, the period was characterized by a multiplicity of modes of sanitation and water supply inherited from the colonial period. As a result of the demographic increase and the poor living conditions in which popular sectors resided, they were unable to prevent the emergence of epidemics. Climatic aspects, such as droughts and floods, also hastened certain decisions. The local elites' aspiration to leave behind the colonial "backwardness" and the marking of the European and North American networks as a symbol of modernity shaped the identification of a single solution. However, the first network sections' expansion was not without its difficulties.

Stage II: Foreign Companies and First Network Services

Between the late nineteenth and early twentieth centuries, Latin American states tried to follow the course dictated by the great powers, even when this did not entirely coincide with the one they had set for themselves (Furtado 1993). The comparative advantages of the neoclassical model were widely accepted by the local elites. The development of the Southern Hemisphere, unlike yet complementary to that of the North, would come from exploiting its natural resources. During this period, the exported primary goods, although fluctuating, showed an upward trend, as did their volumes and average value (Fig. 1).

Most of the exports at the time were mainly destined for Great Britain. This destination, however, represented a smaller percentage of total Argentine exports (Rayes 2015). In other words, Argentina enjoyed greater diversification of products and buyers. Unlike the rest of the region, Brazil's main importer was the United States, especially since the beginning of the coffee cycle (Murtha, Castro, and Heller 2015). The foreign exchange earned through saltpeter nitrate export was the largest contribution to Chile's national budget until 1919, when it lost momentum as a result of a synthetic substitute (Castro Castro and Simón Ruiz 2020). One-third of this budget was absorbed by the Ministerio de Industria y Obras Públicas to develop urban infrastructure.

Until World War I, population growth in Argentina was much higher than in other countries and higher than in later periods (Fig. 2). In global terms, Brazil and Chile lagged behind Argentina and Uruguay. However, during this period, certain Brazilian and Chilean regions grew at the expense of others. In Brazil, for example, some cities prospered around coffee exploitation, which demanded labor, investments, and services (Santos 2013). In Chile, something similar happened with saltpeter nitrate. The population increase of Iquique – which until 1879 belonged to Peru – is illustrative of this. It grew from 300 inhabitants in 1814 to 54,740 by 1895 (Castro Castro and Simón Ruiz 2020). Far from natural water sources and located in the Atacama Desert, one of the driest on the planet, the early – albeit precarious –

access to mains water in Iquique (1890) can only be understood by the income that saltpeter exploitation meant for the coffers of the Chilean state.

In this context of economic expansion and population growth, water network expansion was an expression of the modernization desired by the local elites (Paiva 2000). The expansion of sewage networks was rather considered a priority in the face of epidemics. The latter explains why Montevideo (1857) and Rio de Janeiro (1863) deployed sanitation networks before water (Bertino et al. 2012; Poettering 2018).

Initially, the aim was to extend networks of one type or another through concessions to private companies, as occurred in countries in the Northern Hemisphere (McDonald 2012). Concessions in the Southern Cone, unlike in the Northern Hemisphere, mainly benefited foreign-owned companies (e.g., Bertino et al. 2012). Great Britain, in particular, captured the largest share of the market out of any other country. The British presence in other markets, as well as that of France and the United States, facilitated its dominance in the water and sanitation sector (Rückert 2018). As a result of this presence, commercial water supply was often favored over domestic water supply (e.g., Castro Castro and Simón Ruiz 2020).

The expenditure required to undertake works and extend networks was a factor driving foreign investment. The rentier profile of states that preferred to offload the risks associated with the exploitation of certain resources to the private sector was manifested in specific measures and regulations (Sánchez Andaur and Simón Ruiz 2014). The Código do Imperio (1850, Imperial Code) in Brazil, for example, laid the groundwork for private investment in urban infrastructure and services (Murtha, Castro, and Heller 2015). The laws on the organization and powers of municipalities (1854 and 1887) in Chile did not provide means for local governments to provide networks for themselves (Castillo Fernández 2017).

The impression that Western Europe and the United States had more advanced development and knowledge than those cultivated in the region had much to do with the preference for foreign capital over local capital. The Chilean senate, for example, rejected a sewage network project by local engineer Valentín Martínez pending European bids at the end of the nineteenth century (Muñoz 2019). The first experiences with water networks in Brazil were concessioned to foreign companies under the same pretexts (Rückert 2018).

The concessions in Montevideo were an exception to this pattern. The first master pipes that served the city's sewage network were built between 1852 and 1857 by a Uruguayan firm (Jacob 2011). Montevideo thus became the first city in South America to have sanitation services. In 1869, a partnership between a Uruguayan and two Argentineans won a public bid to supply water to Montevideo. The first sections of the network were inaugurated in 1871. The company, however, had financing difficulties and did not last long in the hands of the Rio de la Plata society, passing into British hands.

The foreign companies, in most cases, were often financed through debentures and shares acquired, on occasion, by members of the local elites and contracting states (Lanciotti and Regalsky 2014). The first experiences with water networks in Brazil are examples of the latter (Rückert 2018). Subsidies, tax exemptions, and interest payments on the applied capital completed the financing strategies for the works, showing the tenor of public participation during the private management stage. In other words, although the services were concessioned to foreign firms, part of the capital with which they developed the works came from the local public and private sectors.

The portion of public capital, however, did not have a major impact on some of the management decisions made by the companies. Among these decisions, the growth of demand – through network expansion – was a priority (Lanciotti and Regalsky 2014). Private investments, on the other hand, were carried out almost exclusively during periods of economic expansion. On the other hand, in less favorable periods, works were suspended, or services became more expensive. This was the case in several regions of the countries analyzed during the crisis of 1890, World War I, and the crisis of 1930, among other contexts. The actions of water and sewage companies owned by the British fund The River Plate Trust Loan & Agency with concessions in Rosario (Argentina) and Montevideo (Uruguay) illustrate this point (Lanciotti and Regalsky 2014; Bertino et al. 2012).

In turn, works aimed at improving the quality of the services provided were developed only under pressure from public counterparts. The creation of municipal companies in Chile and the conflicts in which the central government had to settle, the frustrated expropriation attempts in Montevideo (1875, 1905, and 1921), and the inspections that detected poor quality materials or construction errors in Rosario (1890) are some examples of these disagreements between different levels of government and private companies (Jacob 2011; Castro Castro and Simón Ruiz 2020; Lanciotti and Regalsky 2014).

The services, in most cases, were considered expensive for the time, excluding most of the population from access. The water commodification process formed in similar ways in some regions of Chile and Brazil. Public fountains, which supplied popular sectors water at no cost, were dismantled as the networks were extended. Some state governments in Brazil required concession companies to maintain or build such fountains (Menezes and Aaraújo 1991), but these were exceptions to the rule. More common were cases such as São Paulo (1877), where the argument in favor of destroying the fountains was made in order to force the population to pay for water from the concessioned network (Santos 2013).

With the exception of Chile, and unlike what would have occurred in Europe and the United States (McDonald 2012), it was generally not the municipal states that contracted the services of foreign companies. Most of the experiences in Brazil resulted from agreements between private parties and state governments (Rückert

2018). Others, on the other hand, required large loans from the latter. For its part, the first concession that attempted to extend networks in the City of Buenos Aires was held by the Argentine state (OSN 1993).

The private concession experience in Buenos Aires was one of the shortest in the region. Since 1869, the first water system – only 600 meters of pipes – had supplied the central streets of the city (Lanciotti and Regalsky 2014). Shortly after the city was federalized, towards the end of the 1880s, the Comisión de Obras de Salubridad granted a concession for water and sewage services to the English capital company The Buenos Aires Water Supply (OSN 1993; Pereyra 2009). The crisis that hit Great Britain hard in 1890 pushed the Baring House – the main financier of the awarded company – into bankruptcy and led to the termination of the contract in 1891.

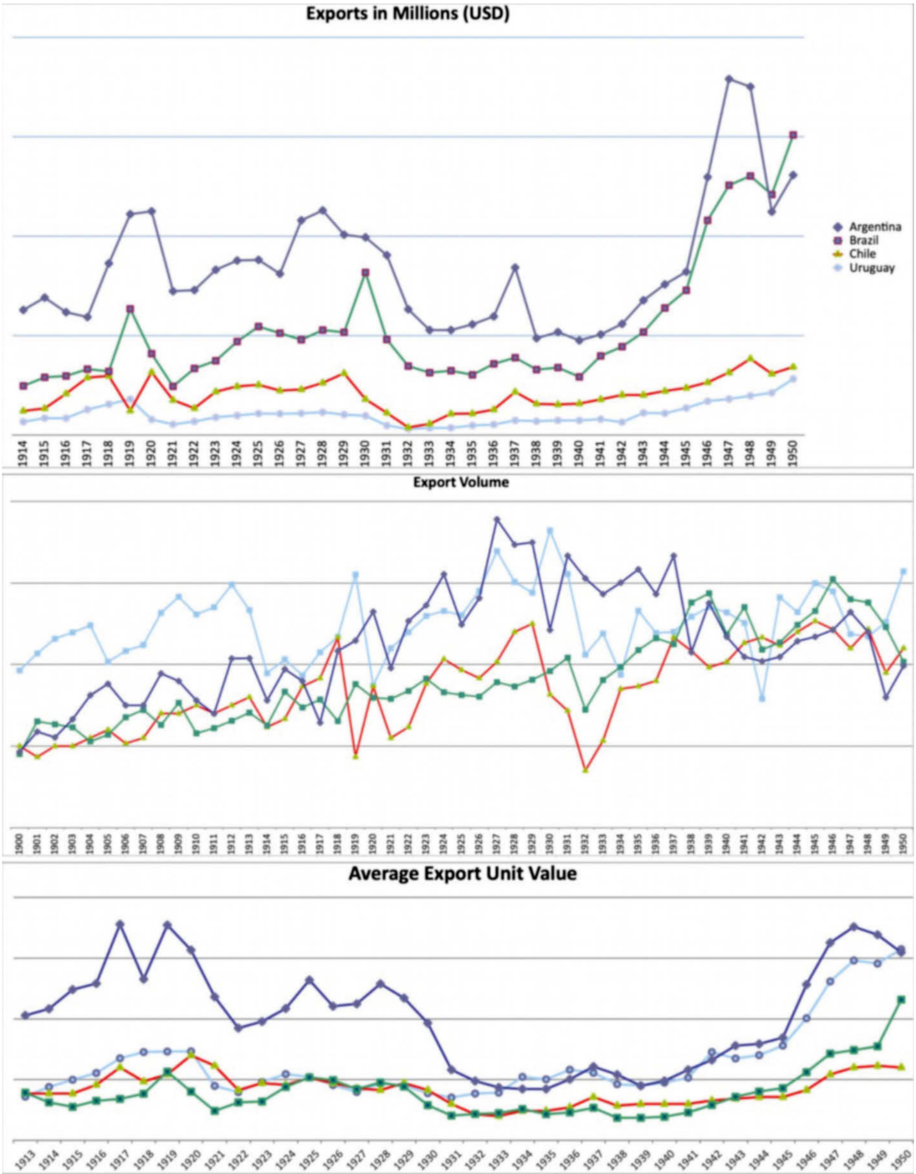
The short duration of private management in the City of Buenos Aires contrasts with the experiences of Rosario, in the same country, and Montevideo, in neighboring Uruguay (Cooperativa de trabajo Comuna and Federación de Funcionarios de la OSE 2020), as well as with those of Santos and Rio de Janeiro, for sanitation services, in Brazil (Castro and Heller 2007). In all cases, the concessions were extended until the mid-twentieth century.

By 1914, the demand for water increased (e.g., Santos 2013). In addition to population growth, this was caused by the effect of hygienist preaching, the implementation of concrete measures that favored better hygiene habits, and the emergence of economic activities that demanded more water, among other factors.

Most private companies, however, only provided services to those with the ability to pay, generally in the central ejidos (municipal territories) of large cities (Murtha, Castro, and Heller 2015). During this period, the remaining sectors continued to access water and sanitation mechanisms of varying quality through multiple means (Castillo Fernández 2017). Privately owned utilities were characterized by several problems, such as low water pressure, bad odors, color, and excessive nutrient load, among others (Jacob 2011).

The end of the first globalization ushered in an international context that was less favorable for countries that based their development on natural resource exploitation (Rayes 2015). While before that period foreign companies considered the water and sanitation market in the region auspicious, later on, disinterest in investing in works without attractive returns led them to divest their assets (e.g., Lanciotti and Regalsky 2014). In view of the dissatisfaction with the services provided by the previous networks, some local and provincial governments tried to extend water and sanitation, but the economic difficulties they experienced presented serious obstacles. A series of factors paved the way for the intervention of central states where they did not beforehand. The idea of an entrepreneurial state that would dynamize national economies and structure societies on a path of modernization laid the ideological foundations for the next stage (Pinilla and Aparicio 2015).

Figure 1: Exported Primary Goods in Millions of USD 1914–50 (top), Percentage Volume 1900–50[1] [1] (middle), and Average Unit Value 1913–50[2] [2] (bottom)



Source: Authors' elaboration with data from MOxLAD (2022).

1 [1] The 1970 value is considered to be equivalent to 100 percent.

2 [2] The 1970 value is considered to be equivalent to 100 percent.

Figure 2: Population growth (1900–50)

	Argentina		Brazil		Chile		Uruguay	
Years	Total Population in Thousands	Interannual Population Growth %	Total Population in Thousands	Interannual Population Growth %	Total Population in Thousands	Interannual PopulationGrowth %	Total Population in Thousands	Interannual Population Growth %
1900	4632		18599		2959	1.16	977	
1901	4762	2.81	19023	2.28	2994	1.18	987	1.02
1902	4893	2.75	19426	2.12	3030	1.20	916	-7.19
1903	5003	2.25	19840	2.13	3066	1.19	1038	13.32
1904	5124	2.42	20254	2.09	3102	1.17	1058	1.93
1905	5315	3.73	20688	2.14	3139	1.19	1089	2.93
1906	5546	4.35	21133	2.15	3176	1.18	1120	2.85
1907	5847	5.43	21578	2.11	3213	1.16	1160	3.57
1908	6179	5.68	22033	2.11	3253	1.24	1069	-7.84
1909	6460	4.55	22498	2.11	3294	1.26	1120	4.77
1910	6832	5.76	22984	2.16	3336	1.28	1150	2.68
1911	7103	3.97	23471	2.12	3378	1.26	1201	4.43
1912	7505	5.66	23967	2.11	3421	1.27	1252	4.25
1913	7877	4.96	24474	2.12	3465	1.29	1303	4.07
1914	8037	2.03	24991	2.11	3509	1.27	1343	3.07
Subtotal	3405	73.51	6392	34.37	550	18.59	366	37.46
1915	8188	1.88	25519	2.11	3553	1.25	1374	2.31
1916	8339	1.84	26067	2.15	3598	1.27	1404	2.18
1917	8490	1.81	26615	2.10	3644	1.28	1435	2.21
1918	8640	1.77	27184	2.14	3690	1.26	1455	1.39
1919	8791	1.75	27763	2.13	3737	1.27	1486	2.13
1920	9012	2.51	28343	2.09	3785	1.28	1506	1.35
1921	9263	2.79	28932	2.08	3853	1.80	1527	1.39
1922	9565	3.26	29522	2.04	3907	1.40	1547	1.31
1923	9936	3.88	30132	2.07	3961	1.38	1567	1.29
1924	10268	3.34	30742	2.02	4017	1.41	1577	0.64
1925	10549	2.74	31373	2.05	4073	1.39	1598	1.33
1926	10851	2.86	32015	2.05	4130	1.40	1628	1.88
1927	11182	3.05	32677	2.07	4188	1.40	1659	1.90
1928	11494	2.79	33339	2.03	4246	1.38	1700	2.47
1929	11805	2.71	34032	2.08	4305	1.39	1730	1.76
1930	12106	2.55	34725	2.04	4365	1.39	1761	1.79
Subtotal	3918	47.85	9206	36.08	812	22.85	387	28.17
1931	12348	2.00	35439	2.06	4429	1.47	1791	1.70
1932	12579	1.87	36163	2.04	4495	1.49	1822	1.73
1933	12790	1.68	36897	2.03	4563	1.51	1852	1.65
1934	13001	1.65	37652	2.05	4631	1.49	1873	1.13
1935	13212	1.62	38428	2.06	4700	1.49	1903	1.60
1936	13433	1.67	39214	2.05	4771	1.51	1924	1.10
1937	13674	1.79	40021	2.06	4842	1.49	1842	-4.26
1938	13905	1.69	40838	2.04	4914	1.49	1862	1.09
1939	14126	1.59	41676	2.05	4988	1.51	1985	6.61
1940	14236	0.78	42524	2.03	5063	1.50	2005	1.01
1941	14467	1.62	43517	2.34	5149	1.70	2025	1.00
1942	14709	1.67	44541	2.35	5244	1.85	2046	1.04
1943	14950	1.64	45503	2.16	5341	1.85	2066	0.98
1944	15201	1.68	46383	1.93	5440	1.85	2097	1.50
1945	15472	1.78	47438	2.27	5541	1.86	2117	0.95
1946	15723	1.62	48586	2.42	5643	1.84	2137	0.94
1947	16005	1.79	49817	2.53	5748	1.86	2158	0.98
1948	16346	2.13	51120	2.62	5854	1.84	2178	0.93
1949	16738	2.40	52506	2.71	5962	1.84	2208	1.38
1950	17150	2.46	53975	2.80	6082	2.01	2239	1.40
Subtotal	4802	38.89	18536	52.30	1653	37.32	448	25.01

Source: Authors' elaboration with data from MOxLAD (2022).

Stage III: Public Management, Centralization, and Attempted Universalization

The expectations with which the South American elites received the twentieth century (Ortemberg 2016) were reduced to little more than memories fifty years later (Furtado 1993). Three international shocks shattered the consensus on the primary goods export model, promoting other models aimed at circumventing the developmental limits it imposed (Pinilla and Aparicio 2015).

South American exports suffered the effects of World War I (1914–18), but showed signs of recovery soon after, reaching record figures between 1924 and 1928. The foreign currency obtained by these means and from international financing favored an initial process of nationalization and the creation of public companies (Lanciotti and Regalsk, 2014). Private concessions coexisted and competed with municipal water companies in Chile between the end of the nineteenth century and the beginning of the twentieth century (Castro Castro and Simón Ruiz 2020). The Dirección General de Obras Públicas (Directorate General of Public Works) of the Chilean state was also empowered to collaborate in the drafting of water and sewage projects in several localities of the country. The sanitation network in Montevideo was transferred to the municipal sphere in 1915 (Bertino et al. 2012). The water and sewage works in the City of Buenos Aires – once the first concession was federalized and aborted – required part of the extraordinary income being obtained by the Argentine state (Lanciotti and Regalsky 2014). Brazilian state governments created public companies after the declaration of the federal republic (1889) due also to the possibility of contracting international debt and obtaining a monopoly on export taxes previously shared with the imperial state (Santos 2013).

More kilometers of networks and better services were reasons given in favor of public intervention in the sector. "The ideal would be that all drinking water supplies are funded by the Public Administration properly and without interest," claimed a commissioner in charge of evaluating access to the resource in Iquique (Salas Lavaqui 1908: 221, in Castro Castro and Simón Ruiz 2020: 20). Such demands became more frequent as the population increased (Fig. 2).

The demographic phenomenon took on a greater dimension in the cities. 81.8 percent of the Uruguayan population lived in cities in 1937; in Argentina, 62.5 percent in 1947; and in Chile 52.5 percent in 1940. The situation in Brazil was different until 1950, with 36.16 percent of the population living in urban areas. However, the inhabitants of São Paulo – among other Brazilian cities – increased significantly, from 64,934 in 1890 to 579,033 in 1920 (Santos 2013).

Population growth and public management of urban services were, in general, linked to economic interests. The immigration subsidies and the nationalization of water and sewage services by the São Paulo government (1892), for example, were implemented only a year after a federal decree that established the decentralization of sanitary organizations and utilized resources from the coffee oligarchy to meet their needs (ibid.). In this sense, the first years of public administration were not aimed at moving towards universal provision. Mains water in Buenos Aires only reached the central streets until the end of the nineteenth century (OSN 1993). Restrictive housing legislation conspired against formal land tenure (1909) and drove vast sectors to the urban peripheries of Santiago de Chile (Fernández Domingo 2015). Something similar happened in São Paulo, Campinas, Santos, Rio de Janeiro, Recife, Belém, São Luis, among other Brazilian cities (Castro and Heller 2007). Informal land tenure conspired against the popular sectors' connection to water and sewage networks as unplanned forms of urbanization advanced (Besana and Gutierrez 2022).

The provided services' poor quality was not exclusive to the private management that dominated in the previous stage. Scarcity and high prices continued to characterize the mains water supply in northern Chile after the creation of municipal companies (Castro Castro and Simón Ruiz 2020). An advertisement for a soft drink in the newspaper O Estado de São Paulo (1921) illustrated the water quality with a cartoon in which the person in charge of the network recommends soft drink consumption – "Doctor, here is an example of the water they make us drink […] My God! […] Do as I do. It is better to drink Guaraná Espumante" (Santos 2013: 17).

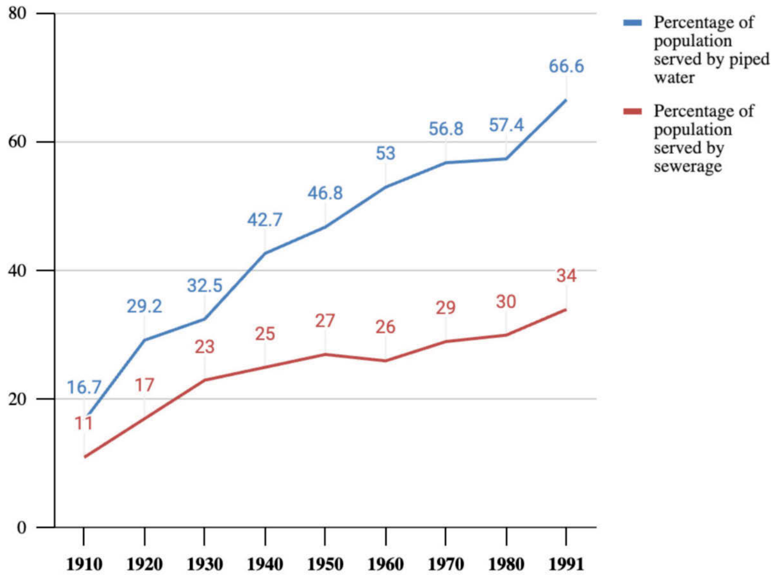
Popular sectors' access to public services began to expand along with incipient industrialization. In Buenos Aires, this process occurred well in advance of development theory's formalization, with emphasis on the domestic market and import substitution industrialization. The Argentine state's management of water and sanitation contributed to this substitution, bringing in American-style filters and ferric aluminum, among other imported goods, until the outbreak of World War I (Lanciotti and Regalsky 2014).

The greater involvement of central states and significant progress in water and sanitation networks coincided with universal male suffrage in Argentina (1912) and female suffrage in Brazil (1933) (Castro and Heller 2007). However, a direct relationship between social actor demands and network expansion during the period analyzed is not indicated – or even hinted at – in any of these cases. On the contrary, some studies suggest that there is no link between these two aspects, both in the region (e.g., Castro and Heller 2007) and in other parts of the world (Dryzek and Pickering 2019).

The creation of the public company Obras Sanitarias de la Nación (OSN, Sanitary Works of the Nation) was a milestone in Argentina's healthcare (OSN 1993). Together with cases in Europe, it inspired the centralization of water and sanitation services in the hands of the Brazilian (1934) and Uruguayan (1952) central states (Murtha, Castro, and Heller 2015).

An accelerated expansion of networks and a surplus balance that allowed the cancellation of loans earlier than requested (1907) took place after the creation of the Ministerio de Obras Públicas (Ministry of Public Works) in Argentina (Lanciotti and Regalsky 2014). The National Congress accepted a request to complete the laying of networks in the federal capital by 1920 and extend it to cities in the interior of the country based on previous successes. In response, OSN was created in 1912 and given autonomy to finance itself (Acuña et al. 2017). The portion of the population served with potable water nearly doubled during its first decade. Such an increase has never been repeated since (Fig. 3).

Figure 3: Percentage of population served by piped water and sewerage in Argentina (1910–91)



Source: Author's elaboration with data from Acuña et al. (2017).

The 1929 crisis ended the illusion of a return to a more favorable context for South American exports (Pinilla and Aparicio 2015). This event began a period in which OSN's good performance was sustained by national treasury contributions (Lanciotti and Regalsky 2014). Such revenues were also the main sources of financing for the nationalization and centralization of services in Brazil, Chile, and Uruguay (e.g., Menezes and Aaraújo 1991).

Bilateral treaties offering significant concessions, increases in export volume (Fig. 1), and the destruction of surplus commodities, among other strategies, proved unsuccessful in addressing the deterioration of the terms of trade, sustaining the export model, and confronting the protectionist policies adopted by core countries (Pinilla and Aparicio 2015). The outbreak of World War II (1939–45) interrupted a budding and timid recovery of exports (1937–38 – Fig. 1), definitively putting an end to a return to the pre-war context.

Measures aimed at strengthening the domestic market and substituting industrial imports for domestic products became more common as a response to the fluctuations suffered by primary goods exports during the first half of the twentieth century. Population growth continued between 1930 and 1950 (Fig. 2). Brazil's demographic rate exceeded that of other countries, while Chile showed higher percentages than the previous period.

Modernizing national industries and providing better welfare became imperative when faced with population growth and the instability of South American exports. The Brazilian revolution (1930), in this sense, put an end to the pact of alternation in federal power between elites associated with the coffee-growing complex in São Paulo and the cattle-raising complex in Minas Gerais (Castro and Heller 2007). Soon after, the sanctions of a new constitution and the Código das aguas (1934, Water Code) nationalized water resources and prioritized hydroelectric power generation for industry and the expansion of price-regulated water and sewage services. In Argentina, OSN's coverage area was expanded twice in 1941 (Besana 2018). First, fourteen districts of the Province of Buenos Aires bordering the federal capital were incorporated, then localities of up to 1,000 inhabitants in the interior of the country (Lanciotti and Regalsky 2014). The nationalization of Uruguayan services went from the periphery to the center. Five cities in the interior of the country were provided with water and sewage by the Dirección de Saneamiento de Uruguay (Sanitation Directorate of Uruguay) around 1930, which also had an impact on reducing the country's mortality rate (Bertino et al. 2012).

On the other hand, a British company continued to be in charge of water supply in Montevideo until 1952. At that time, the creation of Obras Sanitarias del Estado (OSE, Sanitary Works of the State) included in its coverage the entire Uruguayan territory (Santos 2010; Taks 2008), with the exception of the sewage service in Montevideo itself, which continued to be municipal (Jacob 2011). The service centralization in Chile took longer. A water code sanctioned in 1951 and the merger of two bodies into the Dirección de Obras Sanitarias (1953, Directorate of Sanitary Works) gave the Chilean state more tools to combat excessive prices in some territories and to try to expand coverage in the cities (Madaleno 2009). However, until then, the right to use water in some places continued to benefit the private sector. It was only with a new water code (1967) and within the framework of an agrarian reform initiated three years earlier that the central government reserved the power to reassign water rights and establish priority for its use.

In short, service universalization and centralization were the features that nation-states tried to implement during this stage. In general, both were linked to a new development model based on import substitution industrialization to provide services to an enormous labor force. However, despite the change in the model pursued, both import substitution industrialization and service expansion continued to depend on foreign currency obtained through primary goods export. Unfavorably, this situation contributed to the degradation of the region's environment and climate in line with the passage of the geological era without achieving the goal of universalizing water and sanitation services. A discussion of these and other issues concludes this paper.

Conclusions

Of the many controversies surrounding the Anthropocene, its partial coincidence with the modern period does not arouse much discussion. Along with this, the discrimination between culture and nature and the idea of unlimited development, among other foundations of modern thought, are often understood as a symbolic basis for the change of geological epoch. This association, among other issues, is due to the fact that both the Anthropocene and Modernity designate a general state of affairs composed of a set of diverse elements and processes. In other words, Anthropocene and Modernity are not synonyms, but they present an elective affinity.

The expansion of water and sanitation networks in the Southern Cone and Brazil, as well as in other regions, is one of the processes that characterized the modern project that contributed to the passage of the geological epoch. More broadly, historiography associates this expansion with the modernization of the region (Halperin Donghi 2005). In addition, the link between water and sanitation networks and the Anthropocene has been discussed in this work.

This chapter has focused on the analysis of network expansion in order to fully understand how it was associated with the change of the geologic era. In symbolic terms, it showed how network water and sanitation were conceived as an expression of man's dominion over his environment, more specifically, underlining how this was seen as a way of reaching the development of Western Europe and the United States to move away from colonial or pre-Columbian backwardness. In structural terms, it has shown how the possibilities of extending service networks were tied to obtaining foreign exchange through the exploitation of nature and the trade of primary goods.

Considering such exploitation and trade as a counterpart of Latin American overurbanization was reason enough to choose Anthropocene over Urbanocene as the new geological epoch's name. This does not mean ignoring the responsibility regional and international power sectors had in the exploitation of goods and the overurbanization of territories connected to international trade. Various forms of exploitation (colonialist, capitalist, etc.) entrenched geographical, socioeconomic, and ethnic inequalities, among others.

Droughts, on the other hand, had a minor impact on the ways and times in which networks were extended in different territories. Along with other climatic events, these occurred more frequently from 1950 onwards (Castro 2011). However, the main victims of droughts and other climatic events after the mid-twentieth century result from inequalities originating before 1950 (Soluri, Leal, and Pádua 2018). Based on this chapter's approach, the clearing of native trees for commodity production, the overexploitation of some territories, the huge urbanization of others, and the inequality of freshwater consumption, among other vast factors commonly associated with climate change and disaster risks, have a relationship to water and sanitation network expansion.

In general terms, however, this narrative came about from one of the most important research results: the distinction of three stages in the process of extending service networks. Unlike what other research suggests, these stages are not a mere reflection of network expansion in countries such as the United States or Great Britain. On the contrary, the countries analyzed here occupied a subordinate position in relation to those just mentioned, and this had a particular impact on the features common to each period.

The first stage was characterized by a multiplicity of methods inherited from the colonial period that were insufficient to meet the needs of a growing population and avoid the emergence of epidemics. As to the latter, it could be observed that the local elites associated the emergence of epidemics with the "social question" – the hygiene habits and characteristics of subaltern sectors – and identified in European and North American networks a solution to the risks that afflicted them, giving way to a new stage.

In the face of numerous inconveniences, expansion of the first networks through concessions between governments at different levels and foreign companies was the central feature of the second stage. Foreignness was as important as the companies' private nature because both aspects determined how networks spread. In this sense, the companies not only favored the expansion of demand over the quality of the services provided in search of higher revenues but were only active in periods of economic expansion and exchange rate stability. Changes in the terms of trade, international crises, or crises in their countries of origin increased the cost of services and delayed work. Although local actors (state and private) participated in financing foreign companies, the interests of the latter prevailed in management. In this sense, this stage resulted in expensive, low-quality services that only benefited sectors with the ability to pay. As an added bonus, numerous conflicts between these companies and their public counterparts paved the way for the next stage.

A trend toward service centralization and the search to universalize or at least extend services as much as possible characterize the third stage. In the latter, the main purpose of national companies was not to maximize profits, but to strengthen a process of industrialization by import substitution, providing water to production sectors and the huge labor force required in this process.

Despite the commonalities, service centralization in these various countries and subnational territories began years apart. On the extremes, in Argentina, this process began in 1912, while in Chile, it started in 1967. Similarly, the transition from a private company to one dependent on the central state took place almost without mediation in the capital of Argentina, while state and municipal government companies in Brazil and Chile, respectively, took over functions before national public companies did so. In Uruguay, on the other hand, centralization took an inverse path geographically to the other countries, moving from the interior to the capital.

The previous stages also present differences in the ways and times in which they developed in each country or territory. Each stage laid the foundations for the next, although some territories maintained features of the previous. Thus, private companies survived for a long time after centralization, and even today there are still territories and sectors that have access to water and sanitation by the means described in Stage I. In general, these are made up of popular sectors, ethnic minorities, and Indigenous peoples who tend to reside in urban and rural peripheries.

More broadly, each stage was linked to global processes. The first stage took place in the context of the free movement of products, capital, and labor. The countries here analyzed joined the international division of labor as sovereign nations and specialized in primary goods production. To this end, they expanded their national borders and incorporated exploitable lands through military campaigns, generally to the detriment of native peoples and criollos. A development model based on foreign exchange obtained through the exploitation of nature and the export of primary goods was established at that time and maintained during most of the second stage.

During the second stage, three international shocks had a strong impact on commodity prices, profit margins, and export volumes. In an attempt to sustain the export model in the face of deteriorating terms of trade and protectionist policies adopted by core countries, production volume was increased, or entire crops were destroyed. This increased the pressure of the Southern Cone countries and Brazil on their natural assets, although without significant impacts on foreign exchange earnings. After several failed attempts, it was decided to pursue a development model based on import substitution industrialization.

This model characterized the third stage and was related to the influence of central states. However, the same difficulties that pushed the search for a new development model imposed limits on it. Ultimately, neither the path of industrialization taken nor the universalization planned to bring water and sanitation to its workers was completed.

In short, the expansion of water and sanitation networks in the Southern Cone and Brazil followed a different path from that of the major world powers, although marked by their dependence on them. The region's subordinate incorporation into the international division of labor as a primary goods producer was not completely reversed. Thus, water and sanitation network expansion, as well as any other process associated with modernity, exerted strong pressure on the natural assets necessary for its financing. This pushed large portions of the rural population to settle in cities, making Latin America the most urbanized region on the planet. At the local level, this situation has increased the population living in informal conditions, without access to services and exposed to environmental risks. On an international scale, it has contributed to the global climate and environmental crisis and reinforced the conditions associated with the emergence of the Anthropocene.

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Water in the Andes from the Mid-Nineteenth Century to 1950

Water Management: Tensions, Risks, and Legislation. An Articulating Socio-Environmental Perspective

Sofía Luzuriaga Jaramillo, Julien Rebotier, and Samuel Baena Carrillo

Temporal and spatial scales are necessary tools to critically understand social and environmental processes. The borders of the event and the conjuncture, as well as those local and national, are insufficient to comprehend what will happen in the long term or on a global or even regional horizon. However, this insufficiency does not imply exclusion, but rather a combination of scales in a complex structural view. Perhaps one of the broadest structures is the Anthropocene: the epoch structure currently sounding alarm bells about the commons, including water.

With the starting premise thus outlined, this chapter asks how water management in the Andean region – urban and rural – shifted in the rupture of the nineteenth century and the dawn of the twentieth century: a fundamental moment of changes towards "modernizing" according to the logic of the ideal of progress. Specifically, reference will be made to different enclaves in the current Andean countries of Colombia, Peru, Ecuador, Venezuela, Bolivia, Chile, and Argentina, thus seeking a regional perspective that will take certain case studies as indicators of shared trends concerning the overarching theme.

In turn, the topic will be broken down into three areas of interest: the interactions between local and state power and social actors linked to water use and management; the transformations of space that gradually pose risk conditions for communities; and the legislative journey that has accompanied and shaped these tensions and modifications in the space and control of water.

Water Use and Management: Interaction and Tension in Andean Water Spaces

As an introduction, this section will note the perseverance in the occupation of Andean enclaves and the central role of local institutions in managing water spaces.

Next, it will analyze the conflicts over administering watercourses linked to irrigation techniques. Finally, this section will observe the modernizing hygienist projects and one of its articulating axes: water.

The spaces we inhabit today have shaped us in the long term. Although the toponyms have largely lost the trace of their past sounds, the material and symbolic location of these places constitutes us. The settlements and exchange crossings in the Andes have been maintained over time despite the sixteenth-century colonial fracture and the effects of population and land administration. One of the key elements for settlement in a place is precisely its access to fresh water. In this light, the Andean space – the northern Andes in particular – constitutes one of the most important regions in the world, with high levels of rainfall, large surface water basins, and biomes that function as water regulators (Hosftede 2003: 1).

An example of this large freshwater influx and the continuity of inhabited spaces is the populations of the three regional axes in the current borders of Ecuador. Before the sixteenth century, these groups were already located in or traveled on the "thaws of the Pichincha volcano in Quito, in the Daule River in Guayaquil, and the four rivers (Tomebamba, Yanucay, Tarqui, and Machángara) of Cuenca" (Martínez Moscoso 2019: 32). In Colombia, the San Agustín, San Francisco, Arzobispo, and San Cristóbal rivers surround and delimit the city in the Cundiboyacense altiplano of the Bogotá savannah (Osorio Osorio 2009: 2); and in Peru, the conquistadors' gaze went to the coast, to the valley of the Rímac River (Lossio 2003: 18), a valley in which they would found the city of Lima "on top of an aquifer of approximately 390 square kilometers with a depth of 100 to 500 meters"; "water percolation from the mountain range and the Rímac River" served to fill the aquifer, giving rise "to springs and *puquios* [subterranean aqueducts] that provided (and still provide) drinking water to the people of Lima" (Bell 2014: 94).

When the Andes gradually became part of the modern world system, the *cabildo* was the local government body that dealt with colonial needs for the administration of the water space and had jurisdiction over both the land and the management of the water system. The *cabildo* was, therefore, the "axis of urban life, of daily life, of the public, and of the state in the localities," and its power did not diminish at the beginning of the Republic (Borrero Vega 2015: 75–76). With names such as *cabildo* of the *ancien régime*, constitutional city council, or republican municipal corporation of the nineteenth century, this governmental body constituted an organizing pillar of the local territory and water space which, far from being an administrative abstraction, was composed of the colonial or republican elites, thus marking a series of tensions. One of these was the tension between the public interests it was meant to serve and the demands of class, among others, when it came to the distribution and management of water. Another existed between local rivalries and the public policies of the government and central state, which gradually became the organizing axis for the territory and its common goods during the republican period.

When reviewing the judgments of different documentary sources from the colonial period, one can observe the recurrent conflicts between neighbors over watercourses and their diversion, use, and passage.

Thus, the tension between local administrative institutions, the economic-political power groups, and the population over which an intersectional power of domination is exercised in different spaces is palpable. If what happened with irrigation, water courses, and land dispossession is considered, this assertion can be better understood as applicable to the late nineteenth and early twentieth centuries, but which structurally precedes and follows this time frame.

Irrigation Conflicts and Structural Dispossession

As indicated above, the northern Andean area has angular and abundant water complexes. This condition would allow, a priori, that there is no scarcity for irrigation and that the amount of cultivated land transcends, in a high percentage, a dependence on rainfall, that is to say, that irrigation is "a water complement in rainfed crops" (Ruf and Núñez 1991: 95). Moreover, irrigation and drainage are ancestral knowledge and techniques, which for centuries made "water a network of interconnection, integrating human needs with the constraints imposed by the ecological structure" (Rodríguez Gallo 2019: 211). However, despite the circumstances and aforementioned knowledge, irrigation is an element of dispute, dispossession, and scarcity in the long term: a situation that began with the different colonial administrations and officials who were previously familiar with it as a technique and, therefore, projected its use to control space, common goods, and populations.

This project, already established and in operation, reveals its deep cracks of structural dispossession during the twentieth century, even within the legal frameworks that resulted from supposedly inclusive republicanism in this regard. In the Ica Valley, in present-day Peru, the 1902 Water Code was applied, which recognized Indigenous authorities for water management and creating syndicates of landowners and peasants in charge of the infrastructure and monitoring of distribution. In this normative context, the demands of dispossessed groups reached a level of enunciation and action that evidences the dissymmetrical use and control of the commons. The breaking point came with the Parcona massacre in 1924 and the consequent disappearance of the village that constituted the meeting place of the peasant organization: "the Indigenous people, through their union organization, had managed to improve water management, thus clashing with the interests of the landowners" (Apacarana Puquio 2017: 60).

From an epochal understanding, there is an opposition between the owners of *estancias* and *haciendas* and the peasant communities. Outside explicit frameworks of violence – and in its broad and constant contexts – conflicts could be resolved by "capturing an unexploited resource in a neighboring basin; as well as by capturing water downstream from existing systems if the resource [was] fed by other tributaries"; or, equally, by "capturing water upstream from existing systems," which generated "water mobilization conflicts at the intake level" (Ruf and Núñez 1991: 98). In many areas of the Andes and in present-day Ecuador, traditional irrigation canals coexist with those created by state administrations in the twentieth century; the installation of horizontal hydraulic structures, being costly, coexist mostly with vertical ones, which use natural streams as much as possible (Ruf and Núñez 1991: 101). Hence, canals and conflicts, old and new, configure water supply and management relations in an antagonistic structure.

This structure, under the concept of "accumulation by dispossession" – using Harvey's (2004) notion – can also be seen in Santiago de Chile. In 1900, when faced with a biting drought, "the state set as a priority objective the safe provision of water for the population," which was the basis for "greater control of the rivers of the Province of Santiago"; this also led to the enactment of law number 2139 of canal associations, whose board of directors "became, de facto, a court of first instance to resolve any matter, dispute, or conflict occurring within the margins of the canals and over the waters transported by these aqueducts" (Castillo 2020: 26–27). Thus, "the law on canal associations of 1908 and the Chilean Water Code enacted in 1981 are two pieces of evidence that allow us to insinuate that the water accumulation by dispossession has been a process validated at the beginning of the twentieth century and deepened throughout this one" (Castillo 2020: 33).

Thus, irrigation water control and land dispossession are two elements intertwined in the administration of Andean space. Bolivia also demonstrates this in its constant struggles for water, which go beyond the legal framework based on a water law from 1906; these struggles reveal the inadequacy of the regulatory body of the 1970s and 1990s or even the early twenty-first century (SEMAPA). But this entanglement is also ratified in spaces such as the governance of Tucumán, which, although it does not have deep roots with the north Andes in its preconquest process, shares with it "institutions and some common policies" – as Córdoba was part of the Peruvian viceroyalty until almost the end of the Colony (Tell 2011: 418). In this way, between 1870 and 1880, provincial or municipal governments arrogated direct or imminent dominion over the land, selling it, giving it in emphyteusis (land concession contract in exchange for the annual payment of a fee or rent), or charging rent (Tell 2011: 421–422).

Urban Sprawl, Hygiene Movement, and Water Management

Local institutions organize the water space and exercise an intersectional power of domination. From there, public policies for land and population management are outlined, both in rural and urban areas, which are indissolubly intertwined. Properly placed in the cities' challenges at the end of the nineteenth century, the whole system of water collection, conduction, and distribution started to become obsolete. The city was dense and no longer had sufficient resources "for those who make it grow, for those who come from other spaces" in these regional centers, believing they needed to "sign modernization documents with the rubric of unappealable progress" (Luzuriaga Jaramillo 2013: 140).

The above statement, referring to Quito, can be reflected in other Andean urban places that became poles of population growth and densification, since the last decades of the nineteenth century for several of them. For example, Bogotá, which had about 40,000 inhabitants around 1842, grew to about 85,000 in 1881 (in Osorio Osorio 2009: 6); then, between "1900 and 1925, the original population of 100,000 inhabitants practically doubled" (Gallini et al. 2014: 7). Also of note, Santiago's population increased from about 190,000 in 1885 to 333,000 by 1907 (Fernández Domingo 2015: 120). They were considered poles, either because they constituted regional axes with the resulting administrative services in the territory and opportunities for social mobility or because of the productive growth linked to some type of raw material exploitation. An example of this was the productive mountain areas in Venezuela, which experienced the growth of the network of Andean settlements from the last quarter of the nineteenth century until the third decade of the twentieth century. Growth here was consolidated "with the boom in the coffee economy, whose export volumes stimulated the construction of railroads to the ports south of Lake Maracaibo" (Rojas López cited in Pulido 2011: 108).

Other variables are associated with population growth, such as pressure on the cities' ecological structure. With the exponential growth of the population, spaces experienced pressure on common goods, which deteriorated: high consumption of firewood, pollution of water sources due to vertical logics of use, and ecosystemic imbalance due to soil alteration are a few of the elements observed in the different Andean cities in the first quarter of the twentieth century. Thus, in Bogotá, the wetlands "decreased from several thousand hectares at the beginning of the century, to 50,000 hectares in 1938 to only 500 hectares in 2005" (Gallini et al. 2014: 7).

Likewise, a variable of densification of already urbanized spaces can be observed as a fundamental social element when analyzing the transformation of the Andean urban poles, since, simultaneous to a displacement of the elites to other spaces – such as to La Mariscal in Quito, or to the southeast and north of Las Delicias avenue in Santiago de Chile (Fernández Domingo 2015: 120) – there is also an intra-territorial migration and phenomena of population densification and tenancy; or, even, the creation of slums (*tugurización*) (Lossio 2003: 20). In fact, population growth did not necessarily imply architectural growth – as when, for example, the elites moved in – but rather a concentration in existing buildings, with the frequent phenomena of over-occupation. These places were targeted by the hygienist control, being considered possible "foci of infection."

In fact, linked to these and other variables is the management of public and private spaces by local institutions. With the systematic growth of inhabitants and occupied areas, the ruling elites were faced with the challenge of the polity's health, often depleted by epidemics and water diseases, such as typhoid fever, dysentery, enteritis, "*enfermedad de los cotos*" (swollen thyroid), dropsy, and very high infant mortality rates (Fernández Domingo 2015: 124). The paradigm shift that occurred with the pasteurian revolution, the emphasis on social medicine, and the growing body of empirical information from microbiology and chemical analysis were articulated into a modernization project legitimized by the pathway toward progress and the white-mestizo hygienist civilizing project (Luzuriaga Jaramillo 2013).

In this context, the various processes for the provision of drinking water services in the urban Andes, whether massive or incipient, must be situated. They generally took place in the last decades of the nineteenth century and the first decades of the twentieth century, with pipes being laid in the midst of various discourses, projections, resource shortages, and infrastructure works. Globally, however, they were laid and fastened in response to the urgency for a continuous supply of hygienically controlled water. The combination of supply and hygiene proved its effectiveness time and again in terms of the inhabitants' health. It was necessary to implement multiple central and satellite strategies to ensure the aforementioned duplicity. When the river flows that fed the consumption of Bogotá decreased, a sharp sanitary crisis arose; the proposed solution aimed at protecting the hydrographic basins linked to the maintenance of these flows. With this, a notable "decrease in mortality from waterborne diseases [occurred]: mortality rates from typhoid fever dropped from 136 deaths per 100,000 inhabitants in 1915 to 58 deaths per 100,000 inhabitants in 1921" (Gallini et al. 2014).

The pathway toward progress and control over the watersheds was not implemented on the basis of a general agreement. Dissent, rivalry, class interests, and resistance to dispossession marked the tonalities of these antagonistic structural processes, mentioned above for irrigation, but which are clearly observed in the poles of urban expansion. Antagonisms and struggles also took place between local governments and the central state. In fact, another transversal element to consider is that, within the process of institutionalization of water management both in the city and in the countryside, there are moments of overlapping, dominance, and regency between these two orders. In the transition from the nineteenth to the twentieth century, the state and its bureaucratic apparatus sought to control the projects traditionally handled by local institutions (Maiguashca 1992: 194). Likewise – with great clarity in the implementation of potable water conduction and distribution systems – the need to call on private enterprise manifested, "since it was a service that demanded large investments," whose "execution could not be fragmented and implied a more complex industrial and commercial organization" (Matés 2016: 23).

In 1906, the central power marked the push for 2,800 meters above sea level in Quito. But by 1915, the Congress decreed that "the Quito Municipal Council should assume all the powers that correspond to the Government in the service and construction of drinking water, canalization, and paving works" (Luzuriaga Jaramillo 2010: 38). In the middle of this phase, a Düsseldorf corporation was contracted to build the first treated water plant in the city in 1913. This plant had serious management problems in times of flow variability, which were foreseeable in a high-altitude equatorial climate, as later reports would expose. In fact, the works frequently carried out were not sufficient to ensure supply service. It was necessary to contract additional works, opting "to explore larger and more distant watersheds" to "build dams, reservoirs, and treatment plants" (Gallini et al. 2014).

Those previous assumptions that seemed to be decisive for adequate or inadequate water management in the cities were now a thing of the past. The Bourbon contributions in this regard already appeared as echoes of the colonial past; even the new republican policies of the first and second half of the nineteenth century seemed outdated. With the new century, the combination of private resources, the expansion of state control, some key revenues acquired as export peripheries, and the constant of available labor for projects of national and local interest set a new standard in the magnitude and power of provisioning services and implementing population management dynamics.

Water was, therefore, an articulating element of the modernizing projects of the city, both in its supply as treated and in the management of sewage and waste disposal; both aspects of the same horizon of human habitability; both transversal aspects in sanitary planning, which does not occur in unison throughout the populated territory but in a socially constructed cartography. This planning entailed much more intensive institutional action regarding the environment and its transformation.

Gradually, municipal ordinances became one of the guiding bodies of rules that led cities and citizens to irrevocable practices. These were not only citizen practices, however, but also practices of space, turning it into a temporal materiality of social decisions. In fact, some natural enclaves due to their geomorphology or runoff had to be filled, diverted, etc.; this work was done in a constant and exponential manner. Thus, these transformations responded to specific ways of inhabiting the territory, of producing on the land, and of understanding and managing water spaces in the different Andean enclaves.

To speak of landscape transformation implies speaking of the transformation of the societies that construct it and that are structured in it; it implies speaking of dissent, resistance, and tensions over territories, water, and horizons of being and producing in the world; it also implies speaking of political decisions that account for modifications and risks that are difficult to reverse (Peltre 1989: 63), or that are politically challenging due to the structural change they would entail. Thus, the following section will focus precisely on the risks involved in their social construction and long-term policies.

Viewing Risks and the Anthropocene from the Urban Andes

The so-called radical school of disaster studies emerged in the late 1960s and early 1970s among English-speaking students and researchers, mostly in the United States, who questioned both a naturalistic and behavioralist reading (one's own fault, poor individual choice, etc.) of disasters. Situations of risk were considered to be the mark of bad development, social asymmetries, and incoherence in the relationship between societies and the environment. Political economic readings were applied, mobilizing social and power relations, institutional functioning, the social position of social groups, etc. as explanatory mechanisms. For this school, disasters are not natural (O'Keefe et al. 1976). Moreover, any problem linked to the environment (resources, degradation, preservation, etc.) is the result of a social, historical, and spatial context, both in its material dimensions and in the ways in which it is defined and managed (Wisner et al. 2004; Ribot 2019). These perspectives are valid when referring to risk, water, or the Anthropocene (Rebotier 2021).

With regard to water, although not limited to it, this section will follow the evolution of the social relationship with the environment and will study the place of risks in Andean urban societies from independence until the mid-twentieth century. It will develop the cases of Caracas and Quito as starting points to question the dominant view of the Anthropocene and the current global environmental crisis. Furthermore, the epistemological scope of the experiences and representations of the Anthropocene and the relationships with water and the environment observed in the urban Andean Americas will be emphasized.

Wanting without Power: The Rise of Ideas of Control and Reduction of Nature.

Between pragmatic conceptions and technical knowledge and beliefs, traditional knowledge, and superstition, urban colonial America was built on the basis of different paradigms, from which the environment, the presence/absence of resources, natural phenomena, etc. were dealt with (Musset 2002; Diaz 1956). After the struggles for independence, modern ideas that considered the environment as a set of forces alien to society, which must be tamed, both to exploit and to civilize, were disseminated and consolidated. The spread of these ideas took hold with societies that became independent and with nations that were built in opposition to central power, as well as savagery and disorder, with a focus on progress. The phrase that Simón Bolívar, the Venezuelan Liberator, would have pronounced in the ruins of Caracas after the earthquake of 1812 and in the middle of the war of independence is still famous: "If nature opposes us, we will fight against it, and we will make it obey us!" (cited in Altez 2006). This also exists as a remnant in the literary canon of the region's several countries: the allegory of the civilized nation and the civilized city as opposed to wild and rudimentary features (often rural and peasant) that, nevertheless, are part of the constitution of national identities (Gallegos 1929).

Although the intention to do away with the obstacles of nature was widespread, it turns out that, until the last quarter of the nineteenth century, in the case of Caracas, there were no major transformations of the urban landscape nor significant interventions to the environment. What today is known as the capital of Venezuela is remembered as a "city of red roofs" (because of the tiles) of little importance and little demographic dynamism (until the 1930s). The historic site is located at just under 1,000 meters above sea level, at the foot of Mt. Avila, in the San Francisco valley drained by the Guaire River. Due to the low intensity of occupation, the hilly landscape and slopes do not pose significant landslide problems. Historically, in relation to the environment, the greatest challenge had been to tame water and the course of the streams, both to have water available and to protect against the ravages of violent flows. Earthquakes were viewed as the greatest danger to the historic urban settlement of Caracas as was well demonstrated by the seismic history of the city (Altez 2006). More than just physical mechanisms, it was also due to the overflow of urban morphology and the considerable expansion of the city advanced in the twentieth century that risks multiplied and became much more complex (Imbesi and Vila 1995).

As for great paradigmatic frameworks, in the period after the wars of independence, Raúl Villavicencio (1838–1920) is considered to have introduced positivist ideas and progress to literature and social sciences in Venezuela. The influence of Adolph Ernst (1832–1899) in the area of natural sciences is also noteworthy. However, the road from modern ideas to practice was a long one. The consideration of sanitary risk is a case in point. Between independence and the 1860s, the danger of epidemics brought by sailors was of constant concern to local authorities, who increased the quarantine regulations and orders without much innovation or other response. It is also worth noting that Caracas did not regain the population level it had before the earthquake of 1812 and the wars of independence – which caused a considerable number of deaths – until after the 1870s (Rebotier 2008). Ways of occupying space evolve more slowly than ideas.

In 1870, with the coming to power of the "Illustrious American," Antonio Guzmán Blanco, a material rupture in the relationship between the environment and the urban landscape was noticeable. Guzmán Blanco introduced a French modernism inspired by the Beaux Arts and promoted the hygiene movement of the time. Urban facilities were improved, and the relationship with water was rationalized (a sanitation code was adopted in 1880). The sanitation issue or the issue of water supply became central – a phenomenon also observed in other Andean cities in the previous section – as evidenced by Caracas' modernization plan in 1908, the construction of the city's aqueducts, and the creation of several water-related institutions in the early 1910s (González Casas 2002). The city's modernization led to a significant and unprecedented increase in the urban population of Caracas without it occupying more space (Rebotier 2011). The densification process continued until the late 1920s when technical progress made it possible to overcome the obstacles of nature (distance, ravines, slopes, etc.) in a concrete manner.

Power without Fear: Accelerated Transformation of Urban Landscapes

The arrival of the tramway in Caracas caused a radical change in urban morphology and in the relationship between the city and the environment. Large housing developments were able to develop further and further away from the historic heart of the Venezuelan capital. It was the beginning of the colonization of the San Francisco valley, the valley of Caracas (Baby-Collin and Zapata 2006). For this purpose, it was necessary to fill or embank many of the ravines (laid north to south) and tributaries of the Guaire River (oriented west to east), which score the slopes of El Avila.

However, the new ways of inhabiting the city, the possibility of the spatial expansion of the urban fabric, and the disappearance of numerous bodies of surface water also introduced unprecedented urbanity. It was an experience far removed from the environment, far from the nostalgic (and strongly idealized) memory of "the city of red roofs" prior to the urban landscape's modernization. The modern Caracas of the twentieth century ceased to be the city of neighborhoods and springs, becoming a city of oil, automobiles, and gated communities. It is the power of the "bourgeois nightmare" (Fogelson 2005): an eagerness to control the conditions of urban life, from the characteristics of the environment to the type of socio-spatial interactions one has (Almandoz 2002; Caldeira 2001).

The massive process of invisibilizing nature is noticeable in the region's cities as modernization advanced and the technical capacities for intervention were consolidated. The city of Quito has a chronology similar to that of Caracas, although with a time lag, involving a transformation of urban morphology, urbanity, and the physical modification of the landscape. The site in the upper valley of Quito has a meridian orientation (north to south). The spatial expansion of the city in this valley (both from the north and to the south) affected the flat parts, but also part of the lateral slopes (particularly the slopes of Pichincha, to the west). Many streams obstruct the valley of Quito. They have a main west-to-east route, from the peaks of the Pichincha to the rivers of the Quito valley, which drain to the north (for example, with the Monjas River) or to the south and east (for example, with the Machángara River). The massive filling of the creeks (concomitant with the urban expansion of Quito) opened the way for large circulation infrastructures (oriented north-south) while at the same time occupying smaller, unfilled creek beds (Perrin et al. 2000).

Recent work on urban risks in Quito (D'Ercole and Metzger 2004) has shown the multiplicity of hazards present on the site, as well as the complexity of risk situations in the Ecuadorian capital. However, as in Caracas, while a much smaller occupation of space, the biggest problems are related to water (scarcity, access, excess). In addition, more than the seismic threat (not as severe as in Caracas), Quito has no less than eight volcanoes within a 100 km radius, which exposes the urban site to possible consequences of volcanic eruptions from lahars (at least for access to the city) to ash falls and seismicity associated with eruptive activity.

Mudflows (articulating slopes, gullies, and deposits of ash or movable material) are still present disasters in the Ecuadorian capital (as in La Gasca in 2022), but they already have a known history of the denial of urban site's environmental features. From the Regulatory Plan of the early 1940s onwards, the meridian dynamics of the city's physical expansion were built against the hilly morphology of the valley (Sierra 2000; Godard and Bermudez 2005).

Fearing the Risks without Remembering that the Illusion of Control Has Always Been Questioned

Disasters always arouse similar reactions: What were the technical conditions of the accident? How or where can one invest in order to better prevent similar situations in the future? How did the systems of control and surveillance fail? But in the end disasters are neither recent nor are they an exception. This is evidenced by Pierre Peltre's work on mudflows in Quito, taking information from the beginning of the twentieth century. Modernization of the urban site by no means put an end to the disasters. On the contrary, since the environment was supposedly tamed, the damage has become more severe (Peltre 1989), as evidenced by another episode at La Gasca in 1975.

Some authors propose that the modern idea of domination of nature has always been an illusion. Jean-Baptiste Fressoz's thesis proposes that a dominant narrative was socially imposed in a particular context; he constructs a history of industrial risk by emphasizing that confidence in industrial development and progress was never as unanimous as was claimed a posteriori within Europe during the Industrial Revolution. This happened only because alternative and unwavering voices could never, at that time, make themselves heard (Fressoz 2012). In the philosophy of science, Bruno Latour defends the idea that "we were never modern" (Latour 1991). Rather we have told ourselves stories of power and control, denying the agency of forces and assemblages outside the will of human societies.

Such modern confidence was globalized as a result of the "collision of worlds" at the cost of colonization and westernization of the world (Gruzinski 2006). A world-ecology emerged, materialized by the consequences of the great Colombian Exchange (of species and ecosystem connections), as well as by the spread of mercantile capitalism based on the subordination of nature (Moore 2003). The logic of exploitation, extraction, and appropriation was enhanced by the capacity to intervene in the environment to transform it in a way unprecedented in the history of the Earth.

It was also possible, however, thanks to the amnesia, if not the denial, of other ways of thinking about the inhabiting of societies in the world (Mignolo 2011). It is precisely the recovery of alternative ways of thinking about our dwelling and how we occupy space and interact in (and with) our environment that has led us to contemplate the limits of modernity, such as the utilitarian and technical vision of relations to the environment, to water, or to risks.

Legislation and Modifications in the Use of Water in the Andes

Having analyzed up to this point the uses and management of water in its interaction and tension in Andean water spaces, as well as risks and the Anthropocene from the urban Andes, this section focuses on an element that traverses the transformations of the landscape and the relationship with water spaces in an angular way. The following deals with the legislation that accompanies, transforms, directs, and complicates the water use.

Napoleon Bonaparte's fame among jurists is mainly explained by the promulgation of the Civil Code of 1804, a legal project that constituted the main milestone of the codification euphoria of the nineteenth century (Fernández Rosas 2005) and an expression of the liberal and enlightened rationality that sought a detailed and systematic regulation of all aspects of social life. Among them, property was a particularly sensitive issue: it has to not be forgotten that the French Revolution was essentially a bourgeois revolution and that a good part of its explanation lies in the demand for a property regime that would not privilege the state or the nobility but allow its peaceful and full ownership to the bourgeoisie as well.

In short, the Napoleonic Civil Code meant a transformation of the feudal and absolutist property regime (Fernández Rosas 2005) based on the demands of the liberal ethos. This change should not be read in isolation: the French Revolution was also a turning point for legal science as a whole, which orbited until then around the sovereignty of absolute monarchs (Flórez Ruiz 2012) that was supported by the providentialist theory of legitimization of royal power (Hernández Becerra 2008). After 1789, its focus, however, turned to the newly created category of civic and liberal rights, which deified freedom and private autonomy as the insurmountable limits to the power of the state (García de Enterría 1994). In other words, the French Revolution brought with it the dominance of private over public law and, by deepening and making more evident the separation existing since the Roman Empire between these two universes (Vergara Blanco 2010), the Napoleonic Code consolidated this new relationship.

The Napoleonic Code and its Implications for Water Use in the Andes

The citizen's prominent role in social life after the Revolution explains, in turn, the regulation of the ownership and water use contained in the Napoleonic Civil Code. Indeed, as is evident in what is established between articles 640 and 648, under the rules of the Napoleonic Civil Code, the use, enjoyment, and control of water was a matter of the private individual and only marginally that of the state. It was the members of a community who controlled the waters, with no other limitation than that imposed by the rights of others, and it was only in the case of conflict between individuals that the state took on a certain relevance. This is only one of the innumerable manifestations of the minimalist conception of the public apparatus, reduced to the role of mere gendarme of the social contract (Rincón Córdoba 2004).

It might be surprising that an analysis of water law in the Andean region takes into account French codification, especially if one considers that the period under study here is the transition between the nineteenth and twentieth centuries, that is, the post-colonial period. However, the amazement dissipates if one accounts for the profundity of European influence. Thus, even after the American processes of independence – and still today – metropolitan logics have managed to perpetuate themselves in all forms of social life, including law.

Specifically, Andrés Bello was fundamentally inspired by the Napoleonic codification in drafting of the Chilean Civil Code of 1855. This transplantation finds its explanation in two circumstances: firstly, the fact that in our continent Bonaparte's Code was conceived as the symbol of the Revolution and of new ideas, propitious for independence and forged on the philosophical anvil of the Enlightenment; secondly, the fact that the adoption of Francophile legislations served precisely as a gesture of affirmation of the new national projects in the American continent (Fernández Rosas 2005: 172), as in fact also occurred in Europe (Hinestrosa 2006: 6–7). It is unsurprising that, with few variations, Bello's Code contains, between its articles 833 and 838, the same provisions on water use as those outlined in the Civil Code of 1804. These original provisions were generally repealed and sometimes modified by Article 9 of the 1951 *Código de Aguas*, which almost a century later gave the state a prominent role in the administration of inland waters. This greater power can be seen, for example, in numeral 4 of article 7 of the same codification, where it is established that it is incumbent upon the state "to police and surveil the waters and prevent works from being carried out or destroyed in natural watercourses for public use without the corresponding authorization. It shall also prevent water from being extracted from the same watercourses without title or in greater quantity than that which corresponds." (Código de Aguas 1951: Art. 7)

Again, it may seem strange that the Chilean experience should be considered representative of everything that happened in Latin America in relation to water regulation between the nineteenth and twentieth centuries. However, there is a historical reason: Bello's work served as a model for other Latin American civil legislations and, in particular, for the legal discipline of waters in the Andean region. Fernández Rosas (2005) explains it as such: "In the search for models, a homogeneity can be observed in all of Latin American republics. Curiously, in terms of political organization, all of them adapted the North American system, but in terms of civil rights, at least in the eighteenth century, one way or another, the French model was followed" (170).

Legal Discipline of Water in the Andean Region

The first civil codification prior to Bello's Code was that of Santa Cruz, promulgated in Bolivia in 1831. Its name alone suggests an imitation of Napoleon's Code since it was during the government of Marshal Andres de Santa Cruz that the norm was put forward (Guardia 2003). The French tradition was evident in the privatized vision of water regulation, evident between articles 376 and 381, which was only slightly tempered by the 1906 Water Law, since it did not abandon the nineteenth-century approach (Alurralde Tejada et al. 2003: 142) and was still in force in spite of its modifications (Gutiérrez Gronemann 2006: 98).

Almost three decades before the Civil Code of 1861, inspired by that of Don Andrés Bello, the first Water Law was issued in Ecuador in 1832, regulating "access to water through a system of aqueduct easements, on the basis of broadly guaranteeing individual private property rights over water resources" (cited in Acción Ecológica 2022). Its first reform came in 1936, with a law that "incorporates the principle that the public domain of state or fiscal property includes water" (Acción Ecológica 2022).

Subsequently, the Peruvian Civil Code of 1852 replicated the Napoleonic Code between its articles 1131 to 1135. This was later modified by the Water Code of 1902, which considered water as a good of public use, although in practice the logics of private dominion over the water resource managed to perpetuate until 1911, the year in which there was a new reform (Guevara Pérez 2015. 326–327).

With the Civil Code of Páez of 1862, Venezuela emulated the French and Chilean codifications (Guardia 2006: 193), and in the 1867 Code, private ownership of water prevailed. However, the Venezuelan case is curious because the reforms of 1916, 1921, 1924, 1924, 1931, 1936, and 1942 confirmed a private – in contrast to a public – law approach in the other Andean traditions at the beginning of the twentieth century.

On the other hand, the Civil Code of the Argentine Republic of 1871, drafted by Dalmacio Vélez Sarsfield, not only did not represent an exception to the general rule of the French legacy but it is considered to be an even more Francophile than the Chilean code. In Title XIII of Book III, the Argentine codification emulates the Civil Code but also makes the regulation more detailed and meticulous. In this case, it is impossible to identify a regulation that reformed the liberal civil legislation on water matters for the first time due to the Argentine federal system that implies a water code or law for each province, which establishes its own criteria "for the allocation of water resources, conditions of use, authorization, and concession regime."

Finally, the Colombian civil codification of 1873 replicated the French model between articles 891 and 896. With Law 113 of 1928, a state logic in water administration was implemented in the country since Article 9 established that the National Government was the supreme administrator of public goods, among which water resources were already included.

Table 1: Year of Adoption of First Water Legislation and Reform in Andean Countries

Country	**Year of the Adoption of the First Republican Water Legislation**	**Year of Adoption of the First Water Reform**
Bolivia	1831	1906
Ecuador	1832	1936
Peru	1852	1902
Chile	1855	1951
Venezuela	1862	1916
Argentina	1871	N/A
Colombia	1873	1928

Source: Authors' own elaboration.

Conclusions

This chapter has examined from three broad perspectives how water management changed in the Andean-urban-rural region at the turn of the nineteenth century and the beginning of the twentieth century. To this end, it has recovered colonial, independence and modernizing echoes of the last century, thinking of this range of spatial and temporal scales, which is fundamental when dealing with water as a common social good. At first, local institutionalism was placed as the central axis to understand the administration of water spaces in the long term and as a centralizing force of modernizing discourses and practices in the different Andean cities that grew demographically and spatially in the first decades of the twentieth century. To this view of urban management were added the tensions between institutionalism, regulations, and social actors in rural spaces that demanded water access and control in the breaks that arose regarding irrigation policies, among other issues.

Thus, already denoting an inescapable relationship between the management of common goods and socio-political interests, the second section focused on the empowerment of interaction with – and often against – nature, which intensified with technical innovations and with the increase of material capacities at the end of the nineteenth and beginning of the twentieth century. But it is a question not only of material capacity but also of paradigms, visions, and epistemologies (Quijano 1992; Dussel 2000). From a certain angle, the Anthropocene is the paradoxical epoch in which the consequences of human activities on the Earth system culminate, and the fragility of the habitability and conditions of existence of such supposedly potent societies is recognized. The recognition of the existential character of risk situations draws attention to the limits of modernity and appeals to looking toward alternative visions and epistemologies when thinking of the future and sustainability (Mignolo 2001; Alimonda 2017), perhaps breaking with long traditional regulations that have oriented our relationships with the environment and common goods like water.

This chapter, in closing, has sought to highlight the construction of a body of law with modernizing paradigms that have been questioned here. Thus, it has shown that the transition between the nineteenth and twentieth centuries was marked by the desire to consolidate the national projects founded after American independence through the implementation of centralized state apparatuses that could penetrate in a capillary manner in their respective territories. This desire to continue colonizing the territory after the Colony, that is, this kind of *criollo* colonialism in the absence of Spanish metropolitan power, had as a condition of possibility a mutation in the conception of the state and its role in society, broadening the state's administrative structure, the law applicable to its activity, and its relationship with individuals. The transformations that Andean legal systems, generally speaking, have undergone in the area of water law should be interpreted in this context: from the classical liberal states that strictly respected the use, enjoyment, and free control that individuals could exercise over water resources to the states that have actively intervened in their management through administrative policy mechanisms, assuming a prominent role that has continued to gain power, and could be reviewed from an inclusive, proactive, and critical social plurality.

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Water in the Amazon from the Mid-Nineteenth Century to 1950

Frederik Schulze

During the colonial era, the Amazon region – or Amazonia – had suffered only from minor anthropogenic impacts, with the reduction of turtles and manatees due to extensive hunting being the most visible and discussed feature. While the early nineteenth century brought little change in this regard, the turn of the twentieth century constituted a major anthropogenic intensification: The rubber boom integrated the Amazon into the world market, attracted international interest, initiated systematic exploration, and set the stage for development efforts after World War II. This chapter explores the new anthropogenic dynamics that affected water resources in the period. As for the colonial era, little research on Amazonian water is available, so this chapter cannot claim to provide a comprehensive picture. Instead, it looks at existing scholarship and offers a cross-reading of printed primary sources such as travel accounts and publications about steam shipping. The focus is on the Brazilian part of the Amazon basin, but developments in the Andean countries are mentioned as well.

The chapter starts with a section on scientific travelers during what Susanna Hecht has called "the scramble for the Amazon" (2013: 83), discusses the relevance of fluvial steam shipping for the rubber boom, continues with information about urbanization and sanitation, and ends with the beginning of concerted development efforts in the 1940s that would trigger eventually the Great Acceleration of the Anthropocene from the 1960s onwards. The nineteenth century and the first half of the twentieth century were an overture of developments to come, as this chapter argues. Whereas most of the natural barriers to further exploitation remained important obstacles, such as rapids, waterfalls, and tropical diseases, capitalism and science brought drastic change to the region in the form of intensified production of geographical and hydrographical knowledge, border demarcations, steam shipping, sanitation, and tropical medicine. These fields point to human interaction with and tentative mastery of water resources.

Post-Independence and the Increase of Scientific Traveling

When the *Revista Brasileira de Geografia* published a special issue on the Amazon in 1942, the readers could appreciate not only President Getúlio Vargas' speech on the occupation of the Amazonas from the same year but also several articles that condensed the available knowledge on the region. Geologist Carlos Delgado de Carvalho wrote about the hydrographical aspects of the river and offered extensive information about the river itself, its basin, and its tributaries. He claimed that the Amazon had an average water flow that tripled the Congo and was up to six km wide (Carvalho 1942).

Several travelers and expeditions had accumulated the geographical, hydrographical, and climatological knowledge that Carvalho could rely on in 1942. Following early voyagers such as Alexander von Humboldt, Carl Friedrich Philipp von Martius, and Johann Baptist von Spix, and often supported or even commissioned by the governments of Brazil, Peru, and Colombia, these domestic and foreign travelers explored in detail the Amazon basin. They also collected knowledge about botanical, zoological, and human life, sketched maps, and gathered serial data about precipitation and the water level of the rivers. Among them were the British officers William Smyth and Frederick Lowe (travelling between 1834–1835), the British biologists Henry Walter Bates (1848–1859), and Richard Spruce (1849–1864), the Brazilian poet and ethnographer Antônio Gonçalves Dias (1861), the Swiss-American biologist couple Louis and Elizabeth Agassiz (1865–1866), the French geographer Henri Coudreau (1883–1899), the German ethnographers Karl von den Steinen (1884, 1887–1888), Paul Ehrenreich (1887–1888), and Theodor Koch-Grünberg (1898–1924), and the Brazilian government representatives Cândido Rondon (1891–1930) and Euclides da Cunha (1905) (Souza 1994: 77–79; Meirelles Filho 2009: 108–205; Pizarro 2012: 111–112; Cabral 2013: 86–125).

Most of the voyages during the nineteenth century were not simple scientific endeavors but served to conquer the Amazon water landscape. Similar to the African continent, international powers and entrepreneurs, as well as the bordering states of the Amazon, started an imperialist race for natural resources and political influence (Hecht 2013: 83–180), which explains why so many foreigners were touring the region. International business interests peaked during the rubber boom at the turn of the century, and travelers contributed to collecting useful knowledge for further exploitation.

These travel activities also served to demarcate state borders, another aspect of the "scramble for the Amazon" (Garcia 2011: 51–60; Hecht 2013: 85–106). While European powers were successful in establishing their dominion in the Guyana, Brazil managed to enlarge its national territory decidedly. The country signed contracts with France (1900), Great Britain (1901), Bolivia (1903), the Netherlands (1906), Colombia (1907/8), Peru (1909), and Venezuela (1928/9) for its benefit, with the former Bolivian Acre territory being the best-known gain. José Maria da Silva Paranhos, the Baron of Rio Branco and Brazilian Minister of Foreign Affairs, was the most influential figure in these negotiations. The demarcation of borders set the stage for national programs of exploitation, even though international corporations and businessmen were crucial for the first stage of economic expansion around 1900.

Most of the reports written by travelers during the imperialist expansion mentioned two anthropogenic topics. First, they addressed the issue of overfishing, which earlier accounts and Brazilian observers already problematized (Pádua 2002: 206). The English biologist Henry Walter Bates described the turtle hunt in detail, even providing a picture, and pointed to the huge impact of such a behavior, in particular the collection of turtle eggs.

> The total number of eggs annually destroyed amounts, therefore, to 48,000,000. As each turtle lays about 120, it follows that the yearly offspring of 400,000 turtles is thus annihilated. A vast number, nevertheless, remain undetected; and these would probably be sufficient to keep the turtle population of these rivers up to the mark, if the people did not follow the wasteful practice of lying in wait for the newly hatched young and collecting them by thousands for eating […]. (Bates, vol. 2, 1863: 272. See also 252–264)

He lamented that "the turtle has very greatly decreased in numbers and is still annually decreasing." (273) As other accounts underscored, turtles were a fundamental part of the local diet, and even travelers were eating them frequently (Dias 1943[1861]: 385). Authorities did not take measures to protect turtles, and several other reports from the following decades continued to mention the problem (Monnier 2005[1890]: 333). In 1895, the Brazilian writer José Veríssimo published a comprehensive book about Amazonian fishing practices and provided for the first time a historical account of fishing in the Amazon. He articulated very bluntly his conservationist concerns:

> In the Amazon, there is certainly no one who does not recognize and regret the extinction of the fish that is taking place there, which no precaution or providence protects. If things regarding fishing continue as they are, the turtle, the manatee, even the *pirarucu* will have disappeared from Amazonian waters and will only be a legend, as they are already beginning to be in certain portions of them. (Veríssimo 1970[1895]: 127)

Nevertheless, still in 1904, the Amazon Steam Navigation Company requested protection: "This terrible destruction has doubtless been going on for centuries, but with the great increase of the population on the riverbanks, means must be devised to prevent the extirpation" of turtles (The Amazon Steam Navigation Company 1904:

78). However, in the 1930s complaints about diminished or extinguished stock of fish, turtles, and manatees continued (Moraes 1936: 110).

The second anthropogenic topic in the travel accounts was fluvial transportation. As in the colonial era, rivers provided access to the region but also impeded its exploitation. Most explorers expressed their astonishment about the sheer amount of water in the lower Amazon, like Louis Agassiz, who claimed that "[t]his river is not like a river; the general current in such a sea of fresh water is hardly perceptible to the sight and seems more like the flow of an ocean than like that of an inland stream." (Agassiz and Agassiz 1879[1868]: 153) Upstream, however, they faced problems. The most common obstacle for river cruises was the "violence of waters" due to rapids and waterfalls, followed by the oscillating water levels that could complicate travel as well (Dias 1943[1861]: 387; see also Silva Júnior 1875; Wallace 1889; Monnier 2005[1890]: 275; Coudreau 1980[1898]: 128; Koch-Grünberg 1952[1934]: 18–21).

Thus, many travelers relied on Indigenous canoes and rowers who had local knowledge about hydrography and river behavior (Poeppig 1835: 279–282; Smyth and Lowe 1836: 116–145; Monnier 2005[1890]: 259; Coudreau 1980[1898]: 13). According to German ethnographer Karl von den Steinen, Indigenous groups had developed adequate canoes and paddles and were able to cross even strong rapids (Steinen 1894: 234–235). Other travelers described the Indigenous technique of pulling canoes with ropes through rapids (Spruce 1908: 89–90; Cabral 2013: 94). Yet, travel remained exhausting in the mid-nineteenth century, and rapids limited the expansion of missions, trade networks, and statehood in general (Henrique 2018: 77).

Therefore, it is not surprising that the collection of knowledge about water resources and the exploration of rivers for future shipping and trade became more and more important. Often, such expeditions were conducted on behalf of provincial governments or shipping lines and collected meteorological data, mapped rapids and waterfalls, and tried to understand the complex river system of the Amazon and its tributaries which experienced different seasons of high and low water, depending on their water source in the Andes, the Brazilian Highlands, or the Guyanas, or the impact of the rainy season (Smyth and Lowe 1836; Tavares 1876; Agassiz and Agassiz 1879[1868]: 348–349; Wallace 1889; Coudreau 1980[1898]: 21–32; Meirelles Filho 2009: 138–141). But knowledge production remained a fragile endeavor: Richard Spruce reported about the unpredictable dynamics of water flow when he traveled up the Río Uaupés where the normal dry season did not happen the year he visited (Spruce 1908: 332–334). Indeed, several weather abnormalities occurred in the period and resembled earlier El Niño phenomena. In 1912, several huge forest fires struck the Amazon, and in 1925 and 1926, precipitation decreased by 50 percent and caused forest fires in Northern Amazonia (Alves, Marengo, and Cavalcanti 2013: 22–23).

Rubber and Steam Shipping: The Amazon in the World Market

The rubber boom and the expansion of steamship lines are the most evident indicators of the capitalist and imperialist penetration of the Amazon region around 1900 (Hecht 2013). International businessmen and national authorities set out to exploit natural resources and connect the region to the world market. The use of waterways was imperative for that and laid the groundwork for the postwar developmentalism that initiated the Great Acceleration in the area.

Knowledge about the region's rivers helped to establish a network of steamship lines from the mid-nineteenth century onwards. In 1843, the first naval steam vessel arrived in Manaus, the capital of the Brazilian province of Amazonas, and in 1852, Irineu Evangelista de Sousa, also known as Barão of Mauá and as the most successful businessman of the Brazilian Empire, obtained a concession for steamship services on the Amazon for thirty years. He founded the Companhia de Navegação e Comércio do Amazonas (Amazonian Navigation and Trade Company), the first commercial steamship line of the Amazon, which connected Manaus with Belém, the capital of the Province of Pará at the Atlantic, and quickly added routes to other destinations. However, in 1866, Brazil opened the river to all nations. Alexandre Amorim founded his Companhia Fluvial do Alto Amazonas (Upper Amazon River Company) the following year, and some smaller ventures joined the market. Soon, some hundred steamers were navigating the river system (Caldeira 1995; Pennington 2009: 149–151). In Peru, steamers started to serve local river ports in the 1870s (Gómez López 2015b: 158–159).

Steam navigation expanded trade and immigration. While sailing boats needed between forty and ninety days from Belém to Manaus, depending on the season, steamers only needed four to eight days (Bates, vol. 1, 1863: 212–213; Agassiz and Agassiz 1879[1868]: 195–196; Ehrenreich 1890: 157). What was more, they made traveling extremely comfortable and affordable. The German anthropologist Paul Ehrenreich wrote in 1890:

> Whoever has spent weeks on board one of the simple but practical and well-equipped ships traversing these colossal stretches of river and has encountered the articles of European civilization at the most distant landing points, loses all too easily the feeling that he is in the midst of a wild, little-known world. (Ehrenreich 1890: 156)

The opening of the Amazon for international ships was welcomed by many political observers in Brazil who aimed at stimulating trade with neighboring countries and overseas as well as immigration and colonization (Bastos 1866; Silva Júnior 1875). Still, in 1912, authorities lamented inadequate shipping, even though fluvial transportation had expanded (Brazil. Commissão, Exposição internacional de borracha de New York 1912: 29). In 1872, Mauá merged his and Amorim's companies into the Amazon Steam Navigation Company, which was listed on the London stock exchange. In 1904, the company operated thirty-two big steamboats and offered a bimonthly connection between Belém and Manaus as well as several other lines up to Iquitos in Peru. At the time, the Manáos Harbour Ltd. built a new floating harbor in Manaus (The Amazon Steam Navigation Company 1904).

Amorim initiated the first overseas connection between Manaus, which sits 1,500 km upstream, and Liverpool. In 1877, the Red Cross Line replaced that service, and in 1901, the Booth Steamship Company, which had operated international services to Belém since 1866, took over its competitor. Alfred Booth was also a shareholder of the Amazon Steam Navigation Company and the Manáos Harbour (Pennington 2009: 152–153, 162–163). The Booth Steamship Company possessed twenty-five steamships and its subsidiary, The Iquitos Steamship Company, another five, connecting the most important Amazon ports with Portugal, Spain, France, Liverpool, and New York. In 1912, there were four departures from Manaus to Europe and three to New York. The Hamburg-Amerika-Linie and Hamburg Süd offered a bimonthly connection to the most important German harbor, and Brazilian companies connected the Amazon with the Brazilian coast. Lines to Peru and Bolivia were established, as well (Brazil. Commissão, Exposição internacional de borracha de New York 1912: 126; Brazil 1924).

The expansion of steam navigation went hand in hand with the rubber boom, which triggered demand in transportation and profited from new steamship lines alike. Rubber, which is produced from the latex of rubber trees, became an important export product in the mid-nineteenth century and experienced a boom from around 1890 to 1910. Whereas Brazil was the main exporter, Peru and Bolivia also participated in the trade. Pará and Amazonas became rich states and attracted migrants, but when the British started to cultivate rubber trees in Asia, the Amazon market collapsed. Only during World War II did the rubber trade flourish again (Weinstein 1983; Garfield 2013; Sánchez Steiner 2015: 75–82). Regions with the best steamer connections were particularly booming, such as the Río Purus area which does not feature rapids (Ehrenreich 1890: 164; The Amazon Steam Navigation Company 1904: 61).

Anthropogenic attempts to alter the waterscape in order to increase rubber trade were limited, even though some utopian ideas of interconnecting the Amazon to other river systems existed as early as the 1860s (Cabral 2013: 110). But instead of building channels or locks, politicians opted for railroads to bridge dangerous rapids. Already in the 1870s, plans were underway to construct a railway on the Tocantins River to bypass the Itaboca Falls, and between 1905 and 1944, the line was built (Tavares 1876: 25; Cabral 2013: 153–154). More famous was the Madeira-Mamoré railway, which was assembled between 1907 and 1912 to connect Porto Velho with the Bolivian border (Hardman 1988) as part of the Treaty of Petrópolis (1903) and part of the compensation for the Acre territory. The construction work turned out to be very problematic and cost the lives of hundreds of workers. When Euclides da Cunha participated in the commission that demarcated the new border between Brazilian Acre and Peru in 1904 and 1905, he proposed the construction of a railway in Acre, but this plan never materialized (Ferreira 2019: 104–105). Another strategy to bypass rapids and connect different river systems was telegraphy. From 1891–1930, Cândido Rondon led several Brazilian expeditions into today's Mato Grosso and Rondônia, built hundreds of kilometers of telegraph lines, explored rivers in the Southern Amazon basin, and tried to find a connecting point between different river systems. As with other endeavors of the time, these expeditions were burdensome and relied on Indigenous canoes (Diacon 2004: 20–42; Meirelles Filho 2009: 198–205). Even when the rubber boom ended, the Brazilian government continued to improve navigation to revitalize trade (Garfield 2013: 23).

A more spectacular attempt to connect two river systems was tackled in 1894 by the Peruvian entrepreneur Carlos Fermín Fitzcarrald López, who carried a dismantled ship with the help of several hundred Indigenous people over an isthmus between the Urubamba River and Madre de Dios River systems. Since the latter flows in the Madeira River, he could purchase rubber in the Madeira River system and transship it to the Urubamba from where he could then ship it to Iquitos and sell it there, avoiding the higher Brazilian export fees. In 1897, he died when one of his ships crashed into rapids (Brown and Fernández 1991: 62–65). Werner Herzog's movie "Fitzcarraldo" from 1982 retells the story, recreating the physical task of moving a steamer over an isthmus.

Urbanization and Sanitation

The rubber boom went together with immigration, colonization, and urbanization. Most of the reports written by steamship companies or government officials evaluated how fluvial transportation could extend future colonization, and they lamented the decaying settlements and absent statehood in some distant regions (Silva Júnior 1875: 1; Tavares 1876: 3, 40–47). Around 1900, settlement increased, also in the Peruvian and Colombian parts of Amazonia. Again, rivers were important arteries of penetration (García Jordán 1998; Gómez López 2015a: 38–39; San Román 2015; Sánchez Steiner 2015: 75–105).

Most notably, Belém and Manaus experienced a huge growth around 1900. Belém's population skyrocketed from 61,997 in 1872 to 236,402 in 1920, and Manaus more than doubled from 29,334 to 75,704 (Browder and Godfrey 1997: 133, 138). Both cities became important port cities and underwent a profound change in their urban landscape (Pennington 2009: 68–113; Castro 2009; Pizarro 2012: 124–130). This included improvement of sanitation. Belém started to build up a water supply system in the 1850s, and from 1881 onwards, the locally owned Companhia das

Águas do Grão-Pará (Water Company of Grão-Pará) installed a supply and sewage system, which the city took over in 1895. Contemporaries described the water supply system as good, and in the 1930s, the city even operated a sewage treatment plant. However, the system could not cope with the fast growth of the city (The Amazon Steam Navigation Company 1904: 18; Weinstein 1983: 87–88; Veloso 2018: 186–187, 261). Manaus, in turn, still relied on water porters in the 1860s who had to carry clean water from outside the city to town because river water was not drinkable (Agassiz and Agassiz 1879[1868]: 191–192). The capital of Amazonas installed a system of freshwater supply in the 1890s, but in the early 1900s, it still lacked a sewage system (The Amazon Steam Navigation Company 1904: 49; Oliveira and Schor 2009: 66).

Physicians perceived precarious water systems in the outskirts of the cities or in smaller villages as problematic, and tropical diseases constituted a severe hindrance to the further colonization of the region. Malaria and other contagious diseases had constituted a problem for a long time and also affected travelers – Johann Natterer, Ludwig Riedel, Georg Heinrich von Langsdorff, and Theodor Koch-Grünberg are among those who suffered from severe illness or even died of malaria – and annoying insects were a constant topic in many travel accounts (Poeppig 1835: 392–393; Wagner 2021: 337–338). Ironically, the expansion of the steamship lines contributed to the spread of tropical diseases, for instance, yellow fever (Ehrenreich 1890: 162). The drinking of river water could transmit parasites, and many migrants died from tropical diseases (Garfield 2013: 12, 188). That is why government officials and physicians tried to improve sanitary conditions. In the early 1900s, Euclides da Cunha called for hygiene measures in the big cities, and two famous doctors followed his call (Ferreira 2019: 42). In 1910, Oswaldo Cruz inspected Belém and the Madeira-Mamoré region and implemented several sanitation measures to combat malaria and yellow fever, eradicating the latter in Pará's capital (Schweickardt and Lima 2007: 23–27; Garfield 2013: 32). Carlos Chagas traveled from 1912–1913 to the Solimões, Purus, and Río Negro and studied tropical diseases such as malaria or leishmaniasis. In his eyes, it was "the unhealthiness that makes Amazonia an uninhabitable land," but he believed that the fight against malaria and its many fatalities could be successful from a scientific point of view (Chagas 1913: 450, 456; Kropf and Lacerda 2009: 166).

Initiating Anthropogenic Development

In the 1930s and 1940s, Latin American politicians and scientists articulated plans for a comprehensive national development of the region and initiated domestic policies that would affect the Amazon anthropogenically after World War II. Water inspired such utopian visions, as the famous speech of Brazilian President Getúlio Vargas from October 1940 underlined. He called the Amazon a "river-sea" and asked for the region's colonization. "To conquer the land, to dominate the water, to subjugate the forest, these were our tasks." (Vargas 1942[1940]: 259) Such fantasies of conquest and national integration had their roots in the early twentieth century when intellectuals like the Brazilian Euclides da Cunha or the Peruvian Carlos Valcárcel articulated the need to exploit and settle the region (Pizarro 2012: 136–145). Cunha even lamented that "man, instead of dominating the land, enslaves himself to the river" (quoted from Ferreira 2019: 104). In 1912, the Brazilian government provided federal funds to the Amazon region for the first time, a measure that would be repeated after World War II (Souza 1994: 151).

In the context of Vargas' 1940 speech, the federal government again started to act. It founded several agencies to initiate the national penetration of the region, among them the Divisão de Terras e Colonização (1938, Land and Colonization Division), the Instituto Agronômico do Norte (1939, Agronomic Institute of the North), the Serviço de Estudos de Grandes Endemias (Major Endemic Diseases Research Service), the Serviço de Navegação e Administração de Portos do Pará (1940, Navigation and Administration Service of the Ports of Pará). Most of them dealt with water resources and collected meteorological and hydrographical data. Also, the military started to settle down on the river (Garfield 2013: 22, 29). In 1943, the government formed the federal territories of Amapá, Guaporé, and Roraima to boost development. Between 1943 and 1948, the Roçador-Xingu Expedition explored unknown regions in southern Amazonia (Veloso 2018: 261–264). Such efforts were not limited to Brazil: In 1942, the Colombian Minister of Education published a report written by a local teacher of the town of Leticia who demanded from the government "that it prepares the conquest of the Amazon" (Pérez Lozano 2015[1942]: 345). He provided meteorological information, lauded the economic prospects of the region – in particular, the production of canned fish, dolphin oil, and ornamental fish for aquariums – and recommended the construction of roads since Leticia was only accessible by boat.

Conclusion

These plans and imaginaries were the outcome of the first integration of the Amazon region into the world market during the rubber boom. Step by step, humans managed to use the Amazonian River system for transportation, trade, and colonization, and the expanding steamship lines were an important paradigm shift after the dominance of canoes and sailing boats for centuries in the colonial era. The power of water was not yet dammed, but railroads bypassed some problematic river sections. Also, the more silent and invisible danger of water, which often constituted a breeding ground for insects and parasites, could not yet fully be controlled, but urban engineers set out to improve water supply and install sewage systems, and physicians and scientists started to study tropical diseases and implement hygiene measures.

All these technological advancements made more daring visions of the occupation of the Amazon possible and turned the immense water resources more and more into a manageable and useful good. Dam-building, irrigation, agriculture, mining, and urbanization would impose new impacts on the Amazon water system after World War II and would raise awareness for the first time of the profound endangerment of the fluvial ecosystem. For now, humans only noticed the declining stock of aquatic animals and looked at Amazonian waters as unimaginably abundant.

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Water in Mesoamerica from the Mid-Nineteenth Century to 1950

Mexico and Central America in the Hydro-Anthropocene

Sandra Gutiérrez Poizat and Lourdes Sofía Mendoza Bohne

Mesoamerica, the region that includes Mexico and Central America, contains a vast network of watersheds and microbasins in which various civilizations have consolidated, developed, and left a mark on the present. The period between the second half of the nineteenth and the first half of the twentieth centuries is key to understanding the transformation of systems in the management, use, and supply of water. Local and national regulations, technology, and increasing industrialization in important regions have been key in explaining the territorial, environmental, social, and cultural transformation of Mesoamerica. Thus, the general purpose of this chapter is to illustrate the anthropocenic processes of water during this period through four major axes. The first regionalizes Mesoamerica by considering Costa Rica, El Salvador, and Guatemala as a Central American group and Mexico as a separate unit, even though both trace their origins to Mesoamerican civilization beyond national borders. The second axis addresses the extractive history of these regions' relationship with the environment and the societies that settled them, by categorizing types of production, resource uses, and the processes of raw material exchange over water networks. The third axis identifies the regulations that served as models for development. Finally, the fourth and final axis analyzes the development of major cities and megaprojects by looking at hydrologic regions, which reflects on the consequences of development from an anthropocenic perspective. Therefore, it is worth asking what economic factors influenced the transformation of ownership, distribution, and access to water in Mesoamerica. What common elements can represent an anthropocenic model of Mesoamerican development? In this sense, the present work is divided into two major regions: Central America – with an emphasis on Costa Rica, El Salvador, and Guatemala – and Mexico, addressing trends of water privatization and regulation between the nineteenth and the first half of the twentieth centuries in both.

Water, beyond being a resource, can be conceived as a process (Linton 2017). Water as a process both influences and is influenced by us, i.e., "this fluid and dialectical process implies a change in the idea and physical arrangement of water, as well as changes in social and economic processes" (Linton 2017: 3) related to water. That is to say that various technical and social factors and power dynamics contribute to the production and reproduction of water in a society. Linton defines this as the hydrosocial cycle of water. However, from the eighteenth century onwards, water began to be separated from its social, historical, and ecological components as it became ascribed to an abstract and universal identity, one capable of being measured and, therefore, reduced to a mere resource. This water is known as "modern water" (Linton 2010) due to a change in its meanings that historically represents its becoming an object per se and a form of currency.

Mexico and Central America, during their politically liberal eras, appropriated this abstract and universal identity of water, promoting the use and management of modern water through projects like transport infrastructure, irrigation, or the introduction of water and sewage services in cities. Modern water in the liberal states is produced and reproduced from the social, political, and economic reconfigurations of the new republics. In this way, water as a resource helps reinforce the idea of progress promoted by local governments, progress that is sustained on the basis of extractivist approaches to the land and its resources.

Water as an object, the modern and abstract water, has come a long way since the late nineteenth century. While water was once managed by agents who promoted the new republics' progress as it was conceived as a necessary resource to boost the development of the agro-export economy, this same progress left out the majority of the population that had been gradually stripped of the resource. This transition, which started in the colonial period, was accelerated by the profound changes in land tenure implemented in the nineteenth century by the liberal governments, and later furthered by military dictatorships into the mid-twentieth century.

These changes in land tenure, which, as will be seen below, represent radical shifts in this period, also influenced the management of the region's natural resources. Water is stated as an object, as a commodity, and has remained so. In the context of contemporary discussions on the reprimarization of Latin American economies (Svampa and Slipak 2015), the post-colonial extractivisms of the republican period would represent only one more phase in the series of extractivist models that have succeeded each other in Mexico and Central America. Authors such as Edgardo Lander (2014) reinforce this thesis by indicating that, today, as Latin American economies resume their role as suppliers of primary products, they move from post-colonialism to neo-colonialism.

The Anthropocene Impacts of Transitions

Water has always been important in Mesoamerica as an element of life and development. The region's landscape and geography contain a hydrological wealth that includes ground, surface, and fossil waters. Large water-producing forests are found in the region due to the mountain ranges along its continental territory. The history of extractivism in Mesoamerica promotes the analysis and understanding of the environmental transformations of this territory that served as the entrance to the Spanish colonization and conquest of the fifteenth century. Five centuries later, anthropocenic pressures have produced permanent vulnerability due to the constant degradation caused by the commodification of the land and its resources. During the nineteenth century, industrialization and technological development transformed various dimensions of water's use, management, conceptualization, legislation, distribution, and supply, as well as related forms of land tenure. In this sense, policies controlling nature and human resources were the materialization of prevailing ideologies and made tangible in the megaprojects carried out throughout Mesoamerica, such as in the construction of large hydraulic dams and canals, the desiccation of lakes, the diversion of rivers and basins, the redistribution of waters at the federal level, the conversion of swamps and wetlands to farmland, and desertification, to name a few.

Colonial Central America acted mainly as a supplier of agricultural products such as cocoa, indigo, sugarcane, precious woods, and, to a lesser extent, minerals. The new republics, fully operational at the end of the nineteenth century, maintained the same agricultural and extractive export pattern. However, at the beginning of the twentieth century, nation-states with modernizing aspirations were consolidating and positioning themselves in the global economic dynamic by intensifying their exports through investments into key infrastructure: railways and roads, hydroelectric dams, telephone networks, and large territories dedicated to monocultures such as coffee, bananas, and cotton. Progress and development, hand in hand with modernization, were conceived only insofar as these extractivist models could be maintained. It is also relevant to mention that these processes were promoted by military governments, which have been historically recognized as dictatorships that came to power across the region with the notable exception of Costa Rica: Manuel Estrada Cabrera in Guatemala (1898–1920), Tiburcio Carías Andino in Honduras (1932–1948), Anastasio Somoza García in Nicaragua (1936–1956), and Maximiliano Hernández Martínez in El Salvador (1931–1944).

The political transformation linked to the military conflicts and independence struggles with Spain also brought about reforms in the distribution and use of natural resources for the development and consolidation of the new centralities (Melé 2006). Water management also underwent significant changes, gradually shifting from being managed publicly and locally (through municipal open councils) to being managed privately or in public-private partnerships depending on the priorities of the nation-state: agro-export monocultures, hydroelectric production, urban-industrial developments, and centralized urban expansion that prioritized capital cities (Vargas Sanabria 2001; Fernández Vásquez 1988). Thus, the so-called liberal reforms of the late nineteenth and early twentieth centuries introduced new ways of managing water, both in rural and urban territories, and were driven by two parallel processes: on the one hand, land tenure transformations and, on the other, a nascent consolidation of capital cities as centers of power in the system of urban settlement.

In the case of Mexico, configuring the possession of the watersheds went hand in hand with strengthening the *haciendas,* which needed a considerable amount of water for their development. However, this also brought about inequality in the resource's use and resulted in a water oligarchy in the central and southern states of the country, such as the Yucatán peninsula (Chiapas, Campeche, Quintana Roo) and those Guatemalan *haciendas* that abutted the border. All of these *haciendas*, in addition to mining and agriculture, were mainly tasked with timber extraction, which had consolidated due to recent relations with other European countries, such as England and France. England was one of their main customers since "Lacandon mahogany [was] shipped to the ports of London, Liverpool, and New York at the price of gold under the name of *Maderas Tabasco,*" as detailed by Jan de Vos in his work Oro Verde (1988: 10). Thus, as technology in transportation, communications, and industry was modernized, water asserted itself as an element of energy production for both steam systems (trains, factories, workshops, mills) and those operated with charcoal. In this sense, water-producing forests were diminished and threatened in two directions: forestry and water extraction.

On the other hand, throughout the region, the hygienist urban modernization of the late nineteenth century brought about a series of modifications both in the infrastructure of the distribution and drainage of city water as they attracted an ever-growing population.

The Liberal Reforms of the Nineteenth Century

With the consolidation of the international division of labor of the capitalist economy in the second half of the nineteenth century, a center dedicated to industrial production and control of global capital now coexisted with a periphery producing raw materials. The second half of the twentieth century in Mexico witnessed a series of nationalist reforms that provided for the regulation of territories, the institutionalization of development, the expropriation of ecclesiastical property, the regulation of natural resources and raw materials, the normativization of land ownership, and the nationalization of watersheds. Central America, after achieving independence, promoted agro-export economies based initially on coffee and banana production by adopting an outward development model (Acuña Ortega 2015; Demyk 2007), situating itself in the commodity-producing periphery. To strengthen this model, in the late nineteenth and early twentieth centuries, local elites promoted reforms that expanded commercial agriculture, increased exports, and strengthened the role of the state in society and the economy (Mahoney 2001: 222).

For James Mahoney (2001), a "radical liberalism" consolidated in El Salvador, which substantially transformed land tenure, eradicating communal structures in favor of the rapid expansion of agrarian capitalism, thus privatizing and concentrating land in the hands of a few with the support of a strong militarized state apparatus. Meanwhile, in Costa Rica, the implementation of a model of "reform liberalism" promoted a gradual transition to commercial agriculture, allowing small and medium-sized landowners to be central units in the new agrarian economy while retaining a centralized but not militarized state. Although other authors argue much of the land was concentrated in the hands of a few – while certainly true in El Salvador – there also existed processes transforming land tenure and giving rise to small and medium-sized properties, which played important subsistence roles in local economies (Lauria-Santiago 1999). These formed a dual *latifundio-minifundio* (large vs. small landowning) structure, which was both concentrated and polarized (Segovia 2021). Additionally, this transformation in the tenure and subdivision of land also implied an increasingly complex structure of access to water, both for agricultural production and urban development.

These liberal reforms cannot be separated, as Rodolfo Cardenal (1996) puts it, from the processes of nation-state formation in the isthmus. For Cardenal, the agrarian economy resulting from these processes gave the local government both a national dimension and a sense of class. At the same time these agrarian economies were inserted into wider circles of power within the overall capitalist market system of the time. In this case, the formation of the nation-state required a territory as a basis for both its national identity and its very subsistence (Demyk 2015). "Agro-export capitalism" (Segovia 2021: 5) also needed certain elements for its functioning: the land and its resources, capital, and (preferably cheap) labor. It can then be said, as Segovia (2021) argues, that "in agro-export capitalism, land constituted the main factor of production, and capital accumulation depended critically on it" (Segovia 2021: 7).

The new national constitutions, promulgated in 1871 in Costa Rica and in 1880 in El Salvador, consolidated the implementation of the reforms. The main issues on which the governments of this time focused their resources were the agrarian economy, boosting coffee and banana production, education, health, as well as transportation and communication, especially with the introduction of railways. Water played a leading role in all areas. However, its role in agriculture, transportation, and public health stands out. Agricultural issues prevailed in rural areas, especially over access to irrigation systems for monocultures; in contrast, health issues were critical in urban areas and correlated to access to drinking water and sanitation systems (Vargas Sanabria 2001).

At the same time, another phenomenon that began occurring during this land-grabbing process was the creation of a huge group of people without access to this resource who thus became temporary day laborers (i.e., workers who moved from plantation to plantation looking for work during the coffee or banana harvest) or small plot tenants producing for subsistence (Arias Peñate 1988). Later, when the cities had begun to consolidate as centers of economic power, much of this landless population moved to urban centers by settling in the peripheries or other areas unattractive to real estate capital (Sermeño 1980). Dispossessed and migrant populations thus formed another face of extractivism, this time a human one.

The so-called agrarian reforms of liberal capitalism thus constituted a systematic process of dispossession, i.e., the extractivism of the time was exercised through land grabbing. At the end of the nineteenth century, this process, which, as previously indicated, went through various spikes in intensity, consolidated a state apparatus in coordination with influential external actors that facilitated local power groups to access large areas of land. The tenuous dividing line between the state and local elite also added to the factors that fomented this process. This land grab was equally favorable for the external actors as through the injection of capital they could influence decisions key to the national economy in favor of international capital. Moreover, the change in land ownership implied ownership over the resources in the controlled territories, which were equally valuable for global extractivism: forests, biodiversity, mining, water, and even human capital. This reinforced the peripheral place of Mexico and Central America as producers of raw materials.

With the interest of the governments of the new Central American republics to promote ideas of progress and freedom, water-related regulations gradually were adjusted to the changes in land tenure, which also involved changing access to resources. At the end of the nineteenth century, both El Salvador and Costa Rica had very similar water management structures, the difference being that Costa Rica had a national framework while El Salvador only promulgated city water regulations. One of the first regulations adopted in El Salvador was the water regulations in the city of Sonsonate, adopted in 1880. In this case, the municipality became responsible for providing drinking water and sanitation to the city. The regulations established the service costs, fines, and provisions for caring for and maintaining the infrastructure, as well as preventing spillage and waste (Diario Oficial de la República de El Salvador 1880b: 621).

According to Felipe Alpízar Rodríguez (2018), by 1830, water was managed in Costa Rica by municipalities, which were responsible for "the cleaning and sanitation of public places, as well as the provision of water for people and livestock" (2018: 37). The country promulgated its first water law as a result of liberal reforms in 1884 and transferred responsibility to the police to ensure the provision of drinking water for the populations, the construction of the necessary infrastructure for this purpose, and the management of wastewater and sanitation. At the same time, the so-called "*Juntas Acuarias*" (water boards) were created. These boards were managed on the municipal level or by members of the city's neighborhoods. By the end of the nineteenth and the beginning of the twentieth centuries, McDermott (2018) notes that there were 225 cases of forest-related conflict. In some of these, "owners of properties with rivers or sources of water were obligated to plant trees on their banks" (Goebel McDermott 2018: 114), as this was simultaneously a stage of extraction (logging) and an attempt to regulate forests that produced not only wood but also water.

In the case of Mexico, the distribution (*reparticiones*) of ecclesiastical lands during the Reform Laws in 1856 led to another process of dispossession of water from Indian communities. This appropriation of land by the large landowners also transformed the watersheds. An emblematic case is the desiccation of the Indigenous area of Ciénega and La Barca southeast of Lake Chapala, the largest lake in the country, by the landowners in the region in the late nineteenth and early twentieth centuries and again in 1930. In that year, the southeastern part of the lake was significantly reduced to expand farmland. This involved litigation with the federal government and the *caciques* of the villages to achieve a "beneficial" distribution of the lands gained for their communities (González 2013). Due to the desiccation, the lake lost acres of capacity for capturing and storing water, expanding properties. In the case of Mexico, the agrarian reforms are better known in the revolutionary era. However, it is important to emphasize that this process began with the mid-nineteenth century reforms since a reorganization of their ownership occurred by taking church lands, as will be explained later.

In 1888, a national decree was issued for the regulation of the nation's waters signed by then-President Porfirio Díaz, allowing concessions to be made through the new national water law. This law answered the need for legislation concerning management above regional and state levels. By requesting a concession, one could obtain the usufruct of a specific spring, waterfall, microbasin, stretch of river, etc., to develop its productive activities. It did not take long for such requests to be made by the large landowners and industrialists of the most productive regions, like Jalisco and Michoacán in the west; Mexico, Puebla, Guanajuato, and Morelos in the center; and Veracruz and Tabasco in the Gulf. Examples of this include the concessions granted to the *hacendados* (owners of *haciendas*) in the region of Guadalajara, who also converted these waterfalls into producers of electricity over the years. During the reforms of the nineteenth century, land tenure in Mexico was concentrated in only a few *hacendado*s and landowners, consolidating in the twentieth century into a reformist liberalism with the transformation and expropriation of some natural resources such as water.

With liberal reforms, the doors opened for the "liberation of the environment" under the ideology of freedom over those resources needed for development, namely water and land. In line with Octavio González (2013) "the creation of the Comisión de la Cuenca Lerma-Chapala-Santiago, [...] since the early 1950s, was focused on political control of the hydraulic sector rather than the promotion of regional development based on the watershed approach" (129). This brought relief to the cities by satisfying their water supply but widespread environmental conflicts for the towns as the legislation certainly did not benefit the hydrologic regions due to the consequences that followed, mainly major flooding. It can then be understood that an *extractivist liberalism* was created in Mexico.

Aboites Aguilar, Birrichaga, and Garay (2010) argue that the innovative projects that entrepreneurs brought forward in the nineteenth century reflected an "economic revolution without which this [hydrologic and territorial] transformation would not have been possible" (22). They also note the economic and structural importance of the new economies, technologies, and development projects, which opened up

> the possibility of building taller, stronger, and cheaper dams thanks to new designs and construction materials and large conduits or drainage channels, as well as the emergence of the internal combustion engine and electric pump, essential devices for extracting large volumes of groundwater [and] key drivers of that revolution. (Aboites Aguilar, Birrichaga, and Garay 2010: 22)

The thinking of this period is reflected in two main axes of analysis: the quantity and innovation in water use. In practice, it can be seen represented in the necessity to create regulatory bodies for such projects and development companies, which is why

> in 1926, the Comisión Nacional de Irrigación (CNI) was founded in Mexico. Thus, after twenty or thirty years, due to the projects carried out by entrepreneurs and governments, the world knew spectacular engineering works that used water in a completely new way and in a quantity never seen before. (Aboites Aguilar, Birrichaga, and Garay 2010: 22)

The anthropocenic process was embodied not only in these projects but in the ideas, meanings, and a new political culture surrounding the environment since "new projects also changed the landscape and, with overflowing optimism, made some think that humanity was finally able to overcome or subdue nature according to the needs of 'society'" (Aboites Aguilar, Birrichaga, and Garay 2010: 22–23). In the economic process, foreign investments in major parallel projects were notable. For example, railways and oil-producing regions such as Veracruz and Tamaulipas (i.e., the Gulf of Mexico) were crucial in this territorial and environmental transformation. The investment of W. Pearson can be highlighted here, an Englishman invited by Porfirio Díaz to serve as a contractor in oil extraction, but who mainly constructed railways and major water, drainage, and sanitation works (Connolly 1999: 50). It should be mentioned that the first entrepreneur who consolidated oil extraction as an industry in 1900 was Edward L. Dohney, a U.S. American of Irish origin who was also invited by the Mexican government to locate well sites in Tamaulipas (Alvárez 2005: 38). The place where the work started was called Ébano, and he and a compatriot transformed not only the industry and extraction of oil but also local ecosystems and the course of microwatersheds.

Water: A Key Resource of Nineteenth Century Liberal Extractivism in Central America

As some authors argue, colonial-era water management structures were maintained after independence had been achieved (Fournier 2010; Vargas Sanabria 2001) but the introduction of liberal reforms implemented adjustments worth noting. First, *ejidos* and communal lands were privatized, as were their resources, with water being one of the most valuable at the national level for both the introduction of transportation infrastructure and agricultural production. It is important to note that at that time foreign capital, especially from England and U.S.A., had strong investments in the region's entire rail network and were simultaneously supplying funds to emerging nations to promote the agro-export economy (Alpízar Rodríguez 2018; Cardenal 1996; Lindo-Fuentes 1990).

These transformations in land ownership were gradual and cannot be understood without accounting for other local factors that affected the transformation of resource access. Water regulations, ranging from national to local, favored the introduction of private water models. The owners of the land also owned the land's resources, and its use and management were solely at their discretion. Even if the municipalities administered the resource locally, they would have still needed to negotiate with local landowners for access. In this way, the first framework for public-private and private water management began to emerge, as well as conflicts over land ownership, access to water, and local irrigation systems (Lauria-Santiago 1999). In El Salvador, for example, the forms of *Sistemas de Aguas* (water systems) and *Empresas de Aguas* (water companies) appeared. The *Sistemas de Aguas* were partially public systems in which urban use prevailed over the rural. They could provide service to one or more cities and the surrounding rural territories. *Empresas de Aguas*, on the other hand, were entirely private systems. Although both formats promoted urban uses, in practice, *Empresas de Aguas* tended to be more closely linked to coffee-producing *latifundios* (large farms). In Costa Rica, the new administrations gave certain key powers to the police and the *Juntas Acuarias*, especially for the maintenance of the water infrastructure they were responsible for. The final decision over the control and use of the resource, however, remained with the owners of the land and sources of water (Collection of Laws, Decrees and Orders of the years 1841, 1842, 1861 in Alpízar Rodríguez 2018: 38).

In 1884, the first water laws of Costa Rica were enacted. It clearly defined the titling of water in terms of land ownership based on whether it was public or private and stressed that wide-ranging powers should be granted to owners of lands where water was located (Alpízar Rodríguez 2018: 39). Private uses of water were generally prioritized over public uses, protecting private infrastructure and limiting public access to water sources on private land. In the case of El Salvador, a national water law was not enacted as in Costa Rica, and municipalities would continue to manage water in their territories in combination with the private models of resource management. At the beginning of the twentieth century, the highest entity in charge of managing water was the Ministerio de Gobernación y Fomento (Ministry of the Interior and Development), which was in charge of introducing different public works at the national level to promote strong investment in water infrastructure. The ministry delegated the administration of water projects to the municipalities. To do this, a municipality would normally form a Junta de Agua (water board), chaired by the mayor and composed of members suggested by the same municipality, which was then ratified by the ministry. Juntas de Agua were also responsible for drawing up the water regulations for the municipality.

The city system inherited from the colonial government in Central America served as the basis for the organization of the urban space of the new republics. In most cases, the old provincial capitals became the new capital cities. Costa Rica is the exception: the former provincial capital, Cartago, came into dispute with San José, which grew thanks to the surrounding tobacco and coffee crops. In El Salvador, political and administrative power remained concentrated in San Salvador, the former provincial capital, but cities such as Santa Ana, around which much coffee production was concentrated, were more important as centers of economic power. In any case, it was not until the 1870s to 1890s, when the nation-states were more consolidated and the agro-exporting economies around coffee started, that the system of capital cities in the region was reinforced (Fernández Vásquez and Lungo Uclés 1988).

The growth of Central American cities between 1900 and 1950 was an important phenomenon that had a significant impact on the water resources of the region. During this period, the urban population of Central America increased from approximately 3 million to 12 million (Fernández Vásquez and Lungo Uclés 1988). This urban growth was due to a number of factors, including rural migration, economic development, and urbanization, and significantly increased urban water use. By 1950, water consumption per person in Central American cities was about twice that of rural areas. This increase in water consumption in cities had various anthropocenic impacts: first, the simple increase of water demand, which put enormous pressure on water resources and clearly impacted water availability; in some parts of Central America, the increase in water demand exceeded the capacity of local water resources, leading to water scarcity and the need to develop new source of water, for example, by constructing dams and reservoirs. On the other hand, the increase in water consumption resulting from urban growth also had an impact on water pollution. The discharge of industrial and household waste into rivers and lakes polluted the waters and made it unsafe for human consumption.

Another recurring theme in urban water management is public health. The hygienist school of thought that took hold at the end of the nineteenth century and grew significantly in the early twentieth influenced the actions national governments instituted concerning cities. Concerns such as the introduction of adequate water supply systems, waste removal, paving, and the creation of open spaces were key in the fight against epidemics such as tuberculosis, measles, cholera, or influenza (Sánchez Ruiz 2020; García Quesada 2014).

In 1873, the issue of water quality and wastewater treatment concerned the authorities and population of the city of San José when the removal of ditches through which water had been transported resulted in stagnant wastewater. This was solved by maintaining these open-air ditches for the discharge of sewage while digging wells and using groundwater as the new source of drinking water. Unfortunately, this solution did not resolve the health problems resulting primarily from the water that had already stagnated in the ditches during the summer. Only in 1890 would the first sewer construction project begin to amend this problem. By 1927, when San José had 50,580 inhabitants, the city had a decree (issued only a year earlier) that protected rivers and ditches by prohibiting the discharge of wastewater into their channels. Factories also had to handle waste from their activities properly. The problem of discharge from coffee producers took until 1936 to be dealt with legally when a decree was issued that completely prohibited the disposal of coffee husks in rivers without prior treatment (Alpízar Rodríguez 2018; Cortés Ramos 2015).

From a more hygienist perspective, the sanitation code of the Republic of El Salvador gave instructions on "wastewater" pipes for residential facilities. For example, sewage was not allowed to be discharged into aqueducts, dams, or domestic reservoirs, nor could it only be discharged in the upper parts of towns, as the currents of rivers flow down. Regarding toilets, there arose concerns about malodorous emissions or seepage; while some of these toilets are understood to have been connected to a sewer system, reference is also made in primary documents to those that were not (Diario Oficial de la República de El Salvador 1900: 1213). In addition, the construction of roads between the capital and the area La Chacra is mentioned; these roads allowed the city's inhabitants to travel to the hot springs and bathe. Finally, with regard to sanitation in general, other projects included the construction of sewers, which consisted of open gutters that discharged into nearby rivers and the "obstruction of ravines," such as the Zanjón de Zurita, so that residual and "filthy" water could no longer be discharged into them (Diario Oficial de la República de El Salvador 1880a: 54).

As cities expanded, especially capital cities, demand for water increased. This increase occurred not only for access to drinking water and sanitation services but also for other issues related to the construction of water infrastructure, such as hydroelectric dams that served the increasing energy consumption, especially of urban centers, and the introduction of irrigation systems necessary to expand and increase agricultural production, i.e., the basis of regional agro-export economies.

However, this infrastructure had significant anthropocenic impacts. For example, constructing irrigation dams and canals required diverting large amounts of water from rivers and lakes, which altered river flow patterns and reduced water availability for other uses, such as fishing and recreation. At the same time, it significantly reduced biodiversity and plant cover, especially of forests, which were sacrificed with the expansion of infrastructure and agriculture. On top of that, new agrochemicals, such as synthetic fertilizers and pesticides, were introduced into the region in the 1920s. These products were more effective than natural ones. While they allowed farmers to increase the productivity of their crops, it was at the expense of causing serious damage to soils and bodies of ground and surface water.

According to the Food and Agriculture Organization of the United Nations (FAO 2022), the use of agrochemicals in Central America increased by 2,000 percent between 1900 and 1950. In 1900, the use of agrochemicals in Central America was limited. Farmers mainly used natural products, such as manure and ash, to fertilize crops and control pests. The use of agrochemicals increased further through the 1950s due to the expansion of commercial agriculture. Farmers began using agrochemicals to produce export crops such as coffee, bananas, and sugar.

In the case of Guatemala City, in Guatemala, water for the city was brought from the region of Mixco, a municipality adjacent to the capital. This represented a transformation that was not only territorial but also environmental and ideological as the gap between nature and society widened and the use of water among various needs and practices became increasingly unequal. Thus, the present conflicts have three planes: the first is the overexploitation of the water tables by the cities and the surrounding villages to the detriment of agriculture itself. The second plane deals with the political problem of ownership and water use, such as citizens' demonstrations over the regular raids that occurred mainly in poor settlements. In this same direction arise the inter-municipal and interregional problems from the struggle for water among dispossessed populations to provide water to the metropolis and conflicts among states to obtain water from the basin. Finally, a third plane of analysis brings together the problems and conflicts of citizens' struggles for survival, no longer suffering from a lack of water but rather from its exacerbated pollution that devastates the health of entire populations such as the villages bordering the Salto River, Lake Chapala, the metropolises of Guadalajara and Mexico, and beyond. The same is true for other regions, such as the Cutzamala Basin in the middle of Mexico and the Cuatro Ciénegas region in the north.

Historically, there has been irrigation infrastructure since pre-Hispanic times, such as aqueducts, *jagüeyes* or open-air rainwater deposits, Mayan cisterns called *chultunes*, vertical wells, etc. (Rojas 2009). In western Mexico, other infrastructure included the *entarquinamientos,* "a complex hydro-agricultural infrastructure system, whose management allowed one to take advantage of the waters of small currents, important streams [and] was composed of masoned dams used to store, control, and divert the waters of the streams" (González Santana 2013: 133). Through the nineteenth and beginning of the twentieth centuries, water was distributed to homes in two ways: by artesian wells inside of a residence or by public fountains installed in certain key points of cities, mainly on avenues or in squares and gardens. These places served as distributors of public services, and in the second half of the nineteenth century, they were romanticized, becoming a part of orderly landscaping, with pathways to enjoy both the trees and gardens as well as the creeks that began there. This form of nature that served as an aquifer within some cities supplemented the water supply of their own rivers and streams. In the case of Mexico City, several of these distribution points for its various streams, canals, and drains survived in their pre-Hispanic forms within the creole city. The main water-producing forests were naturally distributed throughout the city, and the cold climate of the volcanic mountains and the surrounding region contributed to their conservation. However, the growing use of water and the droughts that manifested in the history of the climate (Arrioja and Alberola 2016) made it necessary to transform the infrastructure that supplied the main cities. In the case of Guatemala, the colonial projects and aqueducts

> required the best available technology of the time, large sums of money, [and] considerable numbers of men to manufacture the materials; haul them; excavate and line tunnels; build dams and bridges; erect the archways, intermediate boxes, sewers, or distribution boxes, as well as the domestic network of clay pipes, utility batteries, and public fountains; this enormous effort is referred to in "Los acueductos coloniales de Pinula y Mixco de la Nueva Guatemala de la Asunción" [by Guillermo Guzmán Chinchilla] (Saravia and Duarte 2022: 54)

In the first decades of the twentieth century, a change towards privatization of some water sources in the country began as "in 1927 the private water company Agua del Mariscal S.A. was created in Guatemala." This system, however, remained in disuse during the government of Jorge Ubico, when the Santa Luisa plant and well were built in 1938 and began to supply the city with water through new cast iron piping.

Originally, water from this aqueduct did not pass through a purification plant, as the first would not be built until 1933. It also had no system to measure usage until 1950, when the Municipality of Guatemala mandated the use of meters. The Empresa Municipal de Agua (Municipal Water Company) would later be established in 1972 (Saravia and Duarte 2022: 55). The above demonstrates an acceleration of the various ways of living in cities. For this reason, the transformation and distribution of public services, especially water and its concession at the federal level in the case of Mexico, brought more orderly control not only of its distribution but also of its use, though it still lacked equity and justice. Water concessions need to be analyzed from the policy dimension because they stem from an institutional regulatory will and because these supply regulations have gone hand in hand with a process of sanitation in most of the countries addressed here.

In the first half of the twentieth century, there was a territorialization of the water basins in Mexico, and, as Arsenio González proposes, hydrobasins or hydroregions emerged (Coos 2016). This led to the reformulation of development plans at the federal, state, and municipal levels. But what happened to the predominantly Indigenous local organization? Confrontations took place over the management and usufruct of local water to prevent it being taken to large *haciendas* and cities. Conflicts occurred among the various Indigenous communities as they would take advantage of each other, especially during the dry season. Some towns in Oaxaca in the south of the country "passed from *codueñazgos* [a term for various legal concepts of land ownership] to municipalities" (Mendoza García 2016: 197). From the Law of 1857, ownership and usufruct of water were reconfigured, and Indigenous communities tried to defend their water resources through this new territorial legal framework that leaned more towards privatization. Agrarian problems and armed uprisings of peasants were also caused by problems of access (Escobar Ohmstede, Sánchez Rodríguez, and Gutiérrez Rivas 2008).

One of the main geohydrological regions in Mexico is the Lerma-Chapala-Santiago Basin, which spans several of the country's most populated and important zones of metropolitan development: from the State of Mexico, Morelos, Guanajuato, Michoacán to Jalisco, it unites with Lake Chapala and follows along the course of the Santiago River, past the metropolitan area of Guadalajara towards Nayarit until reaching the Pacific Sea. Another important basin is the Cutzamala, which encompasses important dams in Michoacán and the State of Mexico adjacent to Mexico City, the capital of the country. In this basin, a significant number of *haciendas* were established, becoming the scene of countless conflicts over the tenure of water – or rather of land with water – prior to the revolution of 1910.

At the national level, water went through various changes in regulation as the vision of prioritizing and using water as an engine for industry and *haciendas* began to shift; in June of 1888, the *Ley de vías generales de comunicación* (Law on General Routes of Communication) was decreed, which included fluvial water – the lakes and rivers where transport took place – as a national good. Once the Constitution of 1917 was passed, Article 27 consolidated the centralization of the federal waters of the nation by giving jurisdiction over water to the federal authorities. This transformed the distribution of water for agricultural use and reinforced land use change, creating irrigation districts in the country to organize and distribute water for national development. But along with previous works

> they erased not only localities from the map, but also waterfalls and lakes, even though they also created new bodies of water. The best Mexican example of such an evolution is the Necaxa hydroelectric plant, completed in 1905 over the river waters of that same name, in the Tecolutla River Basin. (Aboites Aguilar, Birrichaga, and Garay 2010: 23)

These authors further point out that in 1926, water was administered through the Comisión Nacional de Irrigación under the administration of General Plutarco Elías Calles, then-President of Mexico (Aboites Aguilar, Birrichaga, and Garay 2010). Afterward, the administration of Lazaro Cárdenas, under a revolutionary ideal, would continue to pursue protectionist policies, nationalizing parks and forests in the country (Wakild 2011).

At the local level, municipalities primarily intervened while still respecting federal guidelines for water concessions. In other words, municipalities had to enforce the regulations and monitor water supply sites so they could begin to pump and channel water through the clay piping that ran under the streets into the houses. In addition, Indigenous neighborhoods, both rural and urban, continued to retain their traditional ways of supplying water through the use of artesian wells and by doing some activities in the surrounding rivers, such as washing clothes and bathing. González (2013) explains that

> in Mexico, there [was] a technique for the use of floodwaters, [waters] also called torrential, *de avenida*, or *broncas* – occurring during the rainy season between June and August – which consist[ed] of channeling torrential waters into artificial reservoirs called *cajas de agua*, *bordos*, *cuadros de agua*, *trincheras*, *muros*, or *pantles*, among others. The main function of these reservoirs [was] to capture water in order to provide moisture and fertility to the soil. It also offer[ed] advantages for controlling certain weeds and nematodes, and it [was] equally advantageous for avoiding soil salinization. (132)

The modernized distribution based on the new water laws still, however, reshaped access to water. Thus, the increasing transfer of rural water to cities diminished the agricultural production of peasants. This led to a series of local conflicts, land invasions, the theft or diversion of water, and neighborhood problems among different groups. The continuing conflict of water's use and distribution among different localities also brought about the privatization of some aspects of its ownership. Consequently, a process began of privatizing federal stretches of rivers, springs, sources, and microbasins due to the growth of industrial development in the city and the countryside. In the latter case, rural areas saw technology begin to be introduced between 1926 and 1940 under Plutarco Elías Calles and Lázaro Cárdenas.

One of the oldest and still persisting systems was the aforementioned *entarquinamientos*. In the following decades, this was clearly seen in the northern region of Michoacán with fruit production, precisely around the Lerma Basin. Another case near this basin was that of the poultry and dairy industry of Altos de Jalisco. San Luis Potosí, in the northern part of the country, produced a significant amount of wheat and corn. Successively, the regions changed from being states, politically speaking, to agricultural regions that clearly depended on the quantity and quality of water they produced.

Continued use of rivers and open-air channels for sewage disposal from industry and homes accelerated the pollution of the waters. In the mid-nineteenth century, several epidemics occurred in both Mexico City and Guadalajara. The so-called "year of major cholera came to Mexico in 1833 and in that same year arrived in Guadalajara [...] with 3,273 deaths" (Oliver Sánchez 2018: 49–50). In 1836, it was called the Deadly Summer as the number of deaths from these epidemics doubled (Oliver Sánchez 2018). The importance of this disaster, especially in Mexico City and Guadalajara, brought about a change in the mentality of the time. Growing positivism in the sciences and in practice shaped a hygienist ideology that could be seen in technology and environmental issues. Technology was favored in transforming urban river basins and other water sites to eradicate the infectious pockets of diseases such as cholera, typhoid, etc. Thus, several streams and canals in Mexico City during the era of Porfirio Díaz were channeled and piped, creating great roads and avenues in the French style. Something similar happened in the cities of western Mexico. In Guadalajara, the construction of the Alameda Porfirio Díaz made the tributaries of the San Juan de Dios river into a single channel, eliminating the need for the bridges that spanned them. The San Juan de Dios river was channeled underground completely between 1898 and 1922 with intermittent pauses in the work and is today contained in the Lago del Agua Azul (Blue Water Lake). The justification for this action discursively was the necessity to eradicate pockets of disease since people often bathed or washed their clothes in the river, which, at the same time, served as a sewage drain for houses, factories, mills, etc. With electricity's introduction into the city in 1905, it was no longer necessary to make use of the river water for the operation of local factories.

The anthropocenic sense is diluted when considering the Capitalocene, Technocene (Leff 2004), and the early twentieth-century hygienist school of thought since many factors influence the transformation of these natural spaces that previously served as aquifers in the city into environmental hiding places. The ideological argument of the nineteenth and early twentieth centuries includes urban, social, ethnic, and environmental cleansing, which can be seen in the written discourse. The press at the end of the nineteenth century "criticized the problems of unhealthiness and the consequences of midcentury epidemics" (Lezama and Mendoza Bohne 2019: 355). Severe criticism was leveled at "those who had turned the street into public dumpsters" (Oliver Sánchez 2003: 75) and made a link between dirt, poverty, and even ethnicity by associating these problems with "many families [who] lived like the Irish or Chinese" (Oliver Sánchez 2003: 76). Hence, in 1892, the sanitary code for the State of Jalisco emerged as an example of what was happening in other states of the Mexican Republic. The code states that the government would be responsible for regulating several issues, including water. The latter intercedes in the creation of a new system of home concessions in which people would be obliged to assimilate and adopt the new system of local domestic distribution within households, as well as to stop relying on public sources and the *aguadores* who distributed water in earthenware jars from house to house. Article 41 of the code states that "no sewage is to be discharged into aqueducts. Nor shall it be allowed to be thrown into streams or canals where water intended for other domestic purposes flows" (Ayuntamiento de Guadalajara 1892: art. 41).

The twentieth century and its new modernizing and hygienist model for water and its functions brought with it a division and classification not only of water but also of nature itself. It also caused water as an element of the environment to change its image and meaning from being public and open for activities to being something invisible, private, and dirty, including due to domestic drainage.

Geography and environment have gone hand in hand in this accelerated transformation of the territory due mainly to various factors such as population growth in cities, accelerated industrialization – both of cities in the nineteenth century and of the countryside at the beginning of the twentieth century – and the models of water privatization of the mid-twentieth century (Lezama Escalante 2019). Aboites (2009) speaks of the nation's water as a process of reformist regulation and institutionalization in the nineteenth century and of revolutionary institutional modernization in the twentieth, pointing to the fact that water was also regulated as part of the *Plan Nacional de desarrollo* (National Development Plan).

Water then became visible as an object of legislation and territorial distribution in the new configuration of the resource and, therefore, of the lands that contained it. However, the regulation of water as a public service brought about a distortion in its management and distribution that came near to the state fully appropriating water. Thus, in the following decades, municipalities created Consejos del Agua (Water Councils) or Sistemas Municipales de Agua Potable y Alcantarillado (Municipal Drinking Water and Sewerage Systems). In Lezama's words, "in accordance with the Mexican Constitution, the waters are owned by the nation, and therefore, their management is limited to the federal government, which in turn delegates to the states the operation of the [different] states of water" (Lezama 2019: 366). In western Mexico, the Patronatos del Agua (Water Trusts) were first established in 1952, and the construction of the Sistema Intermunicipal de Agua Potable y Alcantarillado (Intermunicipal Drinking Water and Sewerage System) was decreed in 1978. This was no different in the other states of the republic.

As cities grew, the need for regulation and sufficient supply became more controlled due to the growth in population, residences, and, above all, industry. The struggle for water between society and industry became more evident, and water had to be brought in from farther and farther away. In the case of Mexico City, water was brought from the Lerma-Cutzamala basin. In the case of the city of Guadalajara, an aqueduct transported water from Lake Chapala and other surrounding towns.

Conclusions

The factors that influenced the anthropocenic water process in Central America and Mexico during the second half of the nineteenth and the first half of the twentieth centuries were diverse but very concrete. First, there was an economic dimension that transformed the possibility of financing large-scale, territorial projects. Secondly, from the legal point of view, new legislation promoted various forms of land tenure and, therefore, the ownership of its natural resources, mainly water. Thirdly, there was the technological dimension with the creation of an electrical, combustion, and steam industry, as well as hydroelectric pumps that facilitated and accelerated not only the transformation of natural resources but also the use of those resources in the transformation of other objects and substances. This went hand in hand with the production of energetic inputs for the cities themselves, mainly as it was with electricity and the domestic water supply. Technologies also influenced the transformation of basins and their bodies of water, such as swamps, springs, falls, *ciénegas* (wetland biome in the north of Mexico), etc. The desiccation of large bodies of water brought with it the expansion of farmland and increased the need for irrigation water. A fourth factor was the political and social dimension that reorganized both land tenure and the distribution of powers not only among the temporal elites but also among Indigenous communities and the conflicts that occurred with the government and amongst themselves in order to obtain the best communal and local concessions. Finally, the cultural factor makes visible a new conception of water as a resource of nature but also as the property of people, mainly those who had the power and vision to use and exploit it.

Mesoamerica has an economy based on exportation and on attracting foreign capital, so that the extraction and export of raw materials have remained constant. The transformations in land tenure that occurred at the end of the nineteenth and beginning of the twentieth centuries in the region constituted one more of these historical extractive episodes, and by laying the foundations of the nation-state, they also underpin the model of joint operation between the governments of the day, local capital, and global capital, which still continue to fuel these extractive practices. Current local political and economic groups in power are linked to new global capitalists, as happened at the end of the nineteenth century in the process of consolidating the agro-exporting economies of the time; in both cases, the ultimate goal remains the same: the reproduction of a model of wealth accumulation (Robinson 2013). Thus, the processes of accumulation by dispossession that, according to David Harvey (2004), are part of the imperialist logic of capitalism, have been consolidating in Mexico and Central America since the former colonial provinces built their own national projects, including

> the commodification and privatization of land; the conversion of various forms of property (communal, collective, and state) into private property rights; the restriction on access to common goods; and the adoption of colonial, neo-colonial and imperial processes of appropriation of property (such as natural resources). (Ávila-García 2016: 20)

Under the banner of progress, the various models of private water management implemented since the end of the nineteenth century show that water in Mesoamerica has always been privatized since the nation-state's emergence. In the case of water, hydropolitical relations tend to take advantage of local opportunities according to advantageous geographical positions (Guy Caubet 2007), which has made Mesoamerica an attractive territory because of the abundance of the resource. For Guy Caubet (2007), in the context of global strategic resource appropriation, freshwater management is the first international hydropolitical issue. The aim was to see water as a commodity and, therefore, make it available to private companies who, with the support of the national governments of the day, hold the rights to use and manage it. Thus, water management, mainly in large cities, is a central point of discussion that permeates supply models as well as the segregation and discrimination of public services, attacking the human right to water in quantity and quality. This has meant reforms to the legal and institutional frameworks that guarantee private investment, especially of global capital, in land tenure and water rights (Ávila-García 2016).

The liberal reforms of the late nineteenth and early twentieth centuries were a necessary initial step that would later develop at various stages throughout the twentieth century to the present day. The commodification of natural resources, including water (Santos 2014), based on an extractivist model is only the most recent phase. The period studied in this chapter participated significantly in the initial push toward the anthropocenic acceleration in the twentieth century. In this way, the anthropogenic history of water in Central America and Mexico resulted in extraction, overexploitation, transformation, destruction, and scarcity.

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Water in the Caribbean from the Mid-Nineteenth Century to 1950

Imperialism and Modern Water in the Neo-Colonial Caribbean: The Cases of Panama, Cuba, and Puerto Rico

Francisco Javier Bonilla

As part of the onset of the Anthropocene, material and biophysical processes worldwide started to assume more homogenous characteristics during the first half of the twentieth century. Water – similar to space, forests, or human labor – suffered disruptions in the ways it was valued by human beings in the twentieth century. This chapter will be oriented toward a regional understanding of the material and epistemic creation of the abstraction geographer Jamie Linton calls "modern water." This type of water corresponds to the "management regime whereby water is treated in isolation, as a volumetric abstraction, rather than as an integral part of inhabited environments" (Scott-Bottoms 2019: 415). Its emergence is linked to transformations at different scales in different places in the world-system and particular hydro-social cycles. The Spanish-speaking Caribbean, as a case study, offers rich contrasts between the different imperial visions of water and the plebeian or subaltern visions existing in urban and rural or agro-industrial spaces between the late eighteenth and mid-twentieth centuries.

To address this issue, this chapter will focus on various aspects and types of water and infrastructure related to urban water supply and wastewater disposal, as well as water control in rural areas (irrigation and drainage). Geographically, this chapter's approach will vary according to the existing literature for each country: Cuba, Panama, and Puerto Rico. As places penetrated by industrial imperialism and abundant precipitation, these countries were precursors to large hydropower and dam-based developmentalism associated with the Global South in the post-World War II era, especially in countries such as India or Brazil. These Caribbean countries all had a diversity of worldviews and different sets of human-water relations, which did not necessarily disappear but became tangential within a national, hegemonic view of water as an abstract resource.

The Anthropocene posits an era in which humanity has become the chief driver of rapid changes in the Earth System. Humans, especially certain groups, have attained a measure of control and impact upon the Earth's ecosystems and planetary health that is unprecedented. More specifically, the Anthropocene is an era when several discrete planetary boundaries have been exceeded by human action or its effects. These boundaries serve as measures to global environmental sustainability and indicate "safe operating limits for humanity in relation to critical issues arising from human occupation of the Earth" (Battistello, Bosco, and Fetz 2018: 103). One of these boundaries is the use of water resources and freshwater consumption. This specific boundary is currently approaching its safe limit in the first decades of the twenty-first century. Linton (2010) argues that this type of control over water differs from that achieved by ancient civilizations in both discourse and technique. He encapsulates this relationship to water in the term modern water: "the presumption that any and all waters are to be considered apart from their social and ecological relations" (14). By reducing water to H_2O, this vital substance tied to social and geographical conditions "becomes a liquid form of modern, abstract space," in a Lefebvrian vein, "guarantee[ing] its social and political utility" through linear quantification (Linton 2010: 101).

One of the manifestations of the increased control over the planet's life-sustaining systems is a newfound control over the Earth's hydrosphere. This control has a distinct trajectory from that of other manifestations or dimensions of the Anthropocene as a process. For example, the use of fossil fuels or the growth of cities might have some direct or indirect correlation but owes its trajectory to different intellectual and material histories. While these overlap and at times reinforce each other, the history of water use and the emergence of a discourse on human-water relations that justifies or enables this transformation of the hydrosphere merits more attention. While the Green Revolutions in the Global South often had dialectic relations with the advent of modern water, both the industrialization of agriculture and the construction of modern water should be studied on their own terms as particular iterations of human-nature relationships. To illustrate this point, global agriculture's transformation could be seen as an outcome of a genealogy in which the Haber-Bosch process and the initiatives led by Global North elites such as Norman Borlaug occupy central roles, the equivalent for modern water can be found in the formulation of the scientific hydrologic cycle and the process of dam-building in different countries.

Dams are a vital piece of hardware in the infrastructure of modern water. Yet, besides impounding, modern water also demands other sorts of control and isolation from social and environmental surroundings:

> By means of its conceptual abstraction, modern water materializes modern man's legendary distaste for mud, muck, and swamps of all kinds. Modern water has been a tremendous ally of drainage projects and the creation of hardened shore-

> lines. And just as we like to keep it neat and separate in the physical environment, we like to keep it separate from people too. (Linton 2010: 18)

It is worth noting that dams, one of the quintessential elements of modern water, were used by the ancients and have been fixtures of economic systems quite different from capitalist ones, such as premodern India or China. Notwithstanding, the large dams associated with modern water are filled with water that is "fed through scientific discourse, its cultural content [...] filtered out" (Linton 2010: 88). This is only possible for water stored within the ideological confines of Cartesian socio-natures.

A debate rages within geology about the validity of the Anthropocene as an epoch since it differs from others in its time span and the consensus around a "Golden Spike" demarcating its beginning in rock or ice. Historians do not abide by the same rules of universal and firm periodization, especially when studying long-term processes (McNeill 2019). However, it may be possible to shed light on the mentalities that have entrenched different relations between human and non-human nature, and their material manifestations in different parts of the globe. "In strictly material terms," Linton and Budds (2014) write, "various forms of water pollution, river regulation, and the hydrologic implications of anthropogenic climate change mean that virtually all water sources on earth now bear a human imprint" (172) Thus, there is no such thing as a natural circulation of water on Earth anymore, and circulation "has to be described in social as well as hydrologic terms. Indeed, recent work in the hydrologic sciences shows that the very 'character' of the hydrologic cycle is being affected by human society" (ibid.). However, this shift in freshwater resource use cannot be simply explained as a quantitative acceleration in the adoption of technologies, which took root in the Global North and then spread elsewhere.

This spread takes different paths and acquires various meanings based on the respective social and environmental contexts. The Caribbean is a region of the world-system that garnered strategic importance at a time when different commodities, such as sugar, became prized in the markets of the Global North during a conjuncture of heightened tensions between European states in the late seventeenth and eighteenth centuries. Cuba and Puerto Rico became some of the earliest and most important producers of tropical commodities. Panama, on the other hand, achieved strategic importance by serving as the Spanish empire's link between the Pacific and the Atlantic, allowing the plunder of the Incan empire to reach the metropole promptly. Historians have shown how through trade, investments, and capital flows, as well as invasions, occupations, and acquisitions, the U.S. came to dominate the region. The Spanish Caribbean of the second industrial revolution, under the influence of U.S. overseas expansion, thus offers a unique case study to grasp how this set of human-water relations took root in service of neocolonialism. The degree to which control over water and the replacement of pre-existing water cultures with what Donald Worster (2006) has termed "imperial water" aided this process remains to be explored.

The Caribbean area has given rise to some of the longest-lasting examples of colonialism in world history (Morgan et al. 2022: 254). By the nineteenth century, this foreign control intertwined with the industrial revolution despite regional independence movements. Central Panama's interoceanic corridor, the main economic driver of the isthmus, fell under the control of U.S. capital by the 1850s with the construction of a transisthmian railroad in the then Colombian province. As early as the mid-nineteenth century, the U.S. was also the single largest market for Cuba and Puerto Rico's exports (primarily sugar).

The chosen case studies also offer a chance to examine the introduction of a homogenizing hydrological discourse where Indigenous cultures existed with different ways of conceiving of and treating waters. In Cuba and Puerto Rico, colonialism decimated the numbers of Indigenous peoples in an early onslaught. In Cuba's case, for example, a "black legend" has impaired the historiography of Indigenous influence beyond the sixteenth century, claiming that diseases, enslavement, and collective suicide resulted in the physical and social elimination of Indigenous descendants. Others have claimed that the Indigenous element ultimately survived as an ethnic and historical component of Cuban society, even amidst a hostile milieu (Padrón Reyes 2017). A similar process took place in Puerto Rico. Even though modern genetics studies have demonstrated the assimilation of Indigenous peoples through *mestizajes*, their cosmologies and views on water as a life-sustaining element could have survived. Scholars have documented that Taino cultures attributed religious and mythical qualities to water. For example, Atabei, the creator, and Yocahú, the supreme deity, are associated with water. In some Afro-Cuban belief systems, derived from the Yoruba religion, Yemanjá, the mother of all Orishas, is a major water spirit associated with both freshwater and the sea (Pesoutová 2019).

In Panama Indigenous peoples survived in large numbers and constitute one of the pillars of its contemporary population. Owing to its colonization at a different stage of Spanish settlement and local resistance to *reducciones* at the peripheries of the isthmus, many of them were able to pass down their traditions and cosmologies, even as these changed over time. For example, the Naso people's connection to water is well documented, and the Emberá people, who currently live in the Canal's watershed, believe water comes from the fall of an ancient tree, whose vines ultimately became the rivers known today. One of the main spirits in their cosmology, Antúmia, is also closely associated with water and visible to their shamans (Forero 2013).

European cultures also conceived of different waters having distinct properties, although greater homogeneity existed than in more animist cultures. "A transition," identified by historian Christopher Hamlin quoted in Linton (2010),

> from an empirical emphasis on diverse 'premodern waters,' which were regarded as heterogeneous entities exhibiting different properties and qualities, to a modern 'essentialist conception of water itself,' [...] appears to have taken place throughout the industrialized world by the end of the nineteenth century. (20)

A remnant of the last stage of this transition, the promotion of mineral waters with medical properties, was still very relevant in Panama, Cuba, and Puerto Rico prior to the stabilization of modern water through science and engineering. Linton elaborates on Hamlin's argument by adding the erasure element, emphasizing that the consolidation of the essentialist conception of water inevitably "destroyed the irreducible variety of waters encountered in premodern times" and "had the effect of disembedding these waters from the myriad social contexts and relations that had constituted them in the first place" (Hamlin quoted in Linton 2010: 75–76).

In Latin America, different governments, often working with foreign experts, ushered in during the late nineteenth century an epoch of water management called "the Great Hydraulic era" by historians (Aboites Aguilar 1998). While this process allowed for the expansion of irrigation and the industrial cultivation of lands miles away from rivers, it only foreshadowed the transformations entailed by the later advent of modern water under more ideological hydrologic science in the twentieth century. This literature helps decentralize the role of the U.S. in bringing modernity to the region. Yet, once modern water is isolated as distinct from the ideology of Progress, it is clear Washington proved instrumental in transforming regional human-water relations.

Panama

In Panama, the Spanish had to contend with difficult drainage in their transisthmian routes in order to make them pay. Sixteenth-century Spanish cosmographer and historian Juan López de Velasco wrote that the mixed terrestrial-fluvial route between the termini at the Pacific and Atlantic, roughly crossing the same region that the modern Canal does, snaked: "through lands of rugged mountains, rivers, and marshes difficult to cross [...] of hills and continuous downpours that disrupt the journey [...] between mountains, of very high groves and marshes, then destroyed with how much it water pours down" (López de Velasco 1894: 346).

Thus, the roads that enslaved people and mules traversed had to be constantly maintained to ensure proper drainage. The corridor was nonetheless subjected to seasonal whims. At both termini of the interoceanic corridor, drinking water was always a challenge, owing in part to the brackish quality of its coastal aquifers. Yet no large-scale municipal aqueducts were built.

The construction of the first transisthmian railroad, one of the first in the tropics after the 1837 Havana to Bejucal line in Cuba, generated a demand for impounded water. Along the line, controlled by U.S. capital, small streams close to the stations began to be impounded to provide water for the interoceanic transit sector (Dudley 1887).

When the French arrived in the isthmus to excavate a sea-level canal, they brought with them much of the incipient science that would later become modern hydrology. However, their plan for a sea-level canal – which came up short due to a series of miscalculations pertaining to the local disease ecology – had the burden of conceiving water as an obstacle to the construction of the waterway. However, it is revealing that their intrusion into the upper watersheds also entailed an increased control of urban waters at the termini. For example, one of several attempts to build an aqueduct in Panama City came during this time at the hands of a French water company, although administrative irregularities prevented it from materializing (Figueroa Navarro 2021). From an engineering perspective, the French effort was doomed because it failed to conceive of the isthmus' waters as a resource. The French also used the excavated soil to fill in mangroves and lagoons they blamed for the spread of tropical diseases from miasmas or deadly vapors. They did not do it in a systematic way as would the U.S. after succeeding them in the project. The lack of sufficient drainage of lagoons and other wetlands also exacerbated the problem of landslides, which frequently haunted the progress made by the French (Parker 2007).

When the French finally gave up, following a bloody civil war in Colombia, Panama achieved independence aided by the U.S., and the latter obtained the rights to build the Canal. Notably, the U.S. engineers inherited all the hydrological data gathered by the French, as well as their cartography, which today resides in a single archive in the National Archives in College Park, Maryland. Moreover, U.S. hydrographers had been gathering their own data in the Chagres River basin since at least 1901. Although useful as a starting point, U.S. technocrats found significant flaws in the French data, attesting to the rapid refinement of hydrology as a science between both efforts. While the French figures for rainfall and discharge of several of the Chagres sub-basins were accurate enough to aid canal design, their figures for area were "questionable," often with outlandish estimates that complicated ensuring a water supply over time (Bates 1905: 32).

The U.S. government ultimately decided to build a lock canal, which allowed them to harness the watershed to build an aquatic staircase over the continental divide. This meant the creation of Gatun Lake, the largest man-made reservoir on Earth at the time. The lake's creation would inevitably entail the displacement of the most populated part of the country, which had funneled transisthmian transit for centuries. Recent scholarship has shed light on the forced displacement of many towns in what became the Canal Zone and adjoining areas, which depended on myriad fluvial sources for their potable water, not due to the engineering requirements of dams but stemming from the racism of U.S. technocrats. This was achieved, in part, through cartographic representations of the future canal line as a territory devoid of people, a tabula rasa yearning for U.S.-led reclamation (Lasso 2015).

Following Castro Herrera, the U.S. succeeded in working with nature, whereas the French attempted to work against it:

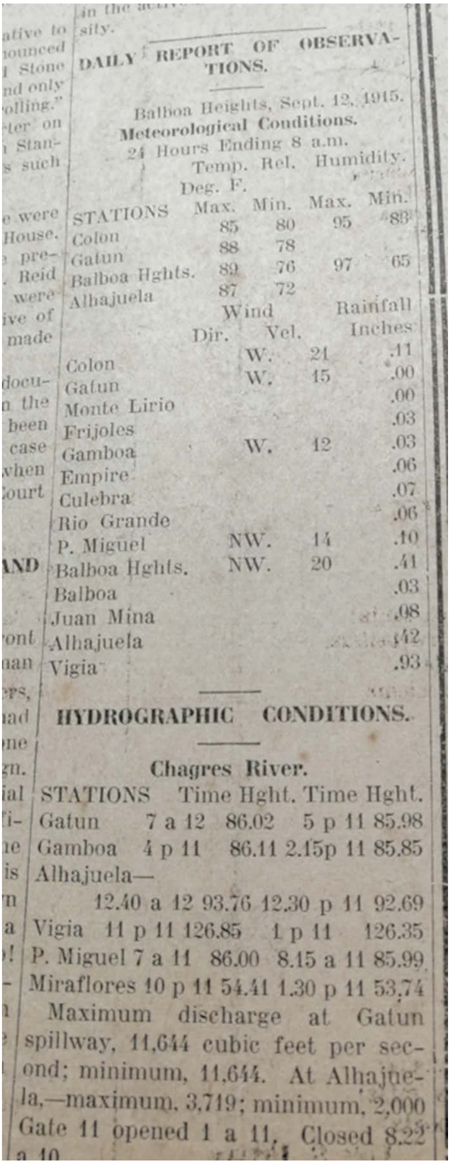
> For the culture that conceived the Canal and organized its construction, the most important fact of nature consisted of the coincidence of a series of physical circumstances – geographical location, topography, climate, hydrography – which made possible a technological solution capable of converting into an advantage what until then had been one of the great obstacles to the development of large-scale infrastructure works for interoceanic transit through Panama: the rainfall regime and the difficult topography of the Chagres basin. And that technological solution, in turn, demanded the creation of essential political and administrative conditions for its success. (Castro Herrera 2009: 54)

The control over people during the construction of the Canal rivaled that over nature in its pretension of totality. The U.S. implemented a segregated labor regime and, through its hydraulic technique, was able to harness the Chagres and the Rio Grande rivers' watersheds and the ecosystem services they provided to make the project feasible.

At both ends of this waterway, the U.S. had complete control of the urban waters at the termini through treaty-given jurisdiction over sanitation inside and beyond the Canal Zone. In the terminal cities of Panama and Colon, the U.S. banned the use of rainwater collection and wells, which for centuries had supplied water to urban dwellers. Sanitarians justified this ban as necessary to prevent the proliferation of mosquito habitats, especially the yellow fever vector, *Aedes aegypti* (Carse et al. 2016). This ban was accompanied by the U.S.-led, but Panamanian-financed construction of water supply networks in both cities, both with water-treatment plants. It is worth noting that even in terminal cities, the U.S. had to make compromises and allow for regulated cesspools and screened water barrels to persist as the mains did not reach all urban residents.

The networks of the sanitary cities were fully controlled by the Canal Zone until World War II, which generated great resentment among Panamanian urban dwellers and officials. The U.S. also led and financed the construction of a modern sewerage system, a combined sewer for rainfall and sewage, in both Panama and Colon. Moreover, the U.S. led a mangrove and wetland obliteration campaign, often under dubious sanitary justifications that did not fully fit with the germ theory of disease.

Figure 1: Daily Report of Observations (of Meteorological Conditions in the Panama Canal Watershed)



DAILY REPORT OF OBSERVATIONS.

Balboa Heights, Sept. 12, 1915.
Meteorological Conditions.
24 Hours Ending 8 a.m.

STATIONS	Temp. Deg. F. Max.	Min.	Rel. Humidity. Max.	Min.
Colon	85	80	95	88
Gatun	88	78		
Balboa Hghts.	89	76	97	65
Alhajuela	87	72		

	Wind Dir.	Vel.	Rainfall Inches
Colon	W.	21	.11
Gatun	W.	15	.00
Monte Lirio			.00
Frijoles			.03
Gamboa	W.	12	.03
Empire			.06
Culebra			.07
Rio Grande			.06
P. Miguel	NW.	14	.10
Balboa Hghts.	NW.	20	.41
Balboa			.03
Juan Mina			.08
Alhajuela			.42
Vigia			.93

HYDROGRAPHIC CONDITIONS.

Chagres River.

STATIONS	Time	Hght.	Time	Hght.
Gatun	7 a 12	86.02	5 p 11	85.98
Gamboa	4 p 11	86.11	2.15p 11	85.85
Alhajuela—	12.40 a 12	93.76	12.30 p 11	92.69
Vigia	11 p 11	126.85	1 p 11	126.35
P. Miguel	7 a 11	86.00	8.15 a 11	85.99
Miraflores	10 p 11	54.41	1.30 p 11	53.74

Maximum discharge at Gatun spillway, 11,644 cubic feet per second; minimum, 11,644. At Alhajuela,—maximum, 3,719; minimum, 2,000 Gate 11 opened 1 a 11. Closed 8.22 a 10

Source: Star and Herald (1915).

The construction of dams for the Canal also accounted for the first hydroelectric plants in the country at Gatun Dam, which supplied the power needed to operate locks and other Canal infrastructure. Shortly thereafter, local and foreign boosters started to perceive all of the mountainous rivers of the country as wasted, harboring the potential to propel the country to the forefront of the Second Industrial Revolution and further exploit its hydroelectric potential. Members of the English-speaking elite expressed their interest in further exploiting the *food–water–energy* nexus. "All the conditions here," as a newspaper editorial put it, "are suitable for the production of this 'white coal' as it has been called." Since Panama had no coal, its rivers, which "rise at high levels [...] and fall abruptly on their way to the sea" could help Panama "jump from the candle to the electric light" via the "modern hydro-electric turbine" (Star and Herald 1916).

Even before the Canal was open for transit, Panamanian newspapers in English and Spanish started to feature daily reports of meteorological conditions, using the data from the Canal Zone's hydrological stations from many of the Chagres and Rio Grande rivers' watersheds. While Panamanians were aware that the potable water supply depended on the same reservoirs and infrastructure as the locks, this was not evident in these daily reports. These reports served to popularize the notion that the infrastructure feeding water to the Canal was fickle, and nature's whims could at any moment suspend transit, whether by drought, flood, or landslide. Therefore, these also served to pave the way for the controversial land takeover of the area around the village of Alajuela, located at the confluence of several Chagres River tributaries, located outside of the Canal Zone (Lindsay-Poland 2003: 29). In the early 1930s, the U.S. built a dam at this site for the purposes of achieving "optimum regulation" of the Chagres, and later for the generation of electricity (Kirkpatrick 1936). This was the start of a never-ending appetite for the waterway, whether controlled by a foreign power or the Panamanians, to expand into other watersheds not included in the original treaty for its excavation.

Cuba

Cuba's history under Spanish rule was characterized by much more intensive cultivation than Panama and a more thorough establishment of colonial landscapes. Cuba can be "seen as a typical plantation economy with external controls over key sectors of the economy," abetted by "powerful, if uneven, manifestations of internal complicity, often associated with race, class, and rural/urban status" (Wilson 2016). Abundant rainfall served to enable this type of development, although it only partially translated into a steady supply of freshwater due to major seasonal and cyclical fluctuations. The country's geography gave way to periods of overabundance of water followed by periods of water shortage. The frequency and intensity of hurricanes have a major bearing on seasonal and secular fluctuations in rainfall. Sugarcane's expansion across the island following the Industrial Revolution transformed Cuba's hydrology, creating the need for a scientific management of water resources. References to droughts, floods, and the decrease in the flow of water in some rivers and streams in the rainy season are frequent in works from the nineteenth century.

Cuba, since an early stage of its insertion into the world-system as an exporter of tropical agricultural commodities, had dams to regulate its water supply. The needs and location of the sugar mills required that the railways follow the river courses since they linked up with the cabotage networks that went from the river mouths to the ports. This brought the rivers and other water sources in the island close to the purview of Cuba's scientific assemblage, one of the most Europeanized of Latin America. Despite being the first country to produce cement in Latin America, dams were limited in size by their masonry construction. A local tradition of hydrology already thrived on the island, influenced by mid-nineteenth century Spanish medical hydrology. For example, in 1861, D. Fernando Valdés Aguirre and D. Marcos de Jesus Melero published a *Cuadro de hidrología cubana*, paying special attention to several mineral waters (Fernandez de Castro 1876: 68).

Shortly after the U.S. occupation, "much interest was aroused in the water resources of the island." Although there were no inland hydrography studies like those the country had gathered for Panama, one of the salient characteristics that the U.S. reports listed beside the several municipal water supplies were the "underground water courses in the soft limestone, some of them of considerable size, [which] are everywhere present." They also specified that "the waters are generally pure, except for the lime, but mineral waters have been exploited for drinking and bathing purposes at a number of localities" (Geological Survey U.S. 1904: 16). U.S. technocrats conducted a survey of "Mineral Waters" in Cuba, documenting the existence of waters with curative properties in different regions. "Although Cuba has at present no commercial production of mineral waters," the report concluded, "it is probably merely a question of time until the waters of its various excellent mineral springs shall be on the market" (Brown 1903: 118).

Unlike in Panama, many Cuban cities did build aqueducts to obtain a stable water supply during Spanish rule. Havana's first aqueduct and Zanja Real date back to the sixteenth century and was considered one of the jewels of Spanish overseas engineering, but sanitary standards made it obsolete by the advent of the Industrial Revolution. Between 1831 and 1835, the Count of Bagaes and Nicolas Campos began work on an aqueduct that bore the name of Fernando VII. The waters of the Almendares River reached a large purification tank equipped with sand and charcoal filters. From there, the water was pumped to Havana through a pipeline, but it was not enough. Under these conditions, the 895 cisterns and the 2,976 Havanan wells supplied the water that was lacking (Fernández-Armesto and Lucena Giraldo 2022: 383). By the late nineteenth century, the city had a newer aqueduct that U.S.

Americans deemed "excellent" in a report from 1899. U.S. observers noted that, at its enclosed source, "masonry drains are laid around the upper surface to prevent any surface water from washing into the spring" (War Department, Office Director Census of Cuba 1900: 172).

In this report, conducted decades after John Snow's investigations on cholera epidemics in England, U.S. experts studied urban water supply throughout the island. Notably, they looked warily upon any form of decentralized water provisioning or unstandardized water purveying, such as street water vendors, since this raised suspicion of dubious water quality. U.S. incursion into overseas colonialism coincided with aqueduct construction in more and more U.S. cities of various sizes and the incipient option of filtering biological impurities, one of the main features of a "modern aqueduct." Thus, water quality and its preservation from outside pollutants were the chief concerns of U.S. technocrats abetting colonialism and not the proliferation of mosquito habitats as it would be in the Panama Canal's terminal cities in the 1900s. In the first decades of the twentieth century, U.S.-style water supply, alongside its regulatory framework, was extended to other cities, including Santiago de Cuba, Pinar del Rio, and Trinidad (Pan American Union 1913: 308).

Table 1: Per cent of urban dwellings obtaining water from sources named.

City.	Per cent of urban dwellings obtaining water from sources named.					Total.
	Aqueduct.	Cistern.	Stream.	Well.	Not specified.	
Cardenas	25	68	0	3	4	100
Cienfuegos	42	7	0	47	4	100
Guanabacoa	1	86	0	3	10	100
Habana	83	4	0	1	12	100
Manzanillo	0	31	30	38	1	100
Matanzas	55	39	0	1	5	100
Pinar del Rio	0	90	6	1	3	100
Puerto Principe	0	54	0	41	5	100
Regla	1	46	0	45	8	100
Sagua la Grande	53	1	8	36	2	100
Sancti Spiritus	73	8	17	0	2	100
Santa Clara	0	89	0	10	1	100
Santiago	94	0	3	1	2	100
Trinidad	0	0	11	87	2	100
Urban Cuba	53	23	3	14	7	100

Source: War Department, Office Director Census of Cuba (1900: 172).

Moreover, it is possible that by the turn of the century, U.S. experts had already applied the principal elements of the hydrologic cycle to the study of Havana's urban waters. In the study conducted on urban Cuba's excreta removal methods, the ignorance shown by U.S. experts of local Cuban adaptations might have served a dual purpose of belittling Cuban engineering and abetting U.S. control of sanitation. U.S. occupiers quickly learned that in Cuba, households had two ways of disposing of excreta: the *pozo* and the *inodoro*. Cuban experts had already studied these disposal methods and published on their efficiency. For example, D. Manuel Fernández de Castro published in 1860 an article titled "Desagües de la Habana por medio de pozos absorbentes" (Fernández de Castro 1876: 68). Nonetheless, in their reports, U.S. sanitarians dismissed these "as it is difficult to find any exact English equivalent for these words" (War Department, Office Director Census of Cuba 1900: 176–177). Elsewhere, when studying Habana's sewers, U.S. officials said that the "existing sewers of Havana do not constitute a sewerage system," stressing the need to modernize, or "Americanize," its hardware and regulatory framework. While a combined system was proposed at first, the plan was shortly revised to a separate system, "with storm-water drains where necessary," possibly attesting to the first incursion of hydrological cycle-based science into the island (Wood 1902: 30–32).

Following the occupation of the war-torn island by the U.S., its sugar economy also suffered changes in its power relations. The U.S. had already bought more than half of Cuban sugar by 1853, but after occupation, U.S. actors now took a larger role in production. The Cienfuegos, Palmera & Cruces Electric Power & Railway Co., for example, got a concession from the Cuban government to construct a railway, build dams, impound water, and generate electricity. Moreover, this concession further granted the

> use of all public waters on the Habanilla and Negros rivers, where a hydroelectric plant will be erected to furnish motive power for the railway. […] The water power development will include a concrete dam 1,000 ft. long and 75 ft. high with a storage capacity of 100,000,000,000 gallons. (Munson Steamship Line 1910: 21)

By the late 1920s, U.S. firms controlled at least 75 percent of the Cuban sugar industry and the majority of public utilities, mines, and railroads (Leogrande and Thomas 2002: 325–326). This transformation did not go unopposed. During the 1912 uprising in eastern Cuba, over 10,000 Afro-Cubans set fire to plantations and documentation, including post-1903 land titles (Pérez 1986: 533). Nonetheless, the displacement of peasant communities was ultimately successful. U.S. capitalists financed the migration of *zafra* workers into the region and have been blamed "for the degradation of a once rich Afro-Cuban culture in eastern Cuba" (McCollum 2011: 7). While the abstraction "land" was much more salient than H_2O in the establishment of U.S. dominance over the sugar industry, it is logical to deduce that different human-water relationships were replaced by the hegemonic view of U.S. monoculture, which reduced waters to a homogenous object or input.

By the mid-twentieth century, modern water had been firmly established among Cubans and foreigners alike as the hegemonic view of water. In the decades following the Great Depression, Global North experts such as Hugh Hammond Bennett, a U.S. soil scientist who had also consulted in the development of the Panama

Canal Zone, saw Cuba as "a country more alive to the need for public and private investments." In 1959, FAO-associated French agronomists singled out "water control," among other factors, as a prerequisite for agricultural development (Funes Monzote 2019: 348). Large dams such as the Hanabanilla dam, begun in 1956 and finished in revolutionary Cuba in 1960, exemplify the widely shared concept. By the 1970s, the rate at which freshwater resources were extracted was much faster than comparable islands in the Caribbean like the Dominican Republic or Jamaica, the great majority of this destined for plantation agriculture (Pérez-López and Díaz-Briquets 1993).

The case of geographer and revolutionary Antonio Núñez Jiménez is revealing about the shifting power relations on the island. Before joining the movement in the 1950s, he was part of a group that proposed using the water of Cuba's second-biggest river to generate electricity and other industrial activities. But years later, at the beginning of the 1990s Special Period, he was opposed to creating a big hydroelectric plant in the same river, an idea finally rejected in times of significant shortages of oil in the country. This also mirrored ideas about the drainage of swamps, such as the Ciénaga de Zapata, which national and colonial officials dreamed of draining but by the late twentieth century had emerged as a site of great biodiversity and environmental services to the Cuban ecosystem.

Puerto Rico

Due to the insular nature of the Puerto Rican archipelago and its complicated history tied first to Spain and later to the United States, José Anazagasty-Rodríguez (2021) argues, "the Puerto Rican waterscape is intricately connected to the colonial history of Puerto Rico." As early as 1899, U.S. hydrologist Herbert Wilson published a glowing report of the development potential of the Cordillera Central in *National Geographic* (Rodríguez Cruz 2018). Even before the culmination of the Spanish-American war of 1898, U.S. technocrats expressed interest in the potential water resources of the island of Borinquen, especially its abundance of streams. In terms of urban water supply and excreta removal, U.S. officials conducted the same type of surveys done in Cuba, with somewhat similar results. Several Puerto Rican cities already had aqueducts, although none fulfilled all of the requirements that U.S. sanitary engineers had adopted by the turn of the century, opening the door for sanitary interventions in cities. San Juan, in contrast to Havana and other cities in Puerto Rico, had less centralized water supply methods, which surprised U.S. officials. Table 2 displays an example of the survey conducted in the three Puerto Rican departments containing large cities to show the similar typologies to the Cuban version. The same prejudices were present in the introductory paragraphs.

Table 2: Per cent of urban dwellings using specified method of disposing of excreta. Report on the Census of Porto Rico, 1899.

Per cent of urban dwellings using specified method of disposing of excreta.

City.	*Pozo.*	*Inodoro.*	No form.	Not specified.
Mayaguez	75	6	18	1
Ponce	79	4	16	1
San Juan	71	11	18	0
Total	76	6	17	1

Source: War Department, Office Director Census of Porto Rico (1900).

In more rural parts of the country, U.S. officials were shocked to find that over 75 percent of dwellings had no provision for disposing of human excreta. They rationalized this by explaining that “it is said that in rural Spain the inhabitants commonly have no closets or outhouses, but resort to the fields, and the same is apparently true of Porto Rico” (1900: 111).

By the late nineteenth century, Puerto Rican cane planters, mill owners, managers, and other interests tied to sugar cultivation had already transformed a landscape where dams were not rare, and the observance of water rights was firmly established in the Spanish legal tradition. As noted in the 1909 *Annual Report of the Governor of Porto Rico*, the first one done after the establishment of the U.S. built an irrigation network and established a new legal framework for water rights, several owners of small nineteenth-century dams were allowed to rebuild them as part of the newly introduced system (1910: 213). In the first decades of occupation, “U.S. capital circulated through nature via agricultural production, mostly in sugar production, or through land improvement projects like the building of water supply and irrigation systems” (Anazagasty-Rodríguez 2021)

One of the major changes brought about by the U.S. occupation of the island was the construction of large irrigation infrastructures. Notably, *hacendados* in the southern part of the island had sought to irrigate their sugar lands since the mid-nineteenth century. The Guayama Irrigation Project relied on schemes drawn up by a British engineer which included a mountain reservoir and several channels and aqueducts. This project never began construction and lost its license, but it evidences that irrigation in part of Puerto Rico had antecedents predating the occupation of the island by U.S.-style plantations and the arrival of modern hydrologists (Ramos 1997).

The imprint of the U.S. occupation in water management materialized in the South Coast Irrigation Project (SCIP), established by The Puerto Rico Public Irrigation Act of 1908. It depended on three major dams: Guayabal, Carite, and Patillas. Two smaller ones, Coamo and Melania, were also completed during the project’s establishment, which doubled sugar production in the decades following its completion in 1914. Despite relatively abundant rainfall compared to the regions of California where U.S. experts had developed some of the techniques associated with "imperial water," modern water had a significantly difficult time becoming stabilized in Puerto Rico due to the cycles of drought, hurricanes, an early nationalist movement amongst locals, and a new disease ecology, which will be treated shortly.

The SCIP was a massive project that entailed a complex regulatory framework to avoid the misuse and undesirable circulation of waters and included the creation of The Irrigation Service, a Law of Waters, and a Public Irrigation Law. Some of these regulations revised or amended previous ones as the system was stabilized along with the conception of modern water. The following is an extract of correspondence between the Puerto Rico Attorney General and the Chief Engineer that illustrates how the conception of water rights was changing and the decoupling of the abstracted water from land:

> Where land in the Irrigation District is transferred by *arrendamiento* without mention of water rights, all water rights appurtenant to the land are, during the period of transfer, under the control of the *arrendatario*. […] If the *arrendatario* of the land directs that the water be delivered upon the land leased, it must be delivered there. […] If the *arrendatario* directs that the water be delivered upon other land, it may be so delivered with the approval of the Commissioner of the Interior. (Puerto Rico Department of Justice 1915: 130)

In this series of correspondence, there is also some resistance to the concept of modern water and its subsumption within an irrigated plantation complex. As it was not yet hegemonic and an independent peasantry could not be fully excluded, the Law of Waters made some room for peasants with no direct access to water:

> The Law of Waters stipulated that while waters run along their natural and public channels, run through canals, irrigating ditches, or uncovered aqueducts, even though belonging to private grantees, any person may take and carry away in vessels what is required for domestic or craftsmen purposes. […] but the taking must necessarily be done by hand. […] It is understood that no person shall enter private property in order to take or use water […]. (Puerto Rico Department of Justice 1915: 5)

One could argue that the U.S. navigated the pre-existing moral economies of water in the area by recurring to appropriate technologies or small-scale, locally controlled technology that would prevent abuse (Willoughby 2019).

Scholarship has shown that, in contrast with the Cuban case, following the entry of U.S. agribusiness land tenure did not become concentrated in fewer hands (Solá

2011). This type of regulation perhaps reflects the persistent, or newfound, power of smallholders to assert their rights.

Owners of livestock and sugar planters often had conflicting interests, as manifested in the regulation of the system. The irrigation authorities also put in some safeguards to avoid abuse by the owners of the best-located fields:

> If the privilege of establishing watering places along any of the canals of the irrigation system were granted without limitation to adjacent land owners, and they were allowed to water stock there without paying for the water used for such stock, the result might well be that large quantities of the water of the irrigation system would be thus consumed without any compensation to the irrigation service. (Puerto Rico. Department of Justice 1915: 5)

The commodification of water in this arid landscape, similar to that of Central Panama's urbanized hydrology, required metering as a technology of surveillance and control.

Recent scholarship has highlighted how the creation of modern water was not linear and had to overcome opposing goals by different departments of the U.S. bureaucracy. Matthew Johnson's study of the unforeseen consequences of irrigation infrastructure on public health highlights how non-human nature challenged the stabilization of modern water on the South Coast. The irrigation system – especially its vegetation-choked irrigation canals, holding reservoirs, wet cane fields, and "stagnant pools that formed when canals overflowed after heavy rains" (2019: 244) – created ideal habitats for *Anopheles albimanus*, malaria's principal vector in Puerto Rico. Palliative measures such as "draining seepages and mangrove swamps and spraying a potent insecticide called 'Paris green' destroyed mosquito breeding grounds, but […] were insufficient" (Johnson 2019: 245). This dialectic between mosquitoes and the plantation complex reached a tipping point when, in 1934, the colonial government proposed legislation to require that all reservoirs be drained each week, infuriating the *azucarero* class (Johnson 2019). From the point of view of hydrologists, this proposal undermined their faith in technical progress and the creation of a homogenous H_2O that could be managed under universal principles.

Conclusion

While one of the main points in this chapter has been how U.S. imperial officials used hydrologic science and its recommendations to underpin colonial rule in the Caribbean, such studies from environmental history call attention to the differences between these officials concerning environmental management and complicate linear narratives. Paul Sutter's (2007) environmental history of the Panama Canal's construction similarly explores how this enterprise, associated with making the tropics safe for the white race, also opened habitats for *Anopheles* in non-urban spaces and generated conflicts between entomological workers (sanitarians) and engineers focused on completing the waterway. These works opened a debate about the place of modern water and its stabilization in a "modernist culture of science" and reinvigorate an older one about the internal relations of Worster's "imperial water" (2006).

One of the areas for further research in the construction of modern water in the region is the common role played by particular U.S. experts in fixating this homogenous view of waters. Beside Bennett, others such as Frank Wadsworth have a big presence in the forest history of Panama and Puerto Rico, and the ideas that he circulated influenced human-water relations. Local voices have also traveled and merit more critical attention, such as the Cuban Carlos Finlay, who laid the epidemiological foundation for future U.S. environmental interventions.

The three chosen cases illuminate different arenas for the construction of the technopolitical conditions appropriate for modern water's establishment. Panama speaks to the dialectics between material and discursive transformations of water. Puerto Rico's case is illustrative of the legal changes that affected agrarian waterscapes in drought-stricken areas. Cuba, on the other hand, shows how the political economy of agricultural activity can play a role in buttressing modern water. This point is rarely made in the historiography of neocolonialism in the region, which has focused generally on the developments of the Second Industrial Revolution and tropical medicine as the main instruments of empire.

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From 1950 to Present

Source: Fernando Efrén Sandoval Herrera (2021)

Introduction: Water and the Anthropocene in Latin America from 1950 to the Present

Ricardo A. Gutiérrez, Susana Herrera-Lima, Lourdes Sofía Mendoza Bohne

Since 1950, water availability and use have been critically affected by three major socio-economic processes: the production and export of raw materials, industrialization, and urbanization. While the specialization of the countries of Latin America and the Caribbean as suppliers of raw materials for the international market began during the colonial period and was later reinforced during the formation of national states in the nineteenth century, industrialization and urbanization (which are connected) are predominantly phenomena from the period post-1950 and a part of the Great Acceleration of the Anthropocene. The Great Acceleration refers to an exponential increase in economic activity and resource consumption that explains the great anthropogenic transformations alluded to in the Anthropocene concept (Waters et al. 2016). In Latin America, this acceleration is expressed in the growth of the population and its purchasing power and consumption levels, as well as in the exploitation of raw materials needed to feed a growing industrialization and/or increase in exports, and in so doing, strengthen the foreign exchange reserves of the states. Across the region, the Great Acceleration has meant an increase in water consumption and pollution, thus pressuring the physical limits of the quality and quantity of that resource (Castro 2016; Ruckert et al. 2021).

Although the region shows declining population growth rates (mainly due to declining fertility), the population of Latin America and the Caribbean increased three times (292 percent) between 1950 and 2022, from 168.3 million to 660.3 million inhabitants (Economic Commission for Latin America and the Caribbean [ECLAC] 2022). While the countries of the region already have high levels of poverty and inequality indices among the highest in the world, the anthropic pressures from this slower population growth will be compounded by the growth of the economy and the population's consumption power. According to World Bank data (n.d.), the region's GDP grew seven times (715 percent) between 1960 and 2023, from USD 732 billion to USD 5.97 trillion. GDP per capita during the same period increased by 169 percent, from USD 3,344.80 in 1960 to USD 8,992.30 in 2023.

As in previous periods, the production of raw materials has been oriented not only to domestic consumption but also to exports. While the demand for agricultural products for domestic consumption has increased along with the population and its level of consumption, the region's international trade continues to be dominated by the export of raw materials and the import of manufactured goods, suffering the respective ecological consequences (Gudynas 2015; Torres et al. 2022). According to World Bank data (ibid.), agricultural production in the region as a whole increased from USD 78.82 billion in 1965 to USD 335.14 billion in 2023, representing a 325 percent growth. For its part, mineral extraction (metalliferous and non-metalliferous) increased five times (503 percent) between 1970 and 2017, from 659 to 3,972 million tons (Bárcena 2018), generating strong ecological pressures and social conflicts, with special emphasis on water availability.

In terms of economic activities, one of the main novelties of this period has been the development and growth of manufacturing production driven by the import substitution industrialization model that is mostly oriented to domestic consumption (Furtado 1993). With significant variations among countries, this model was in force between the 1940s and 1990s. Since the 1990s, both the economic policies that liberalized and deregulated the market and the neo-developmentalist policies that followed in some countries have not been favorable to industrial development. Despite this, according to 2022 data, the manufacturing industry's share in the region's GDP (13.9 percent) is higher than the share of the agricultural and mining sectors combined (6 percent and 5 percent, respectively) (ECLAC 2023). Over the entire period, the region's industrial production grew four times, from USD 207,320 in 1965 to USD 984,540 million in 2023 (World Bank n.d.).

If the growth of the urban population is one of the most distinctive features of the Great Acceleration at the global level, this is particularly noticeable in the case of Latin America and the Caribbean, where this population has increased extremely rapidly since 1950, reaching levels of urbanization only comparable, from an interregional point of view, with those of North America. Between 1950 and 2010, the region's urban population grew from 69 to 469 million people, and its share of the total population increased from 41 percent in 1950 to 80 percent in 2010 (ECLAC 2012). Along with urbanization, metropolitan areas grew. Between 1950 and 2010, the number of cities with 1 million inhabitants or more grew from eight to fifty-six. However, there is significant variation among countries in the region. While some of them had reached, at 2010 values, urbanization rates higher than 85 percent (Argentina, Chile, Uruguay, Brazil, and Venezuela), in other countries, the percentage of urban population remains below 60 percent (Costa Rica, Honduras, Nicaragua, Paraguay, Guatemala and Haiti).

According to ECLAC data (2012), urbanization levels are positively associated with those of economic and social development: the higher the level of urbanization, the higher the human development index (HDI) and gross domestic product (GDP) per capita. In ecological terms, this implies that despite the alarming levels of poverty and social inequality in Latin American and Caribbean cities, the urban population demands and consumes more natural resources than the rural population.

In addition to the demands on water from industrial, agricultural, and mining activities (which have increased considerably during the post-1950 period), growing urbanization adds its own demands. In fact, some authors consider urbanization as an "accelerator" of the processes that characterize the Anthropocene (Elmqvist et al. 2021). This is due to several reasons (CEPAL 2012; Intergovernmental Panel on Climate Change [IPCC] 2022; United Nations Development Programme [UNDP] 2022). First, urbanization inherently entails a significant degree of artificialization of the environment, which creates greater ecological pressures on the territory where cities are established, depending on their density and dispersion. Second, the ecological effects of urbanization are not limited to the occupied territory or its surroundings but reach to more distant ecosystems from which most of the resources for urban life are obtained. Third, the lifestyles and higher incomes of the urban population are associated with patterns of production, consumption, and waste generation that are more burdensome to the environment. Finally, urbanization is a prominent cause of climate change, mainly due to increased greenhouse gas emissions associated with activities in and for cities.

In Latin America and the Caribbean, where planetary imbalances interact with social inequalities, rapid and unplanned urban development further increases pressure on natural systems. The most socially vulnerable populations tend to settle in environmentally fragile or high-risk areas, such as slopes and flood plains, affecting not only these environments but also human health, as these are areas without basic services such as drinking water, sanitation, or waste collection (Santos 1993; UNDP 2022). In addition, the most vulnerable urban populations are also more exposed to the effects of climate change. Nowhere is the interdependence between ecological vulnerability and social vulnerability more evident (IPCC 2022): manifestations of climate change, such as extreme heat waves, disproportionately affect human health, livelihoods, and health infrastructure (water, sanitation, energy, and transport systems) in informal urban settlements.

In addition to the above, urbanization is closely linked to natural disasters, which have increasingly dominated political, academic, and media agendas due to several factors, including the increasing frequency of such events, their possible connections with global environmental changes, and the significant role of human actions, both deliberate and unintentional, in exacerbating these disasters (ECLAC 2012). Besides, there has been growing frustration with the human inability to control these phenomena despite technological and scientific advances, which contributes to a sense of resignation, as reflected in the theories of the risk society (Beck 2002). The relationship between urbanization and disasters is complex. On the one hand, urbanization amplifies the weight of the "human factor" in disasters through the artificialization of the environment and unsustainable patterns of production and consumption, which increases the likelihood that ecological imbalances, both global and local, will lead to disasters. In addition, urbanization intensifies the impact of such events by exposing larger populations and assets to their effects. On the other hand, urban areas facilitate more effective disaster mitigation with early warning systems and rapid response measures (ECLAC 2012).

In summary, as the chapters in this volume will show, the growth of urbanization, industrialization, and dependence on the extraction of raw materials has entailed – during this period in the context of climate change – the growing and excessive use of water, leading to what some refer to as a "water crisis," despite the fact that this is the region of the world with the highest per capita availability of freshwater (Fernández Colón 2009). This crisis is manifested in the reduction of river flows, the loss of lakes and wetlands, the decrease in groundwater levels, and the contamination of the resource in all its sources. Climate change has exacerbated this crisis, impacting human health, livelihoods, and essential infrastructure (IPCC 2022). As the chapters in this volume will further show, the excessive use and persistent contamination of water pose challenges to universalizing access to drinking water and basic sanitation. At the same time, the predominant water management models and practices in the region are inefficient or insufficient to achieve a sustainable use that, among other things, would guarantee universal access to water and sanitation services and allow better adaptation to recurrent droughts and floods and natural disasters (ECLAC 2012; Castro 2016,). Despite international and national declarations of the human right to water (Castro 2016), universal access to water, marked by deep social inequalities, remains an unresolved task throughout the region. This scenario may worsen if the major transformations in the biochemical processes and physical limits of the planet that are typical of the Great Acceleration become accentuated.

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Water in the Southern Cone from 1950 to the Present

The Anthropocene and the Water Crisis in Large Cities: Advances, Setbacks, and Outlook

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With increasing frequency in recent decades, the term Anthropocene has been used in various – mainly academic – spaces and, recently, more timidly in the media and among social movements. "Anthropocene" is a term used to refer generally to the relationship between human development processes, especially industrial ones, and their impacts on the planet. Due to the intensification of these processes, in terms of scale and complexity, and the fact that the term is recent and wide-ranging as incorporating other such processes, it remains complex – and still controversial for others – how one should understand its relationship with other even broader ones. The aim here is to highlight two processes of particular interest: urbanization and the water crisis.

This chapter aims to present historical and analytical elements that highlight the relationship between complex urbanization processes and the water crisis, especially in the context of Latin America, which presents marked dynamics of the exclusion and historical inequality of vulnerable populations and groups. A non-systematic literature review was conducted on the debates surrounding urbanization and the water crisis, focusing temporally on the urbanization process from 1950 and evidencing some of these relationships in the context of three large metropolises in the Southern Cone of Latin America. Thus, the first section addresses some primary debates on the Anthropocene and its connection with the urban debate. This is followed by a discussion about the relationship between urbanization processes and water management. Subsequently, some of the historical water resource management processes are addressed in the large metropolises of Buenos Aires (Argentina), Santiago de Chile (Chile), and São Paulo (Brazil) to contextualize these relationships. Finally, conclusions are presented.

The Anthropocene and its Relation to Urban Growth since the Second Half of the Twentieth Century (Cities in the Anthropocene)

According to a recent IPCC report (2021), current atmospheric concentrations of carbon dioxide are higher than at any time in at least two million years. This converges with the increasing pollution of air, water, and soil, which currently causes some nine million premature deaths annually (PNUMA 2021). For many scientists and specialists, these effects are the marks of the so-called Anthropocene.

Understood as the "epoch of humans" (Rodrigues 2017), the Anthropocene, which would follow the Holocene that began about 11,700 years ago, is characterized by visible traces left by human action on the planet that significantly modify the Earth's functioning and flows.

Studies such as those by Johan Rockström et al. (2009) and Steffen et al. (2011; 2015), based on the concept of planetary boundaries, show how these major changes have been occurring on the planet and the impact of human activities in this process. According to Rockström et al. (2009), nine planetary boundaries delineate the most important dimensions of the global sustainability problem emerging from the scale and speed of human interventions in the Earth System (Pereira and Freitas 2017). This signals the importance of contextualizing the emergence of new actors in global climate governance and their relationship to water governance, as is the case with metropolises.

Among the controversies surrounding the Anthropocene's beginning, some scientists argue that the agricultural revolution, some 10,000 years ago, would be the turning point due to the start of land transformation processes. Others argue that the Industrial Revolution of the mid-eighteenth century would be the starting point due to the massive use of fossil fuels. Finally, other researchers defend a starting point in the 1950s called the "Great Acceleration." This moment would be seen as the acceleration of human activities that caused an exponential increase in natural resource consumption, population, urbanization, and synthetic materials production, among others, generating a marked uptick in carbon dioxide's concentration in the atmosphere, deforestation, biodiversity loss, and several other markers that suggest changes in the planet's dynamics (Rodrigues 2017). For the purposes of this chapter, the latter will be adopted as the moment of analysis for understanding the relevant aspects that contributed – and continue to contribute – to urbanization processes.

Anthropocene and Urbanization

The urbanization process, especially in its present form, is a phenomenon intrinsically linked to human development that manifests itself as a constituent part of modern societies, both in its organization and structure, as well as its development and impacts. In this sense, in its current configuration of interdependence and complexity between cities and their interior and relevant to its global insertion, urbanization is an accelerator of the Anthropocene (Elmquist et al. 2021). This manifests itself in urban area's connection to and dependence on resource extraction, mainly in rural areas, creating a dynamic where the demand for urban resources is influenced by aspects such as population size, infrastructure density, consumption and lifestyle patterns, and urban and management policies, among others. In this context, the disconnect between cities and their peri-urban and rural areas is often reflected in land use transformation, deforestation, and habitat destruction, leading to increased emissions.

Thus, as urban populations expand, rapid and unplanned urban development appears to occur globally, increasing pressure on natural systems. This exacerbates other problems arising from the interaction of these pressures with other socio-economic and structural factors such as inequality, poverty, racism, discrimination, gender exclusion, etc. In this sense, when planetary imbalances interact with horizontal inequalities, mainly to the detriment of poor and vulnerable populations, they tend to reinforce historical patterns of exclusion and power imbalance directly linked to inequalities of recognition (human dignity and rights), procedure (lack of access to consultation or justice), and distribution (by distributing only the negative impacts) (UNDP 2022). Some authors recognize this as environmental and climate injustices (Scholesberg 2007; Martínez-Alier 2007).

Current accelerated urbanization deepens historical inequalities and generates new ones, with impacts not only on their immediate location but also outside it (Biermann et al. 2016). In this context, climate change and biosphere integrity (terrestrial, aquatic, and marine biomes) would be central limits (Steffen et al. 2015), and the Anthropocene would constitute an appropriate concept for environmental awareness and for the search for more sustainable patterns of Earth System governance (Biermann et al. 2016). In a context in which most of the world population's growth will live in urban areas, especially in developing countries, considering the different factors and elements to comprehend the various complex realities becomes relevant, especially in urban growth scenarios in developing countries of the Global South, such as Latin America.

From this perspective, economic development and world population growth have led to an expansion of excessive water use, consequently reducing river flows, leading to the loss of lakes and wetlands, and lowering groundwater levels. Increasing pressures on water resources are included in this context of extensive anthropogenic transformations. The fact that more than half the world's population has no access to basic sanitation and that one-third has no access to water, with 26 percent without access to safe drinking water and 66 percent without access to sanitation (United Nations [UN] 2021), shows a very worrying picture of the challenges to universalizing water access in urban, peri-urban, and rural areas. Among the population still without sanitation, 70 percent live in rural areas and one-third in less developed countries. However, it should be noted that much of this is due to disorderly and exclusionary urbanization processes that occur in most cities but also stem from deforestation and the extent of cultivated land that significantly impacts hydrological systems, affecting both water quantity and quality.

Urbanization Processes in Latin America since 1950

The urban transition in Latin America accelerated in the second half of the twentieth century. In 1950, almost 60 percent of the population lived in rural areas. Latin America is a fundamentally urban region with many sparsely populated areas. More than 80 percent of its population currently lives in cities, making it one of the most urbanized regions on the planet with some of the largest urban concentrations in the world (Mexico City and Sao Paulo exceed twenty million inhabitants) (PNUMA 2021: 34). Although urban population growth and rural-urban migration have lost momentum, projections indicate that by 2050 the proportion of urban population will be near 90 percent (UN-Habitat 2012). Meanwhile, profound distortions have characterized the conditions of urbanization and development, many inherited since the colonial period, unlike the modernization experiences in other parts of the world, such as Europe and North America.

The heavy dependence on natural resource extraction has shaped Latin America as a continent marked by inequalities. Its economic specialization, historically rooted and linked to capitalist, neoliberal, financial, and real estate exploitation (Pereira 2016), has led to a heterogeneity of production that, in current forms of practice, entails strong environmental deterioration and an increase in vulnerability and social exclusion. Social contradictions, such as the concentration of informal settlements and territories dominated by illegality, are more evident; at the same time, the presence of social movements in the resistance and struggle for decent housing and the right to remain in the city has increased in the context of speculative processes of different natures (PNUMA 2021: 35).

Precarious conditions, such as lack of access to basic services and infrastructure, distance from urban, social, educational, and labor services, violence, and insecurity, among others, affect the most vulnerable urban populations and reinforce historical processes of exclusion and segregation. This is compounded by high levels of economic inequality, with the most affected groups being women, Black and Indigenous people, and the elderly.

Thus, in Latin America, the problems typical of accelerated urbanization in the countries of the Global South persist, such as the presence of excluded and poor populations, large peripheral and precarious areas, issues of land degradation and pollution of water bodies, problems in public transport systems and bottlenecks, and violence, among others (PNUMA 2021). These problems, typical of the urbanization process, will be aggravated by the emergence of new threats of systemic crises, such as the coronavirus pandemic, and the intensification of others, such as climate change. The increase in extreme events and disasters already affecting urban dynamics will further intensify pre-existing problems.

Water and Urbanization in Large Cities: Progress, Setbacks, and Challenges

For the United Nations, the water crisis is among the greatest global risks and therefore declared the theme of the International Decade for Action: "Water for Sustainable Development 2018–2028" (UN 2018). The challenge of universalization of services is present in all countries of Latin America, with a projected accelerated urban growth in the coming decades due to the high mobility of the rural population to urban areas (UNESCO 2016). In this way, urbanization constitutes an environmental change whose continued growth will increasingly require complex processes to sustain urban dynamics. Concerning water dynamics, this relationship is close and immediate, as in the water-city relationship, new environments are formed to meet urban demands, from new urban landscapes to new ecosystems around water reservoirs (Swyngedouw, Kaïka, and Castro 2016).

In this context, global climate change has become another aggravating factor of global environmental changes related to urbanization, causing "impacts on human health, livelihoods, and key infrastructure" (IPCC 2022: 11). Thus, the urban environment, in its various forms, is highly impacted, affecting strategic infrastructure services, such as water access.

The infrastructure model currently adopted for water and sanitation (piped water systems) was exported from cities in the Global North (Braadbart 2013). Thus, the current scenario of water and sanitation access in cities of the Global South, especially in large metropolises, reflects the way urbanization took place: unplanned and accelerated – even known as "superurbanization" – with no capacity to receive the rural population, which was pushed into urban areas, rather than attracted to them as a result of urban pressure in rural areas (Sovani 1964; Braadbart 2013).

Back to sanitation systems, water channeling, and drainage, the "monopolization of the urban home water market" was completed in the mid-twentieth century (Braadbart 2013: 130), associated with the sewerage channel. However, interest in investing in water pipelines was much higher due to the immediate – though not permanent – improvement in public health indicators, as well as domestic, commercial, and industrial demands and the increasing scarcity of urban water resources, which was not the case with sewage systems in the Global South (Braadbart 2013; Hall and Lobina 2013). In this way, the paradigm of channeled water – increased water channeling at the cost of less investment in sewage systems – contributed greatly to the pollution of urban water resources and regions near cities, affecting both the water supply with the pollution of springs and the public health of populations in excluded areas of urban centers (Braadbart 2013; Heller 2013; Paz, Almeida, and Günther 2012).

Meanwhile, the unsustainability of this single model of health infrastructure, a so-called gray infrastructure, has been guided by the growing recognition of green infrastructure: nature-based solutions or the valuation and insertion of environmental or ecosystem services in urban and/or regional development projects. Integrating ecosystem services has been an increasingly used alternative, whether to meet the demands of the limited pipeline water paradigm for all types of human settlements or address the climate emergency.

Rural water use is extremely relevant, especially for irrigation. However, direct consumption to meet basic needs such as drinking, hygiene, and food preparation correlates to population concentration, largely in urban areas (Table 1). Considering the need for water services in the context of ecosystem services, urban demands depend on rural areas, which encourages surface water production while preserving its multifunctionality and proper management. Therefore, investing in ecosystem services through policies such as Payment for Environmental Services (PSA) are ways to contribute to the "promotion of rural development models based on production systems that contemplate ecosystem services and the multifunctionality of the rural landscape" (EMBRAPA n.d.).

Following this trend, similar initiatives are growing, and with the mediation of institutions such as the Inter-American Development Bank (IDB), the FEMSA Foundation, The Nature Conservancy (TNC), and the Global Environment Facility (GEF), today the continent has about forty Water Funds established in metropolitan regions of the continent. In Brazil, in particular, PSAs evolved around water services, with the National Water Agency's Water Producer Program in 2006 (Fidalgo et al. 2017) connecting the city (consumer) with the countryside (producer). Such programs complement investments in sanitation infrastructure services, regardless of their nature. In Brazil, 84 percent of the population has a treated water supply, yet 35 million people do not have access to this basic service. Regarding sanitation, in addition to being precarious and unequal throughout the country, the national average collection of sewers is 55 percent and treatment 51 percent (SNIS 2021). In Argentina, 87 percent of the population had access to safe drinking water, but only 53 percent had access to the sewage network. In Chile, 95 percent have adequate service and access to drinking water and 91 percent to sewerage.

Table 1: Access to Water and Sewerage by Urban Population

Country/City	Urban Population	Water Supply	Sanitation and Sewerage (collection)
Argentina*	92 %	89 %	63 %
Chile**	90 %	91 %	89 %
Brazil***	86 %	94 %	63 %

Source: *MOP (2019), **OLAS (2020), ***SNIS (2020).

The data presented here for urban areas show similarities in terms of access to safe drinking water in all three countries. However, Chile shows much better results in terms of basic sanitation access (Table 1). All three countries have chronic water scarcity problems in several of their regions, which manifest recurrently (Paz et al. 2021).

In this context, water security can be seen as an increasingly strategic issue, which, as Linton and Budds et al. (2014) affirm, emphasizes the relationship that describes how individuals, families, and communities can transform hydrosocial relationships to access water. This requires a systematic effort, empowering individuals and social organizations to participate actively in the various water governance bodies. To better understand these dynamics, the following section presents a portrait of how large metropolitan cities in Argentina, Brazil, and Chile approach the development of this water-city relationship and their actions around urban water and ways of reaching the population.

The Anthropocene and the Water Crisis in Large Southern Cone Metropolises: The Cases of Buenos Aires, Santiago de Chile, and São Paulo

Buenos Aires, Argentina

The history of Greater Buenos Aires (GBA) can be described as early metropolization and late peri-urbanization. Already by the 1960s, the fracture between the city, the municipal centers of the first ring, and the periphery was marked, and institutional fragmentation manifest throughout the metropolitan territory (Prevôt-Shapira 2000). Since that decade, the supply of infrastructure and public services has not followed the growth of the metropolis, causing issues of transport and flooding, with special emphasis on the lack of water and sanitary sewerage (Pirez 2002).

As in many Latin American cities, Buenos Aires' urban growth went beyond the city limits, spreading to the periphery through public lots and settlements (Brunstein 1989; Prevôt-Shapira 2000) without the accompanying urban infrastructure development. This consolidated into a paradoxical situation of "urbanization without services," where a large part of the population – especially those outside the formal market – began to inhabit and occupy (formally or informally) urban land without sufficient infrastructure (Pírez 2013; Pírez 2006).

The deterioration of public areas in many municipalities of GBA from irregular settlements in flooded and contaminated areas without infrastructure, services, and accessibility created the socio-environmental liabilities that exist today, with close links between vulnerability, poverty, pollution, segregation, and exclusion (Pírez 2006, Merlinsky et al. 2012). Urban infrastructure services affected by this process include water and sanitation access. Historically, until the end of the 1970s during the military dictatorship, the federal government was responsible for water and sanitation throughout the country, serving 85 percent of the national population (Urcelay 2007). The decentralization that took place from that decade onwards made the provinces autonomous. In 1980, the provision of water service and sanitation was transferred to the twenty-three provinces with the decentralization of the state-owned Obras Sanitarias de La Nación (OSN, National Sanitary Works). This organization was left responsible only for the Buenos Aires Metropolitan Area, which at that time consisted of the city of Buenos Aires plus thirteen districts. Since 1991, a vast and accelerated process of privatization of almost all its public enterprises, including water and sanitation, has been initiated, conditioned by deficiencies in technical diagnosis and inaccurate information (Lentini 2004). In 1994, Argentina underwent a constitutional reform that introduced an environmental clause (Article 124), recognizing the historic right whereby the twenty-three provinces and the Autonomous City of Buenos Aires possess and have jurisdiction over water resources, including interjurisdictional rivers, as well as responsibility for the provision of water services within their boundaries.

According to Catenazzi (2017), the OSN was given a concession for thirty years in a horizontally and vertically integrated manner, and the winning proposal was a consortium with more than 50 percent foreign capital. In the first ten years of the concession, fares increased by 88 percent, well above inflation, and consideration should also be given to the fact that irregular settlements and unconsolidated areas of municipalities were not covered by the contract with the consortium (Bujak 2018). All this generated high social and economic liability, and expansion through investments in works was limited, impacting the human right to water and the absence of citizen participation in decision-making and control of service delivery (Azpiazu et al. 2005).

In 2006, after almost thirteen years of successive contractual renegotiations with the connivance of the national government, low water quality indices in several regions, and a long and contentious negotiation process that began in 2002, the concession was revoked, demonstrating that private management did not result in the expansion of access to these services (according to the targets set in the concession contracts) for the most impoverished social groups. Thus, in the same year, the main state company in charge of providing the service, Agua y Saneamientos S.A. (AySA, Water and Sanitation), was created, whose company shares belong 90 percent to the state and 10 percent to workers through an equity stake in the Single Shareholding Program.

The universalization of urban services has not been achieved, mainly affecting the poorest sectors of the population living in the most remote and degraded areas, where urban land is cheaper (Pírez 1999). It should be noted that Greater Buenos Aires (GBA) is located in a territory with abundant watercourses. This "water" scenario shows that, unlike other regions of Argentina where water is a scarce resource, in Buenos Aires, water is present everywhere.

The GBA comprises the Autonomous City of Buenos Aires and twenty-four adjacent districts of the Province of Buenos Aires, concentrating about 75 percent of the water deficit of the agglomerations (equivalent to 55 percent of the total urban deficit). In the Buenos Aires suburb, 3.7 million people do not have access to piped water and 6.8 million do not have access to sewerage. Also, the district of La Matanza, the most populous of the whole, has contributed the most to urban growth, representing more than 42 percent of the total increase. The lack of decent housing for low-income families has led to squatting on land without basic services, especially low-cost land prone to flooding – a recurrent issue – and water consumption from community sources.

According to the latest census, only 73 percent of the GBA population has safe drinking water access, and only 56 percent has basic sanitation access through the public network (INDEC 2010). These figures show that water access in Buenos Aires, rather than being a problem of natural or technical causes – associated with the scarcity or abundance of water – relates more to social and political issues associated with its production and distribution (Tobias and Fernandez 2019).

While the City of Buenos Aires has coverage levels close to universal service (99.6 percent for water and 98 percent for sewerage), the GBA districts have values well below the regional average (67 percent and 41 percent respectively) (Tobias and Fernandez 2019). High levels of population density with poor sanitation (sewerage) systems increase the deterioration of aquifer water quality. The disconnect between the expansion of water and sanitation services and metropolitan growth also leads to water resource deterioration, mainly affecting the poorest and most vulnerable sectors.

The commercial logic that prevailed during privatization in the period from 1993–2006 deepened socio-territorial inequalities in relation to service and repeatedly increased fixed service and tariff costs, as well as prioritized expansion in areas with higher incomes (especially municipalities near the capital), increasing the economic and territorial exclusion of the peripheral population from drinking water and sewage service access (Catenazzi 2004).

In 2020, out of a total population of 14,713,137 served by the company, 10,925,276 inhabitants (75 percent) had access to drinking water and 8,798,979 inhabitants (60 percent) had access to sanitation (AySA 2020). AySA's biggest challenge has been the lack of coverage in flood areas and areas with scattered populations, especially the sewage effluent collection service. In addition, the region's topographical and soil characteristics, associated with providing water without the simultaneous collection of effluents, elevate contaminated groundwater in many areas of the GBA, aggravating health risks (Merlinksy et al. 2012).

Santiago, Chile

In 1951, Chile's first national water code was promulgated and remained unchanged until 1967. These regulations incorporated traditional practices and norms with greater state intervention to consolidate national economic development, then in force. Its wording struck a balance between state regulation and private property rights.

In the political context of centralization, the 1967 water code was enacted, which gave broad legal powers to the state and substantially altered the legal nature of water rights. This code had two main objectives, on the one hand, to facilitate the allocation of agricultural land, and on the other, to increase the efficiency of agricultural water use. Prior to the promulgation of the 1981 water code, the government resulting from the military coup in 1973 introduced neoliberal economic policies that boosted private property and free market rights over various components of the ecosystem. Thus, in 1979, a decree was passed allowing the establishment of the water rights market, justifying that the problems of scarcity were due exclusively to the low efficiency of the irrigation system and the predominance of low economic value uses (Retamal et al. 2012).

The 1973 military coup repealed the 1967 code, and the 1980 constitution guaranteed all persons the right of ownership in all various tangible and intangible forms of property. In this way, water was recognized as a fully tradable good, and water use rights were given to people free of charge, in perpetuity, without having to justify what their use would be and even allowing the transfer of these rights like any other property (Retamal et al. 2012; Bauer 2015).

From the perspective of water management, a neoliberal model was developed, characterized by the state's low participation, the market's role in reallocating the resource, and a system of granting private water rights, whose ownership is constitutionally protected and concentrated in a few companies. The 1981 water code established permanent private ownership rights over water resources, allowed market mechanisms for water allocation, and delegated regulation to user organizations. Therefore, based on the principles of privatization, commodification, and marketing, the legal framework was designed to simultaneously increase the role of the private sector while reducing that of the state in water management to encourage investment by users in infrastructure and improve water use efficiency. In this way, allocating scarce water to the most productive economic uses, such as mining and export agriculture, was encouraged, and access was ensured permanently, duty-free, and relatively exempt from state regulation (Budds 2020). This allowed existing water rights to be regularized as private property rights and decoupled them from the land to enable a market in water commercialization.

The first well-founded criticisms of this model were observed with the return of democracy in the early 1990s, which focused on grabbing water rights and the notorious separation between water and other ecosystem goods and services provided by the basin, deepening the sectoral system of natural resource management (Jara 2015).

The most important reform was carried out in 2005, incorporating, among other aspects, the possibility of including water resources in the protection of public interest and human consumption. Also incorporated were the obligation to consider environmental aspects when granting new water rights, the incorporation of a justification when applying for new rights, and the collection of a growing patent fee for unused water rights, with the aim of curbing hoarding and speculation. However, since 2010 and the advent of a center-right government, these programs' objectives have been substantially modified, oriented towards the water market's reactivation, with the conviction that it is an optimizing instrument of the resource economy (Jara 2015).

Subsequently, a 2018 reform introduced relevant changes in control and sanctions, and a modification is currently underway that aims to highlight the national good character of public water use, prioritizing and protecting human consumption and sanitation. These reforms intend to avoid the non-use, accumulation, or appropriation of water use rights; modify the regime of new ownership, which would no longer be given in perpetuity but would be granted for thirty years, extendable; and protect areas of environmental importance, being able to establish a minimum ecological flow in areas with threatened or degraded ecosystems (BCN 2017). However, the amendment in question maintains the current system of water rights redistribution through the market (UN 2023).

The assessment of the problems associated with the imperfections of the current legal-institutional framework indicates the existence of inefficient and ineffective irrigation systems at the farm level that result in higher than necessary consumption. It also shows possible negative developments in the long-term hydrological balances of some basins as a result of increased consumption and decreased water availability due to aquifer depletion or negative cyclical variations in climate functioning. It verifies as well the irregularity and uncertainty of water rights due to the existence of a large number of uses recognized by legislation, the lack of clear mechanisms to resolve conflicts between users from different sectors, the lack of clarity in regulations related to water quality management, the exploitation of groundwater, and the management of natural channels. Limiting user organizations in terms of their composition, functions, and capacities as instances of participation and representativeness on the broader scale of a basin reduces the possibilities for decentralization and intersectoral development (Jara 2005).

In this context, 76 percent of Chilean territory is currently affected by water shortages. More than 50 percent of Chile's municipalities, representing 8.5 million people (47.5 percent of Chile's population), and one-third of the national territory's land area (231,056 km^2) is under an official water shortage decree. 2021 was one of the driest years in the country's history, registering a rainfall deficit of more than 50 percent, a reduction of water in the reservoirs, with only 45 percent of its total storage capacity, and a significant decrease in the flows in the country's main rivers. The structural problem of water management in Chile, together with the climate crisis, are the main causes of the water resource availability problem in the territory. In 2021, 53 percent of the country's communes were declared to be in a situation of water scarcity and rationing.

The study "Transición Hídrica: el futuro del agua en Chile," presented by Fundación Chile in 2019, identifies the main problems related to water resources: 44 percent due to failures in water management and governance, including the lack of transparency in the water market and lack of institutional coordination at the basin level restricting the management of water resources in tranches, as well as limited user control and insufficient, fragmented, and contradictory information on water. Another 17 percent result from the growth of productive activities and the excessive granting of water use rights; and 14 percent come from water pollution caused by the use of chemicals in agribusiness, mining environmental liabilities, lack of effluent treatment in rural areas, and declining quality due to lower aquifer levels and saline intrusion. In summary, agriculture, mining, and power generation, coupled with deteriorating water quality due to pollution, make this resource chronically deficient north of Santiago and often deficient south of Santiago. At 12 percent, natural causes, such as decreasing rain and snowfall and melting and retreating glaciers due to rising temperatures, appear only in fourth place. One contributing factor has been the loss of vegetation on the slopes of hills and ravines, which has accelerated runoff, reduced groundwater recharge, and increased evaporation due to global warming in central Chile, advancing the process of desertification (Santibañez 2015).

The highest demand for drinking water is in the Metropolitan Region of Santiago (MRS), with 50.5 percent, where about 40 percent of the national population is concentrated in an area of 15,403.2 km^2, representing more than seven million inhabitants. The MRS presents high risk conditions in drinking water supply since the increasing demand for home water is compounded by the decrease in availability due to a massive drought that has affected the central area of Chile for more than ten years and is associated with climate change. The country's capital, Santiago, for example, had only 81 mm of rainfall in 2021, according to the Dirección Meteorológica de Chile (Meteorological Directorate of Chile), while the historical average is 520 mm. This reflects anthropogenic climate change, with implications for the frequency and magnitude of rainfall events, and the continuation of a very intense drought would result in a rainfall deficit of 75 percent compared to a normal year. According to experts, it is necessary to restrict the amount of water extraction for less urgent activities than human consumption, as this is a smaller portion compared to the demand for water from agriculture. The region is mainly supplied by the Maipo and Mapocho rivers, whose flows are at their historic low between 1979 and 2021 (Alvarez Garreton, Boisier, and Marinao 2021). The MRS operates seven companies that control the urban drinking water market. These companies have owned the same water rights for many years without an update. In better-off neighborhoods, consumption is 800 liters per person per day, while national consumption is 170 liters per person on average (Duran 2015).

The existing margin between water availability and drinking water demands is tight, and the minimum ecological currents that must flow are insufficient. The city's growth and the demand for water, together with the projections of a decrease in rainfall and the consequent availability of water (Boozkurt et al. 2018) have tended to further tighten this margin, which directly affects the region's water security. However, faced with these questions in the most remote and deprived neighborhoods of the MRS, the solutions observed have focused on technical decisions that silence the issues of social exclusion related to the right of water access (Lukas and Fragkou 2014: 70). Water security problems, due to their complex characteristics, require systemic strategies involving the reduction of consumption in municipalities with excessive rates, loss reduction, and adaptive planning.

Following the defeat in the 2022 plebiscite, proposals for changes to the water code, which prioritize access for human consumption, were suspended, allowing progress towards a just water transition and sustainable water use. The proposal is based on seven strategic priorities of the Dirección General del Agua (General Directorate of Water), which seek to improve information on water resources, collaboration with water user organizations, strategic basin management, records processing, technological innovation, operational transparency, and updates to water legislation.

São Paulo, Brazil

Unlike Chile, which had the agricultural use of water as its central axis, Brazil developed its first water code in 1934, only regulating concessions for the hydroelectric industry since hydroelectricity requires work that interferes with the natural course of rivers, thus defining that access to water must be guaranteed to all people. Therefore, access should be free when destined for the basic necessities of life. Therefore, the code sought to meet the demands of an urbanizing and industrializing country, strengthening a national development project and characterizing the prioritization of the energy sector as an economic input to the detriment of other sectors (Jacobi et al. 2015). Subsequently, it was only in the 1990s that progress was made in regulating the water sector, inspired by the Dublin principles and integrated management.

In the 1990s, Brazil introduced a new water resource management model focused on watersheds. This model was introduced in the state of São Paulo in 1991 and the rest of the country in 1997. Although it involves participatory, integrated, and decentralized management – the watershed is the regional water planning and management unit in the state of São Paulo – in practice, features of the old model persist. The Basin Committees are composed of a parity representation of the central administration of the state and municipalities, the local communities, and the different categories of users. Its primary function would be the arbitration of conflicts in water use and access based on efforts to reduce pollution (Jacobi et al. 2015).

Since 2012, several municipalities in Brazil have faced decreases in rainfall, outlining a complex scenario of water scarcity. This climatic phenomenon has caused serious impacts on the supply of water for public supply and other uses, such as irrigation and power generation (ANA 2014). In this context, the metropolitan region of São Paulo experienced a severe supply crisis as a result of the water governance crisis. The Metropolitan Region of São Paulo (MRSP) is located in southeastern Brazil and is considered the third-largest urban conglomerate in the world. Its area is almost entirely contained within the Upper Tietê Watershed and comprises 7,947.28 km^2. The MRSP comprises thirty-nine municipalities with more than 20 million inhabitants, including the municipality of São Paulo, with a population of approximately 12.5 million (IBGE 2021). It is an area marked by the complexity of an urban environment with disorderly and intense land use and occupation, in addition to high population density.

The MSRP's geographical configuration also makes water retention difficult as it is a basin embedded with higher areas that, despite pouring water into the Tietê River – the main river that cuts through this part of the São Paulo territory – do so with a reduced flow through the metropolitan region. Added to this are factors such as intense deforestation, accelerated urbanization, and a very small river slope, which causes the water flowing through the MRSP, especially in the municipality of São Paulo, to have a lower velocity.

Therefore, the water collection, treatment, and distribution system involve several basins, part of which are located in other units of the federation, making the water supply issue federal with the consequent political implications. Most of the thirty-nine municipalities that make up the MRSP have water supply and wastewater collection and treatment services through eight water-producing systems operated by the Compañía de Saneamiento Básico del Estado de São Paulo (SABESP, Basic Sanitation Company of the State of São Paulo), a mixed economy company responsible for the sanitation of more than 370 municipalities of the state of São Paulo and thirty-one municipalities of the MRSP.

Seasonal crises, which used to occur every ten years, have been recorded at shorter intervals in recent years, demonstrating the fragility of water in the MRSP. In addition to the factors inherent in the systemic functioning of the MRSP's water balance, the progress of climate change impacts is monitored (Di Giulio et al. 2018; Buckeridge et al. 2018).

Along with the climatic alterations associated with deforestation in the northern region of the country, it is also necessary to consider the disorderly occupation in the nascent protected areas of the MRSP, created in 1978, to avoid degradation of the water used to supply the inhabitants. The population with the lowest income occupies outlying areas due to land valuation and income concentration, which leads to the expulsion of the poorest and most vulnerable to more deprived areas of basic urban services.

It should be noted that the issue of water security (Jacobi et al. 2019) in the MRSP has been the main agenda of the media since early 2014 due to the anomalous spring and summer between 2013 and 2014. In fact, the problem of climate cannot be ignored among the reasons that have led to the water crisis; it has, however, highlighted problems related to water resource management and demonstrated the need to establish a new relationship between management and use to ensure sustainable consumption.

From this perspective, in addressing the water crisis, it is necessary to link water scarcity to the imbalance in access and the problems of the current governance model, which mainly affect the poorest people. Factors that accentuated the impact of the water crisis should also be highlighted, including the lack of domestic wastewater treatment, deforestation and occupation in emerging areas, lack of planning for the construction of new reservoirs, lack of investment to reduce losses, and institutional incoordination.

According to Jacobi, Cibim, and Leão (2015), the crisis shows that a lack of transparency was a constant feature in the behavior of the water management bodies in the state of São Paulo and that the decision-making process on the emergency works adopted was carried out without consulting the Basin Committees involved. The water crisis has complex roots, stemming from inadequate management and lack of transparency. The absence of a systemic vision and failure to fully use scientific data that could have provided society with a transdisciplinary view of the problem also contributed. This would have allowed the crisis to be articulated in advance, mitigating the impacts on the population, especially that on the periphery, which has poor infrastructure and tends to be the most affected by increased extreme weather events, both due to a lack or an excess of rainfall.

In this context, some civil society initiatives have emerged that have demonstrated the ability of multiple actors to articulate against the paradigm of scarcity and the construction of a new water culture. These representatives of civil society also emphasized the need to promote a transition from the current management model involving the orientation of public policy and governance in five areas: care for water sources in rural and urban areas, water waste and loss reduction; water treatment and reuse wherever possible; the revision of economic instruments, such as sanitation tariffs and water rights; and, finally, the expansion of participation and social control in a context increasingly threatened by climate change (Jacobi et al. 2018).

Final Considerations

Although there is still no consensus on the understanding and scope of application when using the Anthropocene concept, it is feasible to evidence its relationship with urbanization processes, especially since the 1950s. However, when referring to the Anthropocene, it must be seen that countries and their populations do not contribute equally to processes related to the intensification of ecosystem degradation, just as all groups are not affected equally by its impacts.

Regions of the Global South, such as Latin America, suffer from the impacts of these processes disproportionately, mainly as a result of uneven urbanization. The historical inequities that characterize the region influence the accelerated process of urban growth, which reinforces exclusionary dynamics in the same expansion of urban spaces. This form of exclusion is manifested in a lack of access to the city or to various essential public services, such as insufficient housing and unequal access to water and sanitation, causing health problems among the most vulnerable populations.

The three cases analyzed demonstrate, on the one hand, the problem of water insecurity and, on the other, the need to adopt policies that, in a climate emergency context, require a new approach to sanitation deficits, the need to guarantee access to all segments of the population, and water loss reduction in supply systems. It is, therefore, increasingly necessary to promote policies that consider water scarcity as a factor in a new perspective on water governance. Faced with the impossibility of increasing water supply without causing multiple conflicts and impacts, solutions that seek to optimize water demand (eco-efficiency, reduction of consumption, use of reused water, etc.) must acquire greater prominence in the agenda of managers and government officials.

In this context, the most innovative aspects of the water security agenda include a conceptual approach focused on vulnerability, risk, and resilience; an emphasis on threats, impacts, and critical thresholds; and a focus on adaptive management, due to the limited predictability of hydrological systems. Thus, to ensure water security, it is necessary to change the hydraulic paradigm and its technocratic, centralized, and technological bureaucracy to recognize power asymmetries and inequality in the dynamics of water distribution and access – but also recognize the capacity of the population to contribute with solutions that guarantee access to water in quantity and quality. At the same time, it will be necessary to reconcile different water demands with supply over time, considering seasonal climatic variations and appropriate risk management of extreme events (such as droughts and floods).

Within this framework, four dimensions of water must be considered essential in the context of its crises in the Anthropocene: (i) human rights and the reduction of access inequities and inequalities; (ii) support for ecosystems; (iii) strengthening transparent and shared governance systems; and (iv) ensuring water security and recognizing the value of the ancestral uses of populations directly dependent on it for their livelihoods. It is also essential to ensure anticipatory and precautionary tools to address the environmental and climate justice emergency in mitigation and adaptation, which take into account human rights, since it is essential to modify the asymmetries that exist in access to environmental benefits for various uses.

Finally, the need for participation must be stressed in the various stages and dimensions of governing the various actors involved and, therefore, the importance of the right of access, especially to information. Equally important is the Escazú agreement, which aims to guarantee water access rights and is linked to environmental justice. Adopted in Escazú, Costa Rica, on March 4, 2018, it is the first agreement in the world to contain specific provisions on human rights defenders and access to justice in environmental matters, as well as creating and strengthening abilities and cooperation, contributing to the protection of the right of everyone to live in a healthy environment with sustainable development (UN 2023).

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Water in the Andes from 1950 to the Present

The Hydro-Capitalocene: Extractivist Coloniality and Decolonial Struggles of Andean Peoples in Defense of their Waters and Territories

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Since its conquest by European empires, Latin America has been subjected to the extractive exploitation of its natural wealth. The Andean zone – which stretches from the Sierra Nevada de Cocuy in western Venezuela to the Tierra del Fuego on the border of Chile and Argentina, passing through Ecuador, Peru, and Bolivia – has been an extractive epicenter from the start of the Spanish colonies through to globalization. Beginning with the plunder of gold and silver mining and continuing with monocultures and agribusiness, the environmental history of the Andean countries has been marked by subordination to the centers of metropolitan power, whether during the European colonial era, the nineteenth-century processes of independence, or the twentieth-century deepening of structural dependence.

This extractivist coloniality has increased in volume and intensity during the last decades, with water and energy being the primary inputs and conditions of possibility that materially sustain the large-scale extraction and export of commodities for the Global North, mainly Europe and North America, as well as China (Gudynas 2015; Torres et al. 2022). In this sense, from the 1950s onwards, a transition from second to third-generation extractivism occurred, where the scale of extraction and depredation of energy and water increased. In this regard, Gudynas proposes a historical temporality of four "generations of extractivisms" (Gudynas 2015: 21–30). The first generation spans from 1492 to the independence processes in the first decades of the nineteenth century, distinguished by the extraction of nature through human and/or animal power with limited or no application of technology. The second generation goes from 1850–1950, mainly characterized by an "increase [in] the volume and intensity of appropriate resources thanks to the more wide-spread use of technological applications" (22) generated by modernity, which overcame the contribution of human and/or animal power. The third-generation extractivism extends from the 1970s to the present and is defined as "the appropriation of natural resources increases even more in volume and intensity" (24). Finally, fourth-generation extractivism overlaps with the third and appears in the "last quarter of the twentieth century" (27). However, it differs from the third generation as now

> the highest intensity and input of energy and matter to obtain resources can be observed. This category also includes, for now, obtaining hydrocarbons through hydraulic fracturing (also known as fracking or the exploitation of shale gas, etc.) and the removal of hydrocarbons from oil or tar sands. (Gudynas 2015: 26)

Likewise, for the period from 1950 onwards, the literature argues that a new geological era called the Anthropocene is emerging (cf. Crutzen and Stoermer 2000; Svampa 2019a). Critically, this era has also been conceptualized as the Capitalocene (Moore 2015; Ulloa 2017; Machado Aráoz 2020), whose main cause is the anthropogenic rift of the planetary metabolism produced by global capitalism and extractivism's gradual expansion in Latin America, orchestrated by Western imperial powers (Baldwin and Erickson 2020; Foster 2022). Thus, this chapter seeks to answer the following questions: How do capitalism and extractivism produce a hydrological Capitalocene in the Andean territories and what types of territorial struggles and state responses does this new hydro-geological era generate there?

It is argued here that capitalism and extractivism's advance in these countries has been producing ecological, hydro-social, and cultural rifts, which have led to what will be called the Hydro-Capitalocene in the Andes. In the face of this, local responses and territorial struggles are emerging. Andean peoples are mobilizing to decolonize themselves from the Hydro-Capitalocene's various structures, which control access to and manage the socio-natural water cycle in these territories. This chapter is structured in three interconnected sections based on participatory action research experiences in Chile, Bolivia, Ecuador, Colombia, and Peru.

In the first part, an account of the Andean countries' common historical process is constructed in terms of dependent and colonial capitalist dispossession based on the relevant extractivisms in the Andean zone. It is argued that such dispossession and extractivist coloniality, together with climate change, have co-produced the Andean Hydro-Capitalocene, as evidenced by the multi-scale rifts that the hydro-social metabolism has been experiencing (cf. Torres and Rojas 2018), as well as the patriarchal, ecological, and territorial violence generated by extractivisms there.

The second part reconstructs the historical processes of the Andean peoples' decolonial struggles from 1950 onwards, describing the land struggle's general trends. This struggle in the second half of the twentieth century was obstructed and partially reversed by neoliberal globalization, generating a general process that has dispossessed peasant and Indigenous communities of their lands for new third-generation extractivisms. Since the 1990s, the latter have produced a series of socio-environmental conflicts, and gradually, conflicts over water, so that the traditional struggles for land have turned now toward the defense and conservation of water and territories. The significance of these struggles for water as decolonial strategies to confront the Andean Hydro-Capitalocene is observed.

Finally, the third part analyzes the institutional responses of the states to social mobilizations triggered by third- and fourth-generation extractivist coloniality, focusing on constitutional processes, particularly the experiences of Bolivia, Ecuador, and Chile, as well as their contradictions, scopes, and limitations to govern the ecological and social disorder that has produced the Andean Hydro-Capitalocene. The criminalization and state persecution of people and collectives that defend their waters and territories is also highlighted, making visible the contradictions involved in the struggles that are institutionalized. This chapter concludes by considering the concept of the Hydro-Capitalocene in light of the advance of third- and fourth-generation extractivist coloniality and the horizons opening up for research-action on the processes of defense of water and territories in the Andes.

Capitalist Dispossession, Extractivist Coloniality, and the Production of the Andean Hydro-Capitalocene

In the Andes, there is a long history of accumulation by dispossession, originating in the early years of conquest and colonization but lasting until the neoliberal globalization of the second half of the twentieth century (Alimonda 2011; Gudynas 2015; Ulloa 2017). In this part of the world, it is not possible to speak of the Anthropocene without mentioning the historical capitalist plunder to which this part of the world was subjected. Thus, this chapter's approach to this discussion argues that there has been a historical-geographical production (cf. Harvey 2018) to the Hydro-Capitalocene, whose condition of possibility was generated by productive activities based on accumulation by dispossession (Harvey 2003) and extractivisms (Ulloa 2017; Svampa 2019), particularly affecting water. We are now witnessing a moment in which extractivist capitalism and all its coloniality of power (cf. Quijano 2014) are affecting the functioning of Mother Earth and Mother Water.

Extractivist forms of exploitation break and fracture ecosystemic cycles and are a precondition for planetary capitalism. Capitalist dispossession and the Hydro-Capitalocene occur continuously and simultaneously, overlapping each other, making vulnerable Andean communities whose livelihoods are based on nature and its resources. From Latin America, the Hydro-Capitalocene surpasses the vision of the Anthropocene, as it is a geological era produced not only by humans in general but also by the specifically extractivist capitalism that has led to the alteration of water ecosystems. In this regard, water extractivism can be said to be a mode of capitalist appropriation of nature, through which water is extracted on a large scale or with high intensity from the territories of life of the Global South and exported mainly to the Global North through different commodities with little or no processing, such as minerals, food, forest monocultures, timber, cellulose pulp, palm oil, meat, avocado, copper, lithium, etc. (Torres et al. 2022). The concept of Hydro-Capitalocene is similar and expresses how the advance from second- to third-generation extractivisms – a transition that occurred variably between 1950 and 1970 (Gudynas 2015) – produces anthropogenic alterations and rifts in the aquatic ecosystems of the Andes. In this sense – following Marx, Harvey, Moore, and Gudynas – this chapter proposes that Hydro-Capitalocene is a process of historical production. In what follows, its production process in the Andean countries, the mobilizations and territorial struggles it has provoked, and the institutional responses that have emerged from the Andean states to confront or – failing that – deepen the Hydro-Capitalocene are addressed.

There are major extractivisms that have been developed in the Andes since before 1950, such as mining (Alimonda et al. 2011), colonially rooted and key to the developmentalisms that emerged after World War II with the import substitution industrialization model. This extractivism becomes relevant with neoliberal globalization, given that it continues to be a gravitational pull in the process of capitalist dispossession and, therefore, in the production of the Andean Hydro-Capitalocene.

In this regard, Horacio Machado Aráoz (2018; 2020) indicates that 1545 was decisive for extractivist coloniality and the planetary metabolism, as silver mining began in Potosí, Bolivia, for export by the Spanish colonies to Europe. He argues that water was strategic from the beginning of this mining operation:

> the extraction of the silver entrails of the Cerro Rico del Potosí constituted an ecological-political challenge of great magnitude for the imperial will [because] it demanded the creation of great infrastructure works (roads, energy, storage, and transportation); technological and engineering innovations; systems of massive, regular, and efficient provisioning of the enormous amounts of labor force, water, and energy; significant administrative, management, control, and disposition bureaucracies of bodies and objects [in particular] the provisioning of water [...] demanded by the construction of "a pharaonic hydraulic infrastructure" (Bakewell 1990) with thirty-two lakes covering an area of 65 km^2, and a whole network of interconnected canals, and mills, pumps, and winches used for the transport and processing of the ore. (Machado Aráoz 2020: 77, 79).

In Gudynas' (2015) classification, what Machado Aráoz describes fits into the category of first-generation extractivisms (1500s-1800s). Then, in the nineteenth century, the second generation of mining extractivism began, triggered by British imperialism. Due to a soil fertility crisis due to industrialization and rural-urban migration, Britain was forced to push the planetary metabolism a leap further, particularly with guano extraction in Peru and later saltpeter or nitrate exploitation in Bolivia and Chile, which led to the War of the Pacific (cf. Foster 2000). Like Potosí, the extractivist logistics of nitrate extraction required enormous quantities of water and energy.

Then, in 1904, there was an expansion of scale with copper mining from the exploitation of the Chuquicamata mine in Calama, Chile, which grew under British imperial control during the twentieth century until it was nationalized during the socialist government of Salvador Allende (1970–73). However, its re-privatization began with the return to democracy in 1990. During the last few decades, as the world has entered the third generation of mining extractivism, projects exploiting copper and other minerals such as gold have expanded their operations throughout the Andean cordon, particularly in Peru, Colombia, and the Bolivian Amazon.

Likewise, and as a reflection of the historical continuity of capitalist extractivist dispossession, there has been visible pressure on Chilean, Bolivian, and Argentinean territories due to the demand for lithium from the Global North in the last decade. The extraction process, like Potosi, continues to use enormous amounts of water, which is extracted through brine and exported as lithium to China, the U.S., Canada, and Europe, all countries leading the way in manufacturing electric cars. The argument from the Global North has been that the "lithium triangle," composed of territories in southern Bolivia and northern Argentina and Chile, is the way to decarbonize the planet and mitigate the effects of climate change. However, the view from the Global South and Andean communities that currently inhabit these territories of extraction has stressed that this extraction is putting their ways of life at risk through the depredation of the fragile aquatic ecosystems of this arid Andean area. One example is the Atacama Desert, the driest desert in the world, where lithium extractivist corporations such as Sociedad Química y Minera and Albermarle continue to reproduce colonialism and water injustices, now masked under the green discourse of sustainability (cf. Jerez, Garcés y Torres 2021). In addition to lithium, the mining extractivism frontier is advancing with new commodities such as rare earth metals, which have also been argued to "save the planet" from climate disaster. This, however, makes invisible the deep hydro-metabolic rifts produced in these territories of extraction. In summary, mining extractivism has contributed to create the Hydro-Capitalocene in the Andes.

Bolivia

The Agrarian Reform of 1953 marks one of the most profound structural transformations of the Bolivian state in the twentieth century (Soliz 2022) with its agrarian land expropriation and redistribution. This process consolidated many Indigenous communities' vindication struggles to recover their communal lands of origin in the Andean region of the country, as extensively documented by Silvia Rivera (1984; 1993), and more recently by historian Carmen Soliz (2017; 2022).

The endowment of agricultural land was continued even in later periods during the military governments that took power after the 1964 coup d'état of General Barrientos. Unlike previous processes, the land endowed was mainly in the eastern part of the country and initiated the development of agribusiness and expansive livestock farming. Now, this region provides more than 80 percent of the country's basic foodstuffs. However, it has done so based on an unsustainable and predatory production system that has been one of the main causes of deforestation in the Bolivian Amazon (Fundación TIERRA 2019). In general, such expansion of the agroindustrial frontier intensifies the Hydro-Capitalocene, as it "unstoppably advances in the progressive interruption of regional water cycles and weakens the region's forests' ability to regulate temperatures" (Nordgren 2021).

The period of democracy's recovery in the 1980s also saw the implementation of neoliberal measures to transform the state. These measures entailed the privatization of several productive and service sectors that, until then, had been under public control. One of these includes the drinking water and sewage service sector in large cities, under the rhetoric that it would free up resources for necessary investments in small and intermediate cities (Spronk 2007). Resistance to these measures and mainly to private participation through concessions in the water and sanitation sector gave rise to the "Water War," a turning point for several political and social transformations in the country. One effect of the neoliberal models' rejection was the election of Evo Morales of the Movimiento al Socialismo (MAS, Movement for Socialism) as president in 2005. From then on, state policy – at least discursively – has taken on a new direction based on the paradigm of "*Vivir Bien*" (Live Well), which, after a constituent process, was consolidated in the new constitution approved in 2009. However, the radicalism shown by the MAS government in international forums on environmental issues, climate change, and others does not correlate to the domestic level, where the economic basis still comes from extractivism and predatory practices to exploit nature (Tapia 2010).

Peru

During the years 1950 and 1952, the mining and agricultural sectors in Peru contributed similarly to the gross domestic product (GDP). From then on, mining began to consolidate as one of the country's main economic sectors (Del Pozo and Paucarmayta 2015). The transformation was gradual. In the 1980s, after the failed populist measures of Alan García's first government (1985–1990), the country entered a serious economic recession deepened by the internal war with Shining Path. This situation encouraged dependence on natural resource export.

Then, after the neoliberal structural adjustment reforms in the 1990s, a period of expanding the extractive frontier into areas previously outside of interest began (Vélez-Torres and Ruiz-Torres 2015). The mining sector was boosted by a series of incentives promoting foreign investment, tax flexibility, and corporate legal certainty. In 1995, 47 percent of exports already came from the mining sector (Neyra 2017); however, by 2019, they reached 58.9 percent (Organismo Supervisor de la Inversión en Energía y Minería [Osinergmin] 2019). Additionally, between 1995 and 2012, the area of land concessioned to mining increased by more than 200 percent (Del Pozo and Paucarmayta 2015). Communities and social movements denounced the implementation of an economic model based on extractive industries that affected their rights to food security, as well as weakened those social, cultural, and environmental (Zibechi 2010).

Thus, between 2000–2015, the “mining boom” consolidated, impacting relative economic growth and capital accumulation, the dispossession of water and territory, and the recognition of cultural and territorial rights, all with unequal effects according to class, ethnicity, and gender relations. However, very much in tune with the commodity consensus (i.e., the world market for minerals and raw materials), large mining expansion has occurred hand in hand with the increase in hydroelectricity, infrastructure, and agribusiness projects (Neyra 2017). This has led to a major negative impact on the guarantee that peasant and Indigenous communities have land and water rights (Boelens et al. 2015).

In 2020, a period of economic crisis began with the COVID-19 pandemic; after an initial decrease in mining during that year, production was reactivated in 2021. However, according to a recent report by the Inter-American Development Bank (IDB), mining in Peru is positioned as the main source of economic reactivation. In any case, while its economic importance is noted, its high level of social conflict is also understood, even considering the high risk of increasing tensions over access to water (Walter et al. 2021).

Ecuador

Concerns about water use in the region were present both in the colonial era and during Gran Colombia. The general aim was to guarantee water circulation between one farm and another, avoiding conflicts between owners. There was a continuous process of dispossession and subjugation of entire populations (Quintero 1989). Later, an incipient capitalism based on agro-exports came about, with a subsequent increase in water consumption; this was a dependent capitalism with weak industrialization that turned the country into a primary producer (Zapatta and Hidalgo 2009).

In the twentieth century, however, important legislative transformations began to take place due to changes in production and the growth of both the cities and the population. The 1964 Agrarian Reform would allow Indigenous communities to free themselves from the bonds of servitude on someone else’s land, but only partially, as they were given land in high-altitude territories considered useless and unproductive. Thus, a new actor emerged in the dispute over water, in time forming an identity and developing political proposals, eventually leading to the uprising of the Inti Raymi Indigenous movement of 1990.

The struggle for water rights would grow as agrarian, mining, and oil extractivism grew stronger with the enactment of neoliberal policies. By 1972, in the midst of a military dictatorship self-defined as "nationalist and revolutionary," the first Water Law was passed, which stated that water is a national asset for public use. Subsequent neoliberal policies, however, would be directed towards the implementation of different privatization mechanisms. This is evidenced in Antonio Gaybor's research (2008), which shows how large properties, especially those for agro-export, received plenty of water, while small properties did not have enough, despite that they guaranteed the country's food security. Moreover, small landowners comprised 88 percent of irrigation water beneficiaries, while large landowners accounted for only 4 percent.

In terms of water for human consumption, differences arise between rural and urban areas. Many populations are without safe water, and a third of the Ecuadorian population receives treated water thanks to community systems without state support. This is the situation that led to the important proposals in the 2008 Constitution, whose scope was greatly weakened in practice (Isch 2012).

Colombia

In the 1950s, most of the agricultural area was located in the flat areas of Colombia, the inter-Andean valleys, the Atlantic Coast, and the Eastern Plains, where large cattle ranches and large estates prevailed (Zamosc 1992). In the valleys and on the Atlantic Coast, enclaves of agro-industrial production began to be organized, while in the Andean region there was a more diverse agricultural panorama. In the temperate zones, coffee flourished, whereas in the cold altiplanos, *pancoger*, small-scale family production centered on crops to satisfy a part of their needs, predominated (Zamosc 1992). Although peasants in Colombia have been fundamental to maintaining food security, they have historically been subordinated by neoliberal development and agroindustrial modernization policies (Forero Álvarez 2010) that have dispossessed them of their land.

In the 1990s and 2000s, different parts of Colombia were affected by intense agrarian counter-reform carried out by paramilitary groups with close connections to economic and political leaders; this exploitation of land and water access was possible due to the use of excessive violence in the form of massacres, disappearances, sexual abuse, and forced evictions (Ojeda et al. 2015). At the same time, landscapes of everyday dispossession were configured (Ojeda 2016), either by the establishment of regimes of fear or immobility in daily life. Between 1997 and 2007, more than 80,000 hectares of land were dispossessed (Verdad Abierta 2012), while, through privatization policies, several peasant users lost their water rights.

Due to the armed conflict, neoliberal reforms in the Colombian context were not enough; rather, the extractive boom's backdrop was the implementation of territorial security policies (Velez-Torres 2014). In this sense, military security spending went hand in hand with the rise of mining-energy projects, as well as with the expectations of economic speculation (Vargas 2013). In recent years, these large-scale mining projects have inserted rural territories into urbanization processes, reconfiguring spaces according to activities and logistics that optimize and favor the accumulation of capital in the extractive sector (García 2023).

As a counterpoint, such extractivisms and their instrumental rationality with territories and waters in the Andes come into conflict with the hydro-social relations that originate from the ontologies and hydro-cosmologies of peasant, peri-rural communities, women's collectives and native Andean peoples (Roca-Servat and Ocando 2019; Ulloa 2021; Svampa 2021). This is because they affect the ways of "being" and subjectivities of the communities that inhabit the extraction territories (cf. Leff 2014; Leff 2019). In sum, the extractivist coloniality and its hydro-metabolic rifts that have become the Andean Hydro-Capitalocene have germinated multiple strategies of decolonial struggles in the face of these "hydro-colonialisms" (Boelens, Perreault, and Vos 2018: 7).

Strategies of Decolonial Struggle of Andean Peoples in the Defense of Water and their Territories

Faced with the ecological and social debacle generated by the extractivist neocoloniality that has become the Hydro-Capitalocene, various peasant and Afro-descendant peoples, women's collectives, and Indigenous peoples, as well as urban-rural communities, have risen up in the struggle to protect their living spaces from the vertiginous advance of mining and hydrocarbon exploitation, as well as agro-industrial monocultures. This section focuses on the strategies of native peoples' struggle along the Andes. This chapter envisions these strategies as a *continuum* ranging from direct action to making demands of states and institutions. As Gutiérrez Aguilar and Navarro (2019) indicate, socio-environmental struggles are not something static or inherited but changing and diverse collective exercises aimed at questioning the terms of interdependence imposed by capitalist, patriarchal, and colonial mediations in search of more dignified possibilities for the reproduction of life: human and the not only human.

Chile

In the Chilean case, the historic peasant struggles for land ended in the agrarian reform undertaken by Presidents Eduardo Frei Montalva (1964–1970) and continued by

Salvador Allende (1970–1973). As part of the reform, Frei expropriated almost 3.5 million hectares in six years, and in the three years Allende was in office, he expropriated almost 6.5 million hectares. Of the approximately 10 million hectares expropriated in total, some 700.000 were irrigated; the expropriation of these irrigated plots was possible thanks to the nationalization of water in 1969, highlighting its gravitational importance in the Chilean agrarian reform (Bellisario 2007). However, land and water redistribution reform ended violently with Pinochet's coup d'état in 1973, which established neoliberalism and initiated a violent process of land dispossession and its partial return to the former landowners, who, together with the new peasantry that emerged with the agrarian reform, gradually sold these lands to export-oriented agricultural companies (Bellisario 2007). Added to the 1980 Constitution and 1981 Water Code that re-privatized water, agro-extractivisms that had already been in place since the colonial period – but now in a new modality – (re)emerged. These agro-extractivisms have expanded since the 1980s, coinciding with what Gudynas (2015) calls the third-generation extractivisms. An example of this are the intensive monocultures in land and water use, such as avocados (cf. Budds 2009; Panez, Faúndez Vergara and Mansilla Quiñones 2017), in addition to the state-subsidized privatization of pine and eucalyptus plantations, which are beginning to expand spatially (Klubock 2014), contributing significantly to the desiccation of territories (Torres et al. 2016; Torres et al. 2022) and, consequently, to the expansion of the Hydro-Capitalocene.

Given this, struggles for the defense of water and territories began in the 1980s in the midst of the struggle against the Pinochet dictatorship (Torres, García and Rojas 2017), but socio-ancestral struggles for the recovery of lands and waters began later in the 1990s. The Mapuche and environmental movements against hydroelectric power plants in the Alto Biobío (1990–2004) were emblematic. Along with the Indigenous Law of 1994 and the Indigenous institutionality of CONADI implemented in 1997, radical Mapuche movements such as the Coordinadora Arauco Malleco (CAM) emerged in 1997, with decolonial strategies of direct action and the sabotage of forestry equipment (Pineda 2018; CAM 2022; Torres et al. 2022). The socio-environmental mobilization for water saw important milestones in the movement Patagonia sin Represas (Patagonia without Dams) and the anti-mining movement No a Pascua Lama during the first decade of the twenty-first century, as these movements began to politicize and highlight the neoliberal model of water dispossession: a process that was exacerbated from 2009 onwards when the worst megadrought ever recorded in the country began. However, this process did not stop the water extraction frontier's growth from these territories through the socio-spatial expansion of mining, monoculture tree plantations, and agro-extractivism. This has led to an increase in socio-environmental conflicts over water and territories since the beginning of the twenty-first century, and simultaneously, new eco-socio-environmental identities have emerged, bringing together a diversity of environmentalist voices, women, fishermen, and farmers (Bolados 2016), as well as alliances of Chilean water movements (Torres, García, and Rojas 2017). Among the latter is the Movimiento por el Agua y los Territorios (MAT, Movement for Water and Territories) and the Movimiento por la Defensa del Agua, la Tierra y el Medioambiente (MODATIMA, Movement for the Defense of Water, Land, and Environment), whose agenda for deprivatizing water and declaring it a common good reached its peak during the 2019 *estallido social* (social outbreak) and the constituent process that unfolded between 2020–2022 (Torres and Alvez 2023).

Bolivia

Indigenous struggles and demands have a long history in the colonial and republican period of Bolivia, as analyzed by Larson (1992) for the Cochabamba valleys and the work of the Taller de Historia Oral Andina collective (THOA, Workshop of Andean Oral History) (Ticona 1995; Ticona 2016) for the altiplano and valley regions of La Paz. A large part of these struggles for land took shape in the Agrarian Reform of 1953, although previous processes had already consolidated rights in some regions, where there were still territories granted by colonial authorities to the "*Pueblos Reales de Indios*" (Bustamante 1995). After the National Revolution of 1952 and the Agrarian Reform of 1953, the peasant union organization was also recognized as an important political actor that was key in the struggles for land, water, natural resources, and democracy in the second half of the twentieth century (Soliz 2022).

Although there were very prominent Indigenous movements in the country (Albo 2002; Barragan 2008; Ari 2014; Rivera 1984) for a long time, largely due to the mining tradition, the main political subject was the workers' movement, mainly labor. However, since the beginning of the 1990s, peasant and Indigenous organizations have prominently emerged. One of the most outstanding mobilizations in this sense has been the great Marcha por el Territorio y la Dignidad (March for Territory and Dignity) of the Indigenous lowland populations that took place in 1990, demanding health, education, and recognition of their ancestral lands due to the encroachment of logging companies and the usurpation of their communal territories. This struggle, among other things, achieved the recognition of the Territorios Comunitarios de Origen (TCOs, Community Territories of Origin).

In the late 1990s, after a period of governments that transformed the state with neoliberal policies, protests against the effects of measures adopted to reduce the state's participation in various sectors of the economy and services began to resound more loudly. One of the most visible struggles in this regard was the "Water War" in 2000, which mobilized social organizations responsible for water management at the urban and rural levels against the commodification of services and the control of water sources by private entities (Crespo et al. 2005). The Water War marked a milestone in the country's history, as it became a reference point for other struggles and demands for the defense of common resources, as well as for the institutional changes that would follow. Since 2006, with the rise of MAS to power, the narrative that the new administration was the "government of the social movements" became popular; in fact, this entailed the co-option of several organizations or the creation of parallel ones associated with the party (Zuazo 2010). This also meant that opposition organizations and their leadership were persecuted, repressed, and, in some cases, eliminated. However, the resistance against hydrocarbon, mining, logging, and agro-industrial extractivism still exists and has been articulated in the Indigenous organizations that continue to fight for the defense of their territories in several places. One of the emblematic struggles in this regard is that of the Indigenous organizations in the TIPNIS (Indigenous Territory and National Park of Isiboro-Sécure) that oppose opening a road through their territory (Albuquerque Moraes 2018). The other is the struggle of the National Flora and Fauna Reserve communities, Tariquia, against a hydrocarbon project that would expand the oil frontier over the ecosystems it harbors (Quiroga, Pacheco, and Rios 2020).

Peru

After a long process of social uprising and land seizure, the Confederación Campesina del Perú (CCP, Peasant Confederation of Peru) was formed between 1947 and 1960. This was a period of intense peasant mobilization to recover taken land, whether by the agricultural or industrial mining sector. This was followed by a long period of repression against the peasant movement, aggravated by the emergence of the first left-wing guerrillas, and the need for agrarian reform became increasingly evident.

It is important to highlight the Indigenous cultural matrix of the Peruvian peasantry that, under the Spanish colonial mandate, had been converted to "reduction towns," which paradoxically configured communal land spaces with their authorities and customs (Remy 2013). In 1974, the Confederación Nacional Agraria (CNA, National Agrarian Confederation) was created to defend peasant communities against a possible fragmentation of their territories as a result of the Agrarian Reform of 1969 (Espinal 2016). However, the armed struggle of Shining Path guerrillas broke out and had a strong impact on the peasant organization. During these years, peasant patrols played a fundamental role in protecting rural communities from the violent incursions of Shining Path.

After the end of the internal armed conflict, a period of neoliberalization began in Peru under the protection of the new 1993 political constitution. Rural conditions have become increasingly precarious, and the CNA seeks to influence public policies for the well-being of peasant communities (CNA n.d.). Similarly, with the new Water Resources Law in 2009, strategies emerged to guarantee water availability for irrigation user boards. Amid this context, socio-environmental conflicts are forcefully emerging, where local populations express their rejection and/or concern about the environmental and cultural impacts on their territories due to large-scale mining projects carried out by transnational companies.

In 1999, various community and trade associations and/or organizations formed the Confederación Nacional de Comunidades del Perú Afectadas por la Minería (CONACAMI, National Confederation of Peruvian Communities Affected by Mining) in defense of their territories and waters. The movements for environmental justice in the Peruvian Andes, with the examples of Cerro de Pasco and La Oroya, have become a scene of resistance to historical territorial dispossession and the processes of contamination and degradation of soil, water, and air (Glave and Kuramoto 2002). Likewise, the peasant patrols have acquired important recognition by preventing the start of different transnational mining projects, such as that of the Conga in Cajamarca in 2012 (Isla 2017). The Amazonian peoples, in turn, have made clear their concern about oil exploitation in their territories (León and Zuñiga 2020). These processes aim at the reconstitution of community strength and the revitalization of the Indigenous matrix of the Peruvian peasantry, demonstrating their capacity to organize and mobilize in defense of the territory and their ways of life (Escárzaga 2020).

Ecuador

Boelens, Cremers, and Zwartevenn (2011) clearly present the political character of water, which is also an arena of agreements and disputes. This perspective is confirmed in the Ecuadorian Andes, where conflicts were mainly between the interests of large and small landowners, as well as within or between communities sharing what little water was not consistently taken by a few actors. On the other hand, the agreements have been practical within the communities. In the case of Indigenous populations, the weight of their own cosmovision and customary practices has been essential and deserves recognition in formal terms within a legal pluralism that, to this day, is another reason for clashes and misunderstandings, despite the Constitution of Ecuador (2008) defining the state as intercultural and plurinational.

The highest-level conflicts, including Indigenous and peasant uprisings, arise around water distribution, considering that it is a matter not only of quantity but also of quality, making contamination another way of dispossessing usable water (Isch 2012). In the future, it is predicted that new conflicts will arise over groundwater yet appreciated. Frequent protests have been seen at local and national levels, posing a dispute between two contrasting conceptions of development, water management, and water justice. The continuity of these processes has been expressed in legal instruments that are not always complied with, such that they are largely steps towards a new conflict. New forms of water accumulation in the hands of a few have also begun, as has been the case with the increasing number of mining concessions, including those granted at water sources, which the 2008 Constitution now prohibits.

Legal pluralism vanishes at the moment of dispute over the character of general or national norms. This raises three scenarios in which conflicts develop: the ideological, which questions extractivism and current water distribution; the social, which manifests itself in streets and highways; and the legal, which presents itself in the national justice system. The ministries, including the Ministry of the Environment, Water, and Ecological Transition, are losing presence and prestige, acting as arms of extractivism and blocking social and community water rights.

Colombia

It is important to emphasize that one of the bloodiest periods of the bipartisan struggle in Colombia, called "*La Violencia*," took place between 1946 and 1958. This period had a strong impact on the peasant population. Peasants were forced to defend their lives and lands, and some formed the first liberal and later communist guerrillas. Despite a series of institutional mechanisms created to appease violence – the Alianza para el Progreso (1961–1970, Alliance for Progress) and the Frente Nacional (1958–1974, National Front) – and laws to modernize structures, the land problem remained due to an interest in boosting productivity instead of attending to the distribution of land ownership (Loaiza Cordero 2012). In 1964, fighting broke out in the rural area of Marquetalia between peasant self-defense groups and the Colombian army, giving rise to the Fuerzas Armadas Revolucionarias de Colombia (FARC, Revolutionary Armed Forces of Colombia). In the Colombian case, the use of violence in political terms stands out in particular, whether to pressure or prevent social reforms or to recover the state's sovereignty (Reyes 2009).

The 1990s coincided with the promulgation of a new constitution (1991); however, unlike in Peru and Chile, this took place under a broader and more democratic deliberation process, which made possible the enactment of Law 70 (1993) recognizing the collective ownership of Afro-descendant communities. It is worth highlighting the diverse processes the Black communities have undertaken to defend territory and water, whether of water sources, aquatic ecosystems, or amphibious livelihoods. The struggle of the Consejo Comunitario Playa Renaciente (Renaciente Beach Community Council) in Bahía Málaga for conservation and permanence in their territories stands out (Cifuentes 2019), as well as the example of the Consejo Comunitario de La Toma (La Toma Community Council) in Cauca for territorial self-determination (Machado-Mosquera 2021).

Neoliberal policies in the mining-energy sector were also forcefully implemented under the governments of Alvaro Uribe Vélez (2002–2010), Juan Manuel Santos (2010–2018), and Iván Duque Márquez (2018–2022). This is why territories previously used for agriculture or reserve areas, such as the *páramos* and other semi-dry tropical forests, are now becoming potential areas for mining and energy extraction. Resistance movements against these projects are being formed throughout the Andean mountain range, such as the Movimiento Ríos Vivos (Living Rivers Movement), the Comité para la Defensa del Agua y del Páramo de Santurbán en Santander (Committee for the Defense of Water and the Santurbán Paramo in Santander), the Comité Ambiental por la Defensa de la Vida de Tolima (Environmental Committee for the Defense of Life in Tolima), the Cinturón Occidental Ambiental (Western Environmental Belt) in southwestern Antioquia, and the Red Nacional de Acueductos Comunitarios (National Network of Community Aqueducts), to name a few.

The Colombian environmental movement is characterized by the diverse makeup of actors, whether from grassroots movements or organizations: peasants, Indigenous peoples, Black communities, women, workers, and urban collectives, as well as actors from civil society and governmental institutions like scientists, academics, researchers, government agency officials, and several NGOs (Tobasura 2007). This Colombian eco-territorial matrix has been fundamental in social mobilizations for the defense of life and against the precarization and dispossession of livelihoods, such as the great social uprising of the *Paro Nacional* (national strike) of April 28, 2021.

In sum, the Andean struggles for land and water reveal the diverse strategies of South American peoples to defend their territories and waters from third- and fourth-generation extractivist coloniality. As Gudynas argues, the latter are intensive in water use and therefore, together with climate change, are the main triggers of the Andean Hydro-Capitalocene. It is important to note that neoliberalism's establishment in the Andean cordon has been instrumental in the privatization of its lands and waters. These resources have been transferred to global capitals that have subsumed the continent in extractivist coloniality, extracting water on a massive scale – and in some cases desiccating territories – to export commodities to the markets of the Global North. Given this deepening of the anthropogenic fracture of extractivism on the Andean hydro-social cycles and the radicalization of the socio-ancestral struggles of the Andean peoples in defense of their territories and waters, what role have the states taken to face the socio-environmental debacle of the Andean Hydro-Capitalocene?

Institutional Processes of Adaptation to the Advance of the Hydro-Capitalocene and State Responses to the Territorial Struggles of the Andean Peoples

This third part analyzes how Andean states react to the advance of the Hydro-Capitalocene and the demands of societies, cultures, and socio-environmental movements. It examines the politics of adaptation (constituent processes, water justice) and domination established by capitalism and the neocolonial extractivist state in the Andes. As a counterpoint, the chapter closes by analyzing processes and strategies in using the state's apparatus of force to repress the territorial struggles of Andean peoples for the conservation and defense of their waters.

Chile

In the case of Chile, the emerging national water movement converged with the national protests against neoliberalism in the context of the *estallido social* of October 2019. A stance was taken against water as a commodity and private property, as it had been previously re-privatized by the Pinochet dictatorship in the 1980 Constitution and the 1981 Water Code (Budds 2009). In May 2021, Chilean citizens elected 152 constituents with gender parity, which included MAT and MODATIMA activists, as well as Indigenous peoples, demonstrating that water deprivatization and its declaration as a common good were among the main demands of the *estallido social* for a new constitution. On July 7, 2021, the Constituent Convention began to meet, the final text of which was delivered one year later on July 4, 2022. This text established the "natural commons," which were defined as "elements or components of nature over which the state has a special duty of custody to secure the rights of nature and the interest of present and future generations" (Convención Constitucional 2022: 46). In particular, the text established that "these following goods may not be appropriated: water in all its states, the air, the territorial seas, and the beaches, those recognized by international law and those declared as such in the Constitution or the laws" (Convención Constitucional 2022: 46; Acosta 2022).

The introduction of the counter-hegemonic category of "natural commons," as well as the declaration of water as an inappropriable common good under the protection of the state, reflected the will of Chilean society to institutionalize collective demands seeking to address the multiple ecological and social rifts produced by extractivist coloniality and the Hydro-Capitalocene in large territories. Although water was one of dozens of demands that were written in the Constitutional Proposal emanating from the Constitutional Convention of 2022, this was fiercely opposed by extractivist industries and conservative sectors through a multi-million-dollar media campaign, which, among other factors, influenced the Chilean citizens to reject the constitutional text by a resounding 61.87 percent on September 4, 2022 (cf. CIPER 2022). However, in March 2022, President Gabriel Boric signed a reform to the Water Code, making water a human right. Even so, the constitutional debate in Chile continued in 2023 with a new constituent process led this time by the extreme right, which tried to radicalize the current water-focused neoliberalism even more. On December 17, 2023, Chilean citizens again rejected such a constitutional proposal. Nevertheless, and independent of these constituent processes, water continues to be a key socio-ancestral demand, and the proposal to deprivatize water and transform it into a common good to address the Hydro-Capitalocene continues to be on the agenda of broad social and ancestral groups in Chilean society. In other words, the hydro-commons agenda is maintained despite the electoral defeats suffered by the proposals for a new Constitution in 2022 (loaded to the left) and 2023 (loaded to the right). The citizen-led hydro-commons agenda will continue to challenge the neoliberalization of nature and water imposed during the Pinochet dictatorship, pushing proposals from the oppressed peoples for the creation of more sustainable ways of governing mother nature and mother water in the twenty-first century (cf. Torres and Alvez 2023).

Bolivia

With the Agrarian Reform of 1953, not only was a process of redistributing agrarian lands to those who worked them initiated, but also their organizations and right to vote were formally recognized. From then on, the state, with almost no presence beyond a few mainly urban areas, began establishing itself in the country.

Many of the changes that began to take shape at that time were later reflected in the Political Constitution of the State reformed in 1961, which incorporated the measures emerging from the Revolution of 1952, including universal suffrage and the Agrarian Reform. After a period of military dictatorships in the 1970s, the return to democracy also marked the beginning of a neoliberal period that promoted the Structural Adjustment Program, which aimed at reducing the state's role to fully implement a free market economy. One of the policies in this sense was so-called "capitalization," which, as mentioned above, implied private participation in companies and sectors that were previously under public control, as was the case with the provision of drinking water and sewerage services. The central characteristic of these (third-generation) policies was their focus mainly on modifying the legal regime and state institutionality to dismantle state involvement in various spheres. The implementation of the neoliberal regime imposed enormous social and environmental costs on the country (FOBOMADE 1999).

The social reaction against neoliberal policies during the Water War (2000) and later the Gas War (2003), allowed the re-articulation of social, Indigenous, peasant, trade union, and water user organizations, etc. to put together an agenda of demands that largely materialized in the new Political Constitution of the State in 2009 and subsequent regulatory provisions. The new constitution defined the principles of environmental and water management, considering "water as a human right" and a "fundamental right for life" and barring its commercialization. It also recognized the rights of Indigenous and peasant peoples to their water sources, authority, and forms of autonomous management.

In 2010, the Ley de la Madre Tierra (No. 070, Law of Mother Earth) was incorporated into regulations, and later in 2012, the Ley Marco de la Madre Tierra y Desarrollo Integral para Vivir Bien (No. 300, Framework Law of Mother Earth and Integral Development for Living Well). Despite these institutional and regulatory advances, neoliberal and extractivist approaches still influence the government's actual policy. The environmental and social effects of the current ("integral") development model are evident and visible: for example, the desiccation and mining contamination of Lake Poopó, the flooding caused by dams for power generation in the Amazon, the deforestation caused by agribusiness and cattle ranching for export, the contamination of rivers and other water sources caused by gold mining in Indigenous territories, the effects on protected ecosystems caused by hydrocarbon exploration and exploitation, etc. (Fundación Tierra 2023; CEDLA 2018; Campanini 2022). This trend will likely be replicated in new extractivist ventures like lithium (Ströbele-Gregor 2012; CEDLA 2022) and iron mining.

Peru

The Agrarian Reform of 1969 was enacted by the military government of Velasco Alvarado to pacify and restructure land adjudication in the country. Agrarian reform was further carried out through the Water Law (1969) through which the state assumed absolute control of water (Oré and Rap 2009). At this point, it is imperative to understand the inescapable link between water and land. This link was evident in the control and management of water by large landowners (Oré and Rap 2009), which the Water Law attempted to regulate by establishing greater state control and declaring water a public good.

Between the end of the twentieth century and the beginning of the twenty-first, the elected president Alberto Fujimori declared a coup d'état, closed the congress, and promulgated a new constitution (1993) establishing a neoliberal state regime. In this sense, agrarian cooperatives were privatized (Legislative Decree 653 of 1991), the possibility for communities to sell their lands was opened, and later a new law would guarantee the resurgence of the land market (Vazelesk 2017). Likewise, within the package of economic measures, the mining sector was liberalized and privatized (Legislative Decree 708 of 1991), making environmental and tax policies more flexible to attract foreign capital, tripling the hectares destined for mining (Campodónico 1999).

Later, in 2009, the new Ley de Recursos Hídricos (Water Resources Law) was enacted, which handed over the responsibilities of state institutions to manage, operate, and maintain the irrigation infrastructure to the Juntas de Usuarios (User Boards) in an untimely, immediate, and obligatory manner (Oré and Rap 2009). Different research on the implementation of this new legal framework has observed that these water policies reveal disjointed and fragmented decisions between central and regional bodies, as well as power struggles between economic actors and other groups of social relevance, such as peasant communities (Oré and Geng 2017; Lynch 2014).

Ecuador

The Indigenous, peasant, and popular uprisings, together with relevant studies (Gaybor 2008), allowed the construction of general proposals incorporated into the current Constitution of Ecuador (2008) and approved by popular consultation. The final document was the first to include the rights of nature and the human right to water in its text.

Constitutional mandates include that water is a "strategic national heritage for public use, inalienable, imprescriptible, unseizable, and essential for life, a vital element of nature and fundamental to guarantee food sovereignty" (Constitución de la República del Ecuador 2018: Art. 318); the state guarantees equitable access to water and the integral, integrated, and participatory management of water is public or communal, prohibiting its privatization. In addition, an order of priority is established for water use: a) Human consumption, b) Irrigation, animal consumption, and aquaculture to ensure food sovereignty, c) Ecological flow and sacred waters, d) Productive activities.

However, it took five years after the constitutional mandate for the Ley Orgánica de Recursos Hídricos, Usos y Aprovechamiento del Agua (Organic Law on Water Resources, Uses, and Development of Water) to be finally approved. Behind it, there is a new violation for not carrying out the redistribution of water for reasons of social justice, order of priority, and environmental protection. These periods have passed, deepening the causes for disputes as the monopolization of water in the hands of a few continues. The fact that what is positive and guarantees rights in this law has not been fulfilled goes hand in hand with maintaining the conditions of dispossession. On the other hand, this is aggravated when other legal norms, such as the Mining Law, contradict the Constitution and break the order of priority for water use. Extractivism is presented as the greatest threat to the correct water distribution and maintains the history of dispossession. At present, this law is in a reconstruction process due to a resolution of the Constitutional Court that judged the requirement for mandatory Pre-legislative Consultation before the approval of a law that could affect the collective rights of peoples and nationalities had not been met. Ecuador's current political crisis makes the debate surrounding this law much more difficult, raising the possibility of clashes of positions and interests.

Colombia

Throughout Colombian history, it has been very difficult to carry out an agrarian reform that would allow for the redistribution of the *latifundista* structure, which has been strongly protected by landowners and legally endorsed (e.g., Law 200 of 1936). In the context of the Cold War, the U.S. government promoted the Alliance for Progress (1961–1970), at the same time that the Frente Nacional (1958–1974) was implemented as a bipartisan arrangement to put an end to the era of "La Violencia." Within this North American strategic framework, Law 135 of 1961 was issued through which the country aimed to update agrarian systems and supposedly promote reform that addresses inequity in rural territories (Loaiza 2012). However, in practice, productivity and efficiency were pushed instead of income distribution and the strengthening of the peasantry (Loaiza 2012).

The agrarian issue has been decisive in the search for a solution to the internal conflict. Between 1980–2000, emphasis was placed on rural modernization policies aimed at stimulating private investment. Likewise, during the 1990s, economic liberalization was consolidated in the context of the demobilization of several guerrilla groups (Kalmanovitz and López 2006). The promulgation of a new Constitution (1991) was an important moment; on the one hand, it was a symbol of a mechanism for the democratic participation of society, but on the other, it created a path toward economic neoliberalization.

In the context of the constitutional assembly, avenues were opened for the recognition of ethnic rights, such as those of the Afro-descendant population, who were completely invisible, both legally and socially. Law 70 of 1993 was decreed, recognizing "Black communities," along with their territorial and cultural rights (Restrepo 2013). In terms of territorial defense, this law contributed to strengthening the management and autonomy of the collective territory from Afro-descendant cultural practices (Escobar 2015). In this sense, this process within Black communities developed a whole proposal centered on the idea of their own territory, well-being, and conservation, synthesized into the concept of "territory-region" (Proceso de Comunidades Negras 1993).

More recently, in 2016, eco-centric rulings declaring rivers as subjects of rights, such as the Atrato River, were created. This ruling (Ruling T-622 of 2016) gave rise to the same recognition for the Coello, Combeima, and Cocora rivers; and for the Cauca River (Ruling Radicado 2019–071 of June 17, 2019). Likewise, the Amazon rainforest was also recognized as a subject of rights (Sentence STC 4360–2018). On the other hand, the Peace Agreement between the Colombian government and the FARC-EP (2016) is also relevant in terms of defending territory and water given that it established a route for comprehensive rural reform and, in turn, the Peasant Reserve Zones. The Peace Agreement also brought with it the creation of such bodies as the Jurisdicción Especial para la Paz (JEP, Special Jurisdiction for Peace) and the Comisión de la Verdad (Truth Commission), which, based on investigations and testimonies, have gathered information that prove nature was a victim of the conflict.

Conclusions: Hydro-Capitalocene and Just Social-Ecological Transitions for the Andes

Given the continent's history, this chapter has approached the Anthropocene from 1950 to the present as the Hydro-Capitalocene. The Andean Hydro-Capitalocene originates in extractivist coloniality and, in Latin America, cannot be understood without this long-term historical origin, despite its expansion in scale and intensity coinciding precisely with the Anthropocene. This is a long-standing process, but its matrix has been imprinted by the subjugation of native peoples, mestizos, women, peasants, and Andean society to the power strategies of colonists who have controlled and exploited the land, territories, forests, water, economy, and political power for centuries. Nevertheless, with the climate crisis and neoliberalism's emergence in the second half of the twentieth century, the Hydro-Capitalocene has entered a critical stage. It has expanded the institutional and socio-spatial scope of extractivist coloniality by privatizing lands and waters, the same for which the Andean peoples fought hard during agrarian reforms and territorial struggles. The climate crisis, neoliberalism, and land and water privatization are generating a deepening and broadening of the scope of the Andean Hydro-Capitalocene, visible in the increase of territories occupied by extractivism, which together with climate change is desiccating and environmentally degrading territories while dispossessing their communities of their water sources to reproduce their ways of life, culture, trade, and forms of social organization.

Social mobilizations in the Andean countries have diverse causes, but they all bring together peoples in defense of their rights (social, cultural, and territorial). What is happening in Colombia, Ecuador, Bolivia, Peru, and Chile is symptomatic of the general crisis produced by neoliberal policies that privatize nature and appropriate the commons in favor of extractivist coloniality. For this reason, Andean cultures and societies react and try to confront the deep anthropogenic rifts that the Hydro-Capitalocene has produced in the local hydro-social cycles, converging in a common cause to maintain the sustenance of life, that is, "they put life as we know it at the center" (Gutiérrez in Miranda 2023). However, these struggles are sustained in increasingly adverse contexts in which many activists and leaders have lost their lives (Martínez-Alier et al. 2017). On the other hand, they are contexts in which even language and meanings must be defended due to their continual capture, adaptation, adoption, and use by promoters (of Green Capitalism, for example). Raquel Gutiérrez (cited in Miranda 2023) describes this as "an action of political capture, which is based on semantic capture, on buying your words, on stealing your words, on emptying words [and ultimately the struggles] of meaning."

In this sense, the struggles for the defense of water developed in the Andean countries have a gravitating historical significance, since they are territorial struggles proposed from the Global South for a just planetary transition in ecological-cultural and hydro-social terms. To the extent that the states have not been able to adapt to this new Andean hydro-social configuration because they are tied to (neo)colonialism – even in governments considered progressive – these new Andean movements for the defense of their territories, their waters, and their ways of life stand as a horizon of concrete hope to confront the Andean Hydro-Capitalocene. They propose new paradigms and approaches, such as the rights of nature and relational ontologies.

From the perspective of political ecology, this opens up new questions and routes for action research, mainly deepening case studies according to the types of extractivism involved (mining, forestry, agribusiness, among others) but with a horizon of comparing and eventually unifying territorial struggles into a strategy for the continental defense of waters and territories, with a primary focus on the particular struggles of peasants, women, and Indigenous peoples, since they are the principal actors involved in the defense not only of these resources but also of their ontologies and different ways of being in the Andean world.

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Water in the Amazon from 1950 to the Present

Capitalocene and Urbanization in the Brazilian Amazon

Wagner Costa Ribeiro, Marcus Souza, Luciana Ziglio, and Shirley Tozi

Defined from an external standpoint, the Amazon is the target of interests alien to the people who have lived there since time immemorial. In the march of the advance of capitalist productive processes, which aim to extract natural resources in their various forms of expression, a peculiar urban network was formed, interconnected by rivers. This urbanization process marginalized and left the population with a small portion of the wealth generated.

The Amazon comprises a complex natural system that is home to over 48 million inhabitants and about 400 different peoples who speak 300 languages, occupying roughly 45 percent of the emerged lands of South America, according to information on the page of the Amazon Cooperation Treaty Organization (ACTO n.d.). This natural and social complex is divided between tropical forests (67.4 percent) and tropical savannas (13.3 percent) (ACTO n.d.), which are distributed among the following countries: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, Venezuela, and France's overseas department of French Guiana. Therefore, this chapter highlights urbanization processes seen in the Brazilian territory.

While a number of authors claim that the Anthropocene characterizes human action on a planetary scale, others verticalize the reflection and note that the actions that devastate and/or alter the biogeochemical cycles present on the planet are caused by the advance of capitalism. Hence, they coined the term Capitalocene adopted in this study.

Although there were already urban centers dating from the sixteenth century in the lands that would later become part of Brazil, whose occupation and emergence are related to direct access along the coast or when entering the rivers, the most significant advance in Brazilian urbanization occurred in the second half of the twentieth century. In Brazil, the urban population surpassed the rural one in the 1970s. From then on, specific characteristics of this process were seen in the country, with a horizontalization followed by the verticalization of the cities. The first process took the poorest population to peripheral areas, whose urban structures did not exist or were precarious in nature. The second generated centralities dispersed throughout the country's large cities and, later, can be associated with the financialization process of urban space production.

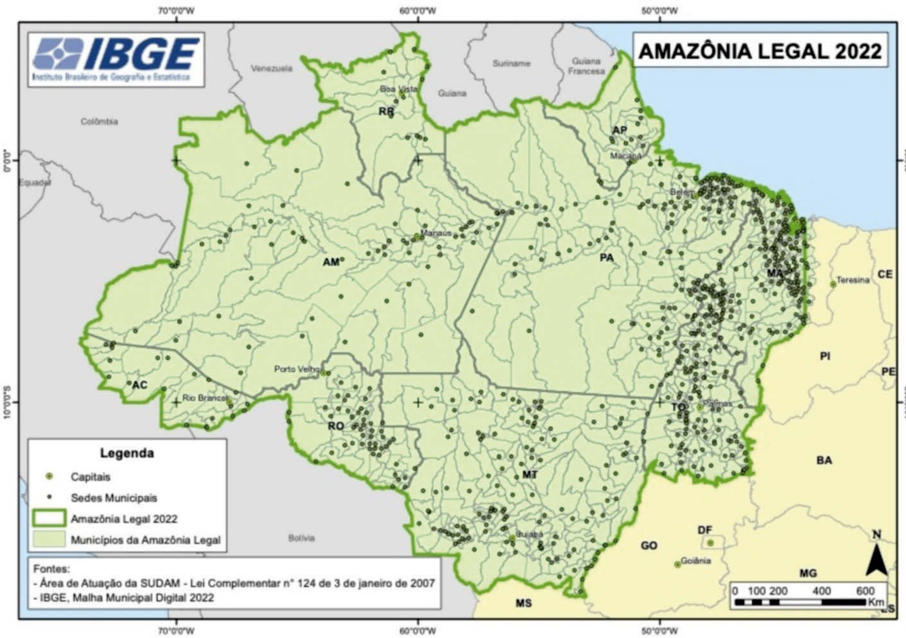
In turn, the urbanization process in the Brazilian Amazon is closely linked to the exploitation of natural resources. It gradually increased as such resources became necessary for expanding capital reproduction. Each exploited natural product left a mark on the urbanization of the Amazonian territory. Rubber played a vital role between the nineteenth and twentieth centuries. In the last fifty years, mining and agriculture have been responsible for connecting the Amazon to the exploratory circuits of capital, reverberating in urban transformations.

Urbanization in the Brazilian Amazon resulted in difficulties in offering collective services to a significant part of the population. This is the case with access to water and the collection of municipal solid waste (MSW). Water supply and access vary throughout Brazil. Delimited by Complementary Act 124, the Legal Amazon (Map 1) comprises an area of 5,015,067.75 square kilometers (about 58.9 percent of Brazil's territory) and covers 722 municipalities, distributed across eight Brazilian states (Instituto Brasileiro de Geografia e Estatística [IBGE] 2020). This region is one of the most emblematic since, despite its high supply of water, accessibility is restricted to part of the population.

The National Solid Waste Policy, established in 2010, defined that MSW management is the responsibility of municipalities. Nevertheless, few managed to make its implementation feasible, and, in most cases, waste is deposited without control in the open, which contaminates bodies of water and makes access to quality water difficult. That is, in the country, and in the Amazon in particular, there is a significant part of the population without access to basic sanitation, defined as access to water, sewage collection and treatment, urban drainage and collection, and proper disposal of MSW.

Given the above, this chapter aims through the concept of Capitalocene to show that the expansion of the urban network in the Legal Amazon generated unequal access to water and fundamental services, such as the collection and correct destination of MSW. The methodological approach is based on a literature review and the use of secondary data from official sources.

Map 1: Brazil: Legal Amazon – 2022



Source: IBGE (2022)

The chapter begins by contextualizing the concepts of Anthropocene and Capitalocene and adopts the latter to assess events in the Legal Amazon. It then presents urbanization in Brazil and its spatial injustice. Following that, it shows how this process took shape in Amazonian cities, as well as its effects on access to water and on the collection and treatment of MSW, to conclude that the ongoing processes, if not changed, could lead to the widespread devastation of an area vital to the existence of today's world, as it is one of the main sources of ecosystem and environmental services that are necessary for the various forms of life on Earth.

Anthropocene or Capitalocene?

It seems clear that human intervention in part of the Earth system's biogeochemical processes is inexorable. Starting with the changes in the Earth's surface, in particular, one can see the deforestation of the original vegetation of various natural biomes in different parts of the Earth, followed by the introduction of crops in vast areas, in which, frequently, substances foreign to the soil in its natural state are added, degrading such soil, as well as surface and groundwater.

Substantially, however, human action is responsible for changing the composition of the gases that act in the atmosphere, which aggravate global warming, with social and environmental implications that can be catastrophic for human existence and for other forms of life on the planet.

When Crutzen and Stoemer (2000) used the term Anthropocene, they pointed to the devastating power of the technical instruments used by the human species, which, despite not being the numerical majority on the planet, is the one that has managed, thus far, to achieve the greatest technological development, capable of altering a number of natural dynamics. This idea was corroborated by many other researchers who discussed various aspects related to culture, technical means, and their consequences, among others (Rockstrom et al. 2009; Steffen et al. 2011; Zalasiewicz et al. 2011; Biermann 2012; Gisli et al. 2013; Latour 2013; Karlsson 2013; Dalby 2014; McNeill and Engelke 2014; Thomas 2014; Biermann 2015; Steffen et al. 2015; Chernilo 2017; Clark and Gunaratnam 2017; Delanty and Mota 2017; Luke 2017; Strydom 2017; Turner 2017; Delanty 2020; Arias-Maldonado 2021). Despite this important literature, the International Commission on Stratigraphy has yet to confirm the new geological period, which would succeed the Holocene. In any case, it is increasingly evident that the Earth is marked by human action on its surface, with consequences for the biosphere and atmosphere.

It is necessary, however, to qualify human intervention in nature and ask which social subject had the driving capacity to change complex natural systems and to what ends. Therefore, it is necessary to go further and reach the level of the agents that promote the environmental devastation that led to the contemporary chaos. In this process, some authors already stress that – less than an "age of man" – it is necessary to identify the social sectors capable of moving such energy, which has resulted in the degradation of the planet.

In this movement, the term Capitalocene emerges with force, as it associates environmental devastation with the Industrial Revolution, followed by capitalist relations of production, which have led to the Great Acceleration seen after the Second World War, especially in the advent of unbridled consumerism that has led, since the last decades of the twentieth century, to a vertiginous increase in the use of natural, energy, and water resources on the planet. This set of historical, social, and political processes has affected natural systems and degraded the planet.

The Capitalocene (Haraway 2015; Jiménez 2017) would therefore be the expression of capital on Earth, with its inexorable marks of destruction and disrespect for the forms of social organization that oppose its way of acting. The capitalist mode of production is irrational, as it disregards the general interest and seeks to obtain profit as the first cause, without considering biological rhythms and other natural processes (Tiezzi 1988), some of which have long-lasting effects that are difficult to recover after capitalist devastation.

In the Legal Amazon, evidence of capitalist devastation can be found in the high rates of deforestation, which have increased particularly in recent years. The destruction of the ecosystem reflects on the spatial organization of cities, a process that has taken place in other locations in Brazil.

Brazilian urbanization is characterized by social inequality and spatial injustice (Ribeiro Rodrigues 2017), as it was based on the financialization of the territory (Carlos 2020). This process must be presented to contextualize how it occurred in the Amazon.

Urbanization in Brazil

Brazilian urbanization intensified in the twentieth century as a result of the industrialization process and the increase in rural exodus. Nevertheless, some urban centers date back to the sixteenth century, as a result of the process of occupation, access, and use of the territory at the time of Portuguese colonization. Already in that period, the hydrographic network was used as the main means of access, exploration, and occupation of the territory, as well as the coastal strip. In the Amazon, the dendritic drainage system (arborescent-shaped river basin) became a transport and communication network, in which cities were formed, consolidating the agrarian export model that remained for centuries in the country. Another form of penetration into the interior followed the paths of native peoples, who were enslaved in the colonization process and later displaced to settlements (Petrone 1995) next to emerging cities, as was the case in São Paulo, currently the largest metropolis in Brazil.

The Kingdom of Portugal, concerned with the defense of the colonial territory that had been threatened by the presence of the French and Dutch, installed a series of forts along the coast, part of which was the embryo of important cities, such as Salvador, the first capital of what later would become Brazil, currently the capital of the state of Bahia. The municipality of Rio de Janeiro also emerged with the role of defending Portuguese lands after a confrontation with the French (Abreu 1987). Forte dos Reis Magos, built in 1598 in the area that currently belongs to the municipality of Natal, capital of Rio Grande do Norte, was also built by the Portuguese and gave rise to the city. Forte do Castelo, whose first installation dates back to 1616, gave rise to Belém, the current capital of Pará (Trindade Jr. 2018), and was established to deter the French presence in northern lands under Portuguese rule, as the Kingdom of France founded the city of São Luís do Maranhão in 1612, the current capital of Maranhão (Ribeiro 2011).

Gold mining also led to the creation of cities across the interior of the country. Cuiabá, Goiás Velho, and Ouro Preto, among others, emerged from the presence of explorers of this resource in the imperial era. Later, penetration occurred through the presence of railroads, as in the interior of São Paulo. The rails accompanied the expansion of the coffee culture, in the late nineteenth and early twentieth centuries (Monbeig 1952).

Planned cities were also established, such as Belo Horizonte, Goiânia, and most prominently, Brasília, the current capital of the country. The urbanization process, however, transcended the limits proposed by architects, with these cities presenting the same problems as previous ones, in particular, the expulsion of the poorest population into areas where urban structures did not exist or were precarious. Consequently, there was an intensive but uneven urbanization process, with numerous areas of high social vulnerability.

According to Santos (1993), Brazilian urbanization underwent the following stages: a) agglomerated urbanization; b) concentrated urbanization; and c) metropolization. Agglomerated urbanization took place before the 1970s and combined growing urbanization with the demographic explosion, with the expansion of the urban site of cities. In concentrated urbanization, it was the turn of intermediate cities to gain prominence, increasing the offer of services. The growth of the urban fabric and the extension of the urban area, associated with demographic growth, internal migration, and the supply of jobs, allowed the metropolization of some locations, such as São Paulo and Rio de Janeiro, classified as domestic metropolises. In Brazil, the definition of a metropolis is determined by the Federal Units, which resulted in several urban agglomerations, many of which have regional prominence. Still, it should be noted how some elements of the industrialization process and changes in the socio-spatial organization of the territory affected cities in Brazil.

Brazil is marked by late industrialization, since, in its state as a colony of Portugal from 1500 to 1822, it was not possible to establish industries in this period, which forced those who lived in colonial lands to consume manufactured products from Portugal or from other European countries. The agrarian export model can be associated with the plantation model employed by Portugal, which, for some, determined Brazil's position in the territorial division of labor even today, as an exporter of primary agricultural and mineral products.

The industrial park was only implemented in the twentieth century, although before that, a few manufactures were present due to the presence of immigrants of European origin. In the 1930s, the textile industry, whose main role was to provide bags for coffee growers to pack and sell their product, was a prominent sector. In the industrialization process, public investments were made in infrastructure and industry, although restricted to the southern and southeastern parts of Brazil. It was based on the substitution of imports (Prado Jr. 1954; Furtado 1954), through the installation of basic industries financed by the state and by private initiative through the durable goods industries.

In the 1950s, the economy was opened to international capital investments, encouraging the establishment of multinationals in the country, mainly automakers. The creation of Petrobras, a state-owned oil exploration company, was crucial to stimulating research and development of technologies, which later generated knowledge for oil exploration more than seven kilometers deep in the sea beyond the salt layer.

With the construction of Brasília, steel, metallurgy, and civil construction companies were boosted, stimulating consumption and industrial production. Later, the definition of the Manaus Free Trade Zone, a tax-free area for the installation of transnational companies, led to the presence of electronic and vehicle assembly industries that operate to this day, leading to the metropolization of the capital of Amazonas (Oliveira and Schor 2009).

Starting in the 1990s, the opening to the international market resumed. This time, the state began to privatize its state-owned companies, making the state smaller in its actions and transferring its assets to the private sector. A new race for foreign investment took place in the country, which saw cities such as Fortaleza, the capital of Ceará, strengthen with the presence of services, as well as consolidating prominent cities, such as Curitiba and Porto Alegre, respectively the capitals of Paraná and Rio Grande do Sul, thanks to the Mercosur Agreement, which intensified trade with countries such as Argentina, Paraguay, and Uruguay.

Agricultural mechanization significantly changed in the country's socio-spatial organization and in the Amazon (Elias 2021; Faria and Osoegawa 2021). The deployment of machines in the countryside boosted the rural exodus by replacing the workforce, which migrated en masse to the city, initially mainly to large urban centers and later to the so-called medium-sized cities (Spósito 2006). Consequently, land was concentrated in the hands of a few (Oliveira 2015); there was an intensification of urbanization that reproduced social inequalities, resulting in the formation of risk areas for the lower-income population and spatial injustice (Ribeiro Rodrigues 2017).

Inhabiting high-risk areas, especially those vulnerable to flooding and mass movements that destroy precarious buildings, has several consequences for society and the environment. First, there is the suppression of vegetation in natural areas, even though they are at risk, in most cases, of slopes and floodplains. Many of these areas do not have a water supply, sewage system, or MSW collection network and, frequently, also become the destination of the waste produced, making the environment unsuitable for human presence. For that reason,

> [w]ith differences in degree and intensity, all Brazilian cities exhibit similar problems. Their size, type of activity, region in which they operate, etc. comprise elements of differentiation, but in all of these issues such as employment, housing, transportation, leisure, water, sewage, education and health are generic and reveal enormous needs. The larger the city, the more visible such ills become. (Santos 1995: 95)

Brazilian urbanization has brought about this amalgamation of growing environmental deterioration, concentration of the means of production, and social inequality – a situation that is also present in the Amazon.

Urbanization in the Legal Amazon

Following an explanation of urbanization in Brazil, an approximation in scale is sought in order to understand the particularities of this process within the Legal Amazon. Additionally, it will be possible to discuss how, in the urbanization process in this part of the country, the interests of capital predominated in the appropriation of the territory and its natural resources.

São Luís do Maranhão is the oldest city in the Legal Amazon. Nevertheless, despite the pioneering spirit of the Maranhão state capital, it was the foundation of Belém that boosted the Amazonian urbanization from the seventeenth century onwards. A number of authors have made propositions regarding the periodization of the Amazonian urban network and the evolution of cities in the Amazon, such as Corrêa (1987), Almeida and Ribeiro (1989), Vicentini (2004), and Castro (2008), among others. The periodization of the Amazonian urban network usually presents a relationship between the "economic cycles" of exploitation of natural resources and the spatial forms resulting from their occupation. Nevertheless, it is also important to consider urbanization from the history of men, "who engendered forms of 'domination' of space by knowledge and culture" (Vicentini 2004: 33).

The foundation of Belém is inserted in the context of the European mercantile expansion that started in the fifteenth century, which sought the insertion of new areas for the colonial expansion of European countries. The protection of the Portuguese colonial territory from outside interests and its position, which served as a base for the penetration and conquest of the interior of the Amazon, was decisive for the foundation of the current capital of Pará, which, thanks to its location, guaranteed "control of the coast and of the Amazon valley [...] acquiring unique prominence throughout the region" (Corrêa 1987: 44).

Both Corrêa (1987), and Almeida and Ribeiro (1989) note that, from 1655 onwards, the search for natural products highly valued in Europe began, the so-called "drugs of the sertão" that were used as condiments, pharmaceuticals, ornaments and construction materials, involving, among other products, cocoa, cloves, cinnamon, sarsaparilla, wood, and fish butter (Corrêa 1987). The search for such products led to the creation of several missionary villages and forts, founded by religious orders, which used the Indigenous people and their knowledge for the collection of products.

However, Becker (2013: 28) considers that these settlements were not yet effective urban centers, as they were subsequently consolidated based on the new "metropolis project for the region, as conceived by the Marquis of Pombal."

Nevertheless, just as the period of activity of Companhia do Grão-Pará e Maranhão represented a moment of expansion of urban centers in the Amazon and the establishment of a network of cities hierarchically controlled by Belém, the extinction of the aforementioned mercantile company also had a direct impact on the urbanization. The establishment of free international trade, outside the monopoly control of state companies, as well as an unfavorable moment for tropical products in Europe, generated a "decrease in urban growth" (Corrêa 1987: 47).

The interests of the European colonial metropolises – sometimes focused on the "drugs of the sertão," sometimes discouraged from expanding agriculture in the tropics – clearly left marks on the expansion-retraction movement of the urbanization of the Amazon from the seventeenth century to the mid-nineteenth century. It was from that moment on that, once again, the external demand for natural products – this time rubber – had an impact on urbanization.

The peak of Amazonian rubber exploitation took place between 1850 and 1920, culminating in the reinvigoration of old urban centers and the emergence of new ones, intensifying the relationship between centers (Castro 2008). According to Corrêa (1987), this movement led to a greater circulation of goods as well as a strong concentration of activities and urban population, particularly in Belém and Manaus, and the creation of a dendritic urban network, which culminated abroad.

Nevertheless, competition with Asian rubber, starting in the 1910s, led to a drop in prices on the international market and regional economic stagnation, with various effects on the urban network. Again, external interests – this time from capital – left marks in the expansion-retraction of Amazonian urbanization.

While the cities that had prospered or even emerged as a result of rubber extraction underwent a process of stagnation and even a decrease in population (Corrêa 1987), others experienced greater dynamism and population growth thanks to the exploitation of other products. This is the case, for example, of Marabá in the southeastern portion of Pará due to the exploitation of Brazil nuts. In turn, the Bragantina Zone (northeastern Pará), from the 1930s onwards, prospered in the middle course of the Amazon, between Santarém, Pará (PA) and Manaus, Amazonas (AM), through the cultivation of mallow, black pepper, and jute, widespread by Japanese colonists (Almeida and Ribeiro 1989).

Starting in the 1950s, another element was introduced in this circuit of exploration of nature and the changes caused by capital: the industrial exploitation of mining, which resulted in significant changes in the patterns of urban occupation in the Amazon. In parallel with mineral extraction, a process of implementing government incentives also began, seeking to integrate the regional Amazonian economy into the national and international capital appreciation circuits and leading to greater intervention by the Federal Administration in the region.

Castro (2008) stresses that, after the period of rubber exploitation, from 1966 onwards, a new pattern of occupation and settlement in the Amazon began due to government programs for the expansion of the agricultural frontier and its association with the urban structure. Similarly, Petit (2003), by periodizing the economic history of the Amazon, noted that, from 1965, the period of "great socioeconomic transformations" began based on the international demand for raw materials.

The creation of the Superintendent's Office for the Development of the Amazon (SUDAM) and Banco da Amazônia (BASA), within the scope of a set of public policies that became known as Operation Amazônia, promoted a "set of instruments to attract capital, facilitating its entry based on tax incentives and other more general guarantees such as access to land and other natural assets in the Amazon" (Loureiro 1992: 72). From that moment on, a series of incentives began to be applied in the Amazon to attract investments in the agricultural sector, in official colonization projects on the banks of the newly opened federal highways, as well as in mineral extraction-industrial activities. Tax reduction and credit facilities were the main methods employed by SUDAM, with BASA as its financial agent, aiming to attract investors to the Legal Amazon region.

From 1964 to 1985, Brazil was governed by a dictatorial system following the military coup. Consequently, the various government projects/programs launched in the Amazon had the aim of guaranteeing state control over the territory (Mello-Théry 2006; Théry 1997). According to Becker (2009), the territorial strategies of regional occupation were based on the production of geographic space by the state, following the construction of a territory and subsequent production of a political space controlled by the state through laws and standards. The author argues that a "programmed mesh" or "technopolitical mesh" was established between 1966 and 1985 with the goal of completing the physical appropriation and control of the territory.

With regard to urban issues, Machado (1999) notes that such actions resulted in the organization of an urban system in the Amazon that was based on two orders: the intentional order and the spontaneous order. The first was characterized by the planning and creation of urban centers based on government policies to encourage the creation of development centers (agricultural, mining, and logging) or by private enterprises, such as company towns. The second order was related to the emergence of settlements around large projects or from rural settlements that emerged on the margins of large farms, settlements, and roads, which grew and eventually became cities.

The search for the use and appropriation of natural resources in the Amazon placed different social groups, endowed with different strategies and interests, in opposition, resulting in a complex urban organization, both in terms of form (from planned company towns to spontaneous occupations) and content (from a myriad of subjects such as entrepreneurs, farmers, migrants and settlers attracted by colonization projects, mining companies, the state, Indigenous peoples, riverside communities, and organized social movements).

The generation of new municipalities is a mark of the complexity of Amazonian urbanization, which demonstrates the footprints of the Capitalocene, as the interests in capital, extracted from the exploitation of mineral resources, lead to the production of geographic space and the appropriation of the territory of the Legal Amazon, often imposing a new order on the multiple territorialities present in the region, such as that of native and riverside peoples (Ribeiro 2021).

Following the passing of the 1988 Federal Constitution, the creation of municipalities in Brazil was delegated to the Federal Units. The northern region of Brazil was the one with the highest percentage in terms of the creation of new municipalities between 1980 and 2001, with an increase of 119 percent. According to Rocha (2008), in addition to political interests, it was the new organization of social subjects and their different economic interests that led to municipal emancipation in northern Brazil. Rocha (2008) assessed the creation of new municipalities from a geographic standpoint through the relationships between territory, politics, identity, standards, and resources. When analyzing the relationship between territory and resources, Rocha (2020) highlighted the economic dimension of the territory, which, according to him, established the political-administrative redivision.

Still following Rocha (2020), two aspects have been highlighted in the search for appropriation of resources that motivated emancipationist movements: funds from royalties and financial compensation and those from the Fundo de Participação dos Municípios (FPM, Municipalities Participation Fund). Souza (2015) identified that, in the period from 1983 to 1997 alone, sixty new municipalities were created in the State of Pará, which is equivalent to 41 percent of the current number of municipalities in this federal unit. A large portion of these new municipalities emerged from the opening of new highways and interests in accessing royalties from mining and financial compensation arising from hydropower projects, as is the case around the lake formed from the creation of the Tucuruí Hydropower Plant, or even in other hydropower plants, such as those located on the Madeira River (Cavalcante 2020; Silva et al. 2021).

A financial compensation program was established by the 1988 Federal Constitution, in Article 20, paragraph 1, which pays the States, the Federal District, Municipalities, and federal administration agencies for the economic use of mineral or water resources in their respective territories (Agência Nacional De Mineração [ANM] 2021; Agência Nacional De Energia Elétrica [ANEEL] 2022). According to data from the Agência Nacional de Mineração (ANM, National Mining Agency), in the State of Pará alone, in 2021, a total of sixty-six municipalities received funds from the Compensação Financeira pela Exploração de Recursos Minerais (CFEM, Financial Compensation for the Exploration of Mineral Resources), totaling R$2,891,227,722.65 (ANM 2021). In turn, the Compensação Financeira pela Uso de Recursos Hídricos (CFURH, Financial Compensation for the Use of Water Resources) generated transfers to fifteen municipalities in Pará, totaling R$176,244,441.08, in 2021 (ANEEL 2022).

Currently, government investments in large projects continue to cause major transformations in the Amazonian urban dynamics, whether in "big projects," as in the past, as was the case with the Belo Monte Hydropower Plant and the changes caused in Altamira, Pará, i.e., through public policies such as the Minha Casa Minha Vida Program (PMCMV), which had a nationwide scope. Following the emergence of the PMCMV, thanks to the alliance established between the state, the financial market, and civil construction companies, an opportunity also opened up for the intensification of private capital to invest directly in the production of the Amazonian urban space.

Cardoso, Melo, and Gomes (2016) identified that modern urban practices, which are characteristic of the metropolis, are now metabolized in the interior of the Amazon, with an increasingly private urban expansion, which was reproduced as a form from urbanized subdivisions, housing complexes, and gated communities, in which nature became private for the high-income sectors and unavailable for the poorest families.

In the twenty-first century, the urbanization of the Amazon presents an expressive diversity of cities, from those over four hundred years old to the youngest with less than half a century of existence. However, the relationship with nature has been transformed. Throughout the urbanization process, the interest in mastering and appropriating natural resources was the guiding principle for the realization of the city as a habitat in the Amazon. Various projects applied in Amazonian municipalities, however, disregarded the natural dynamics of rivers and streams, resulting in new forms of spatial injustice (Batista and Ribeiro 2014).

Nevertheless, contradictorily, this process also carried with it the capacity to destroy the environment and aroused interest in urbanization, creating an antagonistic relationship between cities and nature (Cardoso, Melo, and Gomes 2016).

Despite the expressiveness of the various subjects that make up the spatial sociodiversity of the Amazon, with dwellings in the floodplains, forests, and rural settlements, most of the population of this region currently lives in cities, which sheds light on the various social and environmental challenges that are present in Amazonian cities, as will be discussed below.

Social and Environmental Challenges in Amazonian Cities in Brazil

A number of actions applied in the Legal Amazon have led to the formation of a complex urban network with severe social and environmental implications. External interventions, initially promoted by colonial metropolises and, later, by international capital, have produced the Amazonian space. The Capitalocene imprinted its territorial marks, modifying politics and social relations, which directly affected natural processes.

Through the urbanization process seen in the Legal Amazon, the network of cities spread across the dendritic drainage system did not allow access to basic sanitation, which in Brazil corresponds to four aspects: access to water, sewage collection and treatment, MSW collection and treatment, and urban drainage.

Following that, the situation of access to water and the collection and treatment of MSW in the Brazilian Amazon is presented, whose deficiencies result from an external approach to it, aiming solely to extract wealth from its territory, while neglecting social demands and the maintenance of ecosystem and environmental services.

Access to Water

The Human Right to Water was established as a fundamental right by the United Nations (UN) on July 28, 2010, at the United Nations General Assembly through Resolution A/RES/64/292 (UN 2010). This Right is universal and fundamental, even though it has not been adopted by all countries in the world, including Brazil. Among those who adopted it, it is necessary to standardize, in the form of law, the population's access to water. Petrella (2004) highlights that

> Water is an irreplaceable essential element for individual and collective life. Access to water is not a matter of choice. It is a necessity linked to life itself. As a source of life, it is irreplaceable. […] We cannot replace water in order to live. The essentiality and the fact that it is irreplaceable with regard to life makes access to water an individual and collective human and social right. (Petrella 2004: 12)

In this sense, there is a need for countries to manage and control their waters in order to guarantee access with quality and equality by their populations. Nevertheless, the political distribution of water worldwide indicates a profound inequality in its access (Ribeiro 2008). UNICEF and WHO (2019) note that one out of three inhabitants on the planet does not have access to drinking water and that, although there have been changes in access and quality water quality in the period from 2000 to 2017, as well as improvements in hygiene and sanitation conditions, such changes were still not enough for universal access to water to be guaranteed.

A similar situation arises in Brazil, which appears with insufficient rates related to access to drinking water services, as well as water security (UNICEF 2019). A true paradox can be seen in Brazil. Despite having the highest water availability in the country, the Amazon, in which a large part of the Amazon River Basin is located, is marked by social water availability of around 3,584,117 cubic meters/inhabitant/year, while the total use is 426 cubic meters/inhabitants/year. This situation is very different in other Brazilian regions, where social water availability is much lower, while use is much higher, as in the northeastern and southern regions (Table 1).

Table 1: Social Water Availability and Demand by Region in Brazil.

Regions	Social Water Availability (m^3/inhabitant/year)	Total Use (m^3/inhabitant/year)
North	3,584,117	426
Northeast	38,197	1,561
Midwest	338,737	590
Southeast	22,723	1,082
South	45,045	1,570
Brazil	35,732	273

Source: Organized based on Tundise and Matisuda-Tundise (2020).

The distribution of water resources in Brazil is uneven, as is demand. Access to water could be directly related to availability. This statement is relative, however, as even in regions rich in water, such as the Amazon, access to water is problematic. That is, although there is no shortage of water in terms of volume, access to quality water is scarce. According to Becker (2003), the per capita ratio of water for the Legal Amazon hides reality, as the water supply is abundant, but social inaccessibility to water is the reality.

The northern region has 68.5 percent of the country's water availability, housing about 8.5 percent of the population (IBGE 2023). In this way, water availability is plentiful, but in terms of water quality, there is a compromise in the volumes of water in the Amazon basin (Agência Nacional das Águas [ANA] 2021). In the northern region, 73.52 percent of the population lives in urban areas, while 26.48 percent inhabits rural areas. Manaus and Belém have around 2 million inhabitants and 1.4 million inhabitants, respectively (IBGE 2023; ANA 2021).

The water supply is satisfactory, as approximately 90 percent of the urban population is covered by water distribution, with a deficit accounting for 6 percent of the urban population. Even with this data, investments in the production and distribution of water will be necessary, amounting to R$621.1 million by 2035. Even so, there are “thirteen urban centers that have vulnerability in springs or water-producing systems and which are devoid of solution proposals” (ANA 2021: 80). The demand for water to supply Manaus is 6.0 m^3/s, whose main source of supply is the Negro River.

Public and private concessionaires responsible for the water supply system operate in Pará. Of the 144 municipalities in the state, 116 urban centers are not vulnerable in the supply system, although 103 require expansion or adjustments in the units of the water production systems (ANA 2021). In Belém, concerns are already present regarding water quality, as there is a commitment to the Bologna system. The demand for water is 4.3 m^3/s, with a proposal to improve the Bologna system and increase the demand from 3.2 m^3/s to 6.4 m^3/s. The expansion and improvement of systems also covers isolated systems, with water treatment stations, expansion of connections, and water distribution.

According to SNIS (2021), in 2013, 39 percent of the urban population of the state of Amazonas had adequate sewage services. Nevertheless, 20 percent had a septic tank, 19 percent had sewage collection and treatment, 4 percent had sewage collection without treatment, and 58 percent of the urban population had neither sewage collection nor treatment. In Manaus, 49 percent of the population is not served by sewage collection and treatment, while 29 percent has collection and treatment, and 22 percent use septic tanks.

In Pará, only 4 percent of the urban population is served with sewage collection and treatment, while 25 percent has septic tanks, 5 percent has sewage collection without treatment, and 66 percent of the urban population does not have access to sewage collection or treatment. In Belém, 42 percent of the urban population has access to sewage collection networks, of which 31 percent has a septic tank and 11 percent has sewage collection and treatment, 10 percent of the population has sewage collection without treatment, and 48 percent has no access to either sewage collection or treatment.

In 2020, 86.9 percent of the population in the northern region did not have sewage collection, while 41.1 percent did not have access to water (SNIS 2020). Despite the improvement in indicators over the last ten years, as 1.4 percent more of the population had access to water and 6.3 percent more now have a sewage collection system, the compromise in water quality is undeniable, as most of the sewage is directly discharged into water bodies, while 78.6 percent of the population is supplied with poor-quality water. Therefore, despite the volumes of available water, water security is low. Therefore, the “political distribution of water” (Ribeiro 2008) in the Legal Amazon is defined by income and not by natural processes.

Generation and Management of Municipal Solid Waste

The phenomena of urbanization and industrialization have historically established unique dynamics regarding the extraction of raw materials and the consumption and disposal of materials. Consequently, millions of metric tons of MSW are generated on the planet. For example, 353 million metric tons of plastics became MSW (OECD 2022). Coupled with this scenario, the COVID-19 pandemic has contributed to the complexity of MSW production (Ziglio 2020), including waste from personal protection equipment used in healthcare. According to the World Health Organization (WHO 2022), 87,000 metric tons of personal protective equipment were produced in the period from March to September 2020, which became MSW. Thus, the current pandemic scenario has shown that MSW, diseases, and environmental impacts comprise events of urban and industrial relations. This context is not new in human history, as highlighted by Mumford.

> The slave routine of the mines, whose work constituted an intentional punishment for criminals, has become the normal environment of the new industrial worker. [...] As if to testify to the immense productivity of the machine, the heaps of rubbish and debris reached mountain proportions, while human beings, whose work made those feats possible, were maimed and killed almost as quickly as they would have been in a battle field. (2004: 483)

That is, over the years, industrial society, when faced with labor relations, neglects and/or makes populations precarious with regard to access to sanitation conditions and naturalizes it as the new human/urban condition. As already pointed out, the declaration of the human right to water and sanitation by the UN is an attempt to change this situation. Within the scope of the Brazilian federation, the 1988 Federal Constitution (CF/1988), in its Article 225, emphasizes that "everyone has the right to an ecologically balanced environment, an asset for common use by the people, essential to a healthy quality of life, imposing on the public authority and the community the duty to defend and preserve it for present and future generations." Additionally, to collaborate with the domestic sphere on the subject, the National Solid Waste Policy was defined (Política Nacional de Resíduos Sólidos – PNRS, Act 12,305/2010), which encourages the preparation of MSW management plans with the purpose of guaranteeing the provisions of the Federal Constitution. In this sense, the organization and implementation of agendas for the collection, treatment, and final disposal of MSW are implemented at the municipal level.

In a survey published by the National Sanitation Information System (SNIS 2021), of the total of 5,570 Brazilian municipalities, 450 are located in the northern region of the country. These municipalities have an urban population of 12.5 million inhabitants who generate MSW, which are served by public and/or private companies for the collection and final destination of MSW, which are responsible for managing the generation of 5.3 million metric tons/year of MSW. It is necessary, however, to consider the low percentage of collection in the region that does not reach 38.1 percent of the population (SNIS 2021). Consequently, many types of MSW, such as bottles, fishing nets, and tires, among others that could be recyclable, end up becoming useless waste. Moreover, they are arranged in rivers and streams, impacting their waters and adjacent ecosystems.

Another part is destined for burning, an activity considered prohibited by the PNRS in Article 47. It should be noted that MSW – collected by the public and/or private companies contracted by the municipalities – is disposed finally in sanitary landfills, controlled landfills, and dumps (outdoor areas, without prior preparation to receive the materials).

Additionally, in Brazil, more than 50 percent of its municipalities have final disposal in dumps or controlled landfills (Confederação dos Municípios 2022). The northern region has 235 controlled dumps and/or landfills in operation, of which 114 are in Pará. It should be noted that these previously presented data may be even higher, as they are self-reported by the municipalities (Confederação dos Municípios 2022).

Faced with this situation, it is necessary to qualify the selective collection of recyclable materials in the North region. The definition of selective MSW collection adopted in this chapter is one in which recyclable materials – such as plastics, paper, packaging glass, and metals (aluminum, iron, etc.) – are separated and sent for recovery and/or recycling. The northern region adds 0.03 million metric tons/year of the total generated for recovery and/or recycling in Brazil (SNIS 2021), placing as the smallest national fraction. The volume collected results from the work of thirty-seven cooperatives and/or associations of recyclable material collectors, with a total of 743 workers, of which 52 percent identify as women (ANCAT 2022).

The work of cooperatives and/or associations of recyclable material collectors results in the sale of 17,600 metric tons to processing companies and/or recycling industries (ANCAT 2022). These thousands of metric tons are composed of paper, which corresponds to 65 percent of this amount, and plastics, which account for 29 percent of this total (ANCAT 2022: 18). The average income achieved by cooperative and/or associated workers in the region is nine hundred and seventy-five Brazilian reais (R$975.00) (ANCAT 2022).

Finally, is it possible to consider that the collectors of recyclable materials in the northern region comprise the contemporary workers who testify to the immense productivity of the machine and the mountains of garbage mentioned by Mumford (2004)? It can be inferred that the work carried out by these women who collect recyclable material contributes to the fact that many tons of MSW do not end up in streams, rivers, or dumps, although, despite this important effort, it is still insufficient to guarantee the quality of life for the population in northern Brazil.

Final Remarks

In Brazil, an urban network has resulted in enormous social inequalities. In the Amazon, this network has emerged from economic cycles, initially colonial and then capitalist, as the driving force that devastates the Amazonian ecosystems without respecting their biogeochemical cycles and, worse, the original communities and peoples that inhabit the area.

That is why the concept of Capitalocene is more appropriate to point out the causes of such devastation in an area that has always been defined based on external interests. The gaze of the devastator – whether from European colonizers or capitalist entrepreneurs – left marks on the Amazonian landscape, marks which have grown even more in recent years.

Access to water, the collection and treatment of sewage, and the collection and proper disposal of MSW should be the minimum of what could be achieved, given the wealth generated by intensive mineral extraction activities. Instead, there are cities, Indigenous peoples, and rural communities without access to quality water, as it is contaminated by the release of sewage and garbage in its natural state, coupled with the chemical elements used in mining, such as mercury, which severely affect the health of riverside communities.

This scenario must be changed. The Legal Amazon should be reinterpreted from the perspectives and values of the people and communities that live there. These groups are responsible for providing fundamental ecosystem and environmental services to Brazil and the world.

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Water in the Mesoamerica from 1950 to the Present

Water Management in the Mexican and Central American Anthropocene in Light of its Relation to the Great Lakes

Mario Edgar López Ramírez

It is currently estimated that more than 90 percent of available surface freshwater on the planet is concentrated in natural and artificial lakes (including large dams) (ILEC-UNEP-CITA 2004: 1; UN 2022: 2). For this reason, analyzing what happened in the great lakes of Mexico and Central America becomes essential, since it illustrates the views on water that have been held during the Anthropocene in the region. Lakes constitute a complex system inseparable from the dynamics that occur throughout their basin: "water enters the lakes primarily through precipitation and runoff from the surface and/or filtration of groundwater within a lake basin" (ILEC-UNEP-CITA 2004: 1). In the region of Mexico and Central America lie two of the largest lakes in Latin America: Lake Nicaragua and Lake Chapala in Jalisco, Mexico (second and third, respectively, in extension within the subcontinent, after Lake Titicaca). In addition, Mexico City is a lake city, sitting mainly on the bed of the ancient Lake Texcoco, among other lagoon formations.

This chapter aims to fashion an approach to the Anthropocene in the Mexican-Central American region by focusing on what has happened with water management in light of its voluminous lake bodies. First, it begins by situating the region's historical role since the colonial period and the one it currently plays within the Anthropocene in its modern capitalist phase. It then provides an approach to the similarities and differences between Mexico and Central America regarding the management of their waters. The chapter establishes the overarching tendency in Mexico to dry its lakes either to turn them into agricultural *ciénegas,* thus expanding its wetlands, or to maintain and expand urban developments. In contrast, the abundance of rain for agriculture has managed, in general, to preserve lakes in Central America as water reservoirs and Lake Nicaragua, in particular, as key provider in water supply projects to countries suffering from degrees of scarcity, such as El Salvador, by transporting the resource through large aqueducts. The dynamics of the two largest lakes in the region coincide in their use as urban, agricultural, and industrial discharge drains, which has left them contaminated. The chapter concludes with the necessary transformative vision that will involve climate change's impact on managing water, especially in lake management.

Role of Mexico and Central America within the Capitalist World System and its Historical View of Water as a Resource

What is understood today as Anthropocene is intimately linked with the development of modernity and global capitalism, as well as the beginning of the Industrial Revolution. The concept describes a new geological age defined by human action on nature (Murillo 2020: 12), where a single species, *Homo sapiens* has become "the single most important agent of change in global ecology" (Harari 2017: 88). Thus "the Anthropocene concept refers to the power that human activity has acquired to become a destructive environmental force of geological scale" (García and Jiménez 2020). This capacity for human impact on nature has been clearly present since at least the emergence of the first civilizations and their cities: as an example, the Mesopotamian city of Eridu around 4,900 years BCE was already dedicated to mastering agriculture and nomadic herding and fishing, but was specifically erected to be the "center of worship the god or goddess of freshwater" (Leick 2002: 21–30), i.e. built for water's anthropomorphization and domain. However, the most potent historical manifestation of the Anthropocene has occurred during the construction of the modern era.

From the onset of modernity, once the New World had been discovered and conquered, the initial characteristic of the Mexican-Central American Anthropocene has been the region's role as a subordinate periphery to be exploited within the capitalist world-system, to provide gold and silver, raw materials, and strategic food crops for the European population, harvested through slave or *encomienda* labor; these inputs were then directed to the Spanish Empire, where this wealth was distributed to the rest of the continent, which was much more industrialized and mercantilist, to finally become capital and facilitate trade, as "the metals that enriched Spain in a parasitic way […] flowed to those countries where its purchasing power was greater" (Vilar cited in Wallerstein 1979: 273), thereby inciting a major transformation of anthropocenic human-nature relations. Thus, Mexico and Central America formed part of the subordinate regions constituting the planet's first major political, cultural, economic, and ecological globalization.

Edgar Morín presents a summary of what happened in this growth of the global Anthropocene in talking about the beginnings of what he calls "the planetary age":

> the planetary age begins with the first microbial and human interactions, then with plant and animal exchanges between the Old and New Worlds […] Europeans introduce corn, potato, bean, tomato, cassava, sweet potato, cocoa, [and] tobacco to their countries. They bring rams, cattle, horses, cereals, vineyards, olive trees,

> and tropical plants to America [...] America is populated with domesticated herbivores and dedicated to intensive cultivation of cotton, sugar cane, [and] coffee [...] In the seventeenth century the great English, French, and Dutch maritime companies for the East and West Indies are established. The Europe/Asia/America trade proliferates and, in Europe, luxury exotic products such as coffee, chocolate, sugar, and tobacco will become everyday consumer products. Europe is experiencing accelerated development [...] Cities, capitalism, [and] the nation-state, then, industry and technology, acquire a development that has not been known by any civilization [...] The planetary era begins and develops, in and through violence, destruction, slavery, [and] the fierce exploitation of the Americas and Africa. It is the planetary iron age, in which we still remain. (Morin 1993: 18)

In addition to the historical colonial products that still continue to be supplied by Mexico and Central America to the central regions of the world-system, there is also currently the extraction of crude and transformed oil (only in Mexico), as well as the mining of superconducting or energy-storing materials such as lithium, silicon, and uranium, among others. Sufficient information is still lacking on the regional presence of germanium, zinc, selenium, sulfide, and cadmium, as well as the so-called "rare earth" metals that may exist in the soils of the area, which are now in demand for the production of computer technology.

During the 400 years of Spanish colonial rule in Latin America, all economic expansion required water supply for precious metal extraction and the vast agricultural trade. However, water use, consumption, and distribution had no measurements or balance sheets. The biophysical conception of water as a complex, adaptive, and integrated process in the hydrological cycle (actually a socio-natural cycle) was ignored due to a mechanistic and materialistic scientific understanding, according to which bodies of water were simply inexhaustible liquid reservoirs, "there" and ready to be extracted, contained, stored, distributed, and then displaced by large hydraulic infrastructure, without limit and without manifesting some systemic reaction through its socio-ecological imbalance (San Miguel de Pablos 2010: 93); thus modernity "denatured" the living and creative essence of nature (Leff 2003: 125–145) as an effect of the Anthropocene.

Water was then reduced to being a resource, a concept that persists to this day in mainstream scientific and technical narratives of the Mexican-Central American region: water is still understood as a "hydrological resource." The difference is that, at the end of the nineteenth century, this supposedly inexhaustible resource finally began to be measured by its volume and, during the twentieth century, to be categorized for its quality and impact on public policy decisions. With the arrival of the various ecological crises and the manifestation of climate change, this modern and anthropocenic perspective is developing a new approach that places nature and water in an active, central, and no longer marginal place in relation to the human project. The power of nature has manifested as a new destructive and reconstructive force that confronts social activity (San Miguel de Pablos 2010: 212; López and Preciado 2018: 197–223). This power is characterized by its ability to impact and stop the dynamics of relentless capitalist accumulation; it is a power without conscience but with consequences for humanity.

This change of narrative that places nature in a more active role and problematizes the conception of water as a resource has manifested in different groups of scientists, both globally and regionally. In his July 2023 Thematic Report entitled "Water as an argument for peace, twinning and cooperation," the UN Special Rapporteur for Human Rights to Drinking Water and Sanitation, Pedro Arrojo Agudo, states: "Many water conflicts stem from the perception of water as an economic resource to be managed under the paradigm of human dominance over nature. This perspective regards water as a divisible and controllable asset, which, unfortunately, fosters competition and disputes over its management and utilization, including alterations to the flow regime" (Arrojo 2023). The rapporteur comments that many of the water conflicts start from understanding water as a resource and this view underpins the anthropocentric dominance of nature.

In Mexico, the Consejo Nacional de Humanidades, Ciencia y Tecnología (Conahcyt, National Council for the Humanities Science and Technology) through its Programa Estratégico Nacional sobre gestión del agua (Pronaces agua, National Strategic Program on Water Management) has expanded its focus on national water problems, placing the socio-natural water cycle as a unit of analysis in clear contrast to the technical-commercial visions of water as a resource: "The water problem has a real or potential impact in its socionatural cycle that requires a solution, that is, a new state of water affairs defined by a social subject under ethical, epistemic, and practical standards and criteria" (García y Mozka 2022: 20).

These conceptual changes, however, are still framed in the logic of the Mexican-Central American Anthropocene, which maintains the region to the present day as a capitalist periphery, playing this role of supplier of nature materials and their cheap processing for the central powers that have succeeded each other since the beginning of the Renaissance in the sixteenth century: Spain (Barzun 2001: 195–233) Holland, the United Kingdom, and the United States (Attali 1992: 20). And now the world is in the midst of a power struggle between China, Russia, and the United States/Western Europe to establish who will occupy the center of the capitalist world-system; the dispute is over the oligopolistic control of materials for the production of high-tech computing (artificial intelligence and the Internet of Things) and biotechnology (genetic manipulation of living beings), which are the products of key capitalist accumulation and will define who will be the next center of the system; global high-tech firms also participate in this dispute in alliance-discord with these nation-states, all this amid the appearance of climate change.

Although Mexico is currently considered as part of the rising industrial-technological middle powers with some capacity to be part of the semi-periphery of the system (countries that are exploited but also exploitative, with better economic possibilities to participate in global capitalism); Central America remains only a supplier of peripheral raw materials, although geopolitically linked to U.S. and Mexican dynamics. The type of regional water management is key in all its semi-peripheral and peripheral activity. In the region, the impact of climate change has begun to challenge the dynamics of the Anthropocene and also the conception of water as an inexhaustible resource as the precise result of this peripheral role that depends on the better management of the goods offered by nature with which it participates in the world-system.

General Characteristics of Water Management in Mexico and Central America: Similarities and Contrasts to Understand the Region

The countries that make up the Mexican-Central American region share a characteristic in their geopolitics of water: a significant number of their large urban settlements, as well as many of their industrial corridors and territories for agriculture, livestock, and mining, are located within their continental mass and connected to surface bodies of freshwater (lakes and rivers), away from the coasts (except major cities such as Panama) as to be able to introduce seawater desalination systems. This condition creates an urgency for them to improve the management of surface freshwater, both in quantity and quality, as a condition for the future. There is no other option for supply, use, consumption, and distribution but "to make peace" with rivers, lakes, lagoons, and underground water flows (Ochoa and Bürkner 2012: 10).

The evolution of the institutions for the administration of water has been determined by synchronous historical processes due to the great influence that Mexico has exerted on Central American history, as the conquest of the region – carried out by Hernán Cortez's captain Pedro de Alvarado – originated from there after the arrival of the Spanish. During colonial rule, the Captaincy General of Guatemala – which belonged to New Spain (Mexico) – encompassed much of what is known today as Central America; only Panama was part of the Viceroyalty of New Granada (Colombia). The independence processes of Mexico and Central America coincided; the influence of struggles between liberals vs. conservatives and the establishment of the modern nation-state share regional characteristics. Likewise, the implementation of the system of relentless capitalist accumulation, the advent of the welfare state, populism, authoritarian regimes, the context of the Cold War, the fall of the Socialist Bloc, democratization, and the advent and questioning of neoliberalism are common processes.

At each of these stages, water management took similar forms, such as the role major hydraulic engineering has played in the region, particularly aimed at prioritizing water supply by focusing on the quantity of water offered, forgetting the control of its demand, its quality, its equitable distribution, and the regulation between urban, industrial, agricultural, and environmental uses. From this perspective of supply, the construction of large dams has been the symbol of capitalist development in this peripheral area of the modern capitalist world-system (unlike Brazil, for example, where the command has been through sanitary engineering), replacing the efficient management of lakes, rivers, and their ecosystems.

Around the generation of knowledge about the historical evolution and current forms of water management in the region, there are important differences between Mexico and Central America, which have a particular impact on the management of their lakes. In Mexico, institutions that centralize public information and decisions on water have been consolidated. In this sense, the current Comisión Nacional del Agua (Conagua, National Water Commission) is one of the greatest examples of the centralization of water policy in Latin America and maintains control of what happens in the lakes that are considered the nation's waters. The Instituto Mexicano de Tecnología del Agua (IMTA, Mexican Institute of Water Technology) has been merged with Conagua. There are also a variety of academic groups, research centers, non-governmental organizations, and even environmental stakeholder groups constantly producing both social and technological knowledge around a national vision of what happens to water. The Programa Nacional Estratégico "Conocimiento y Gestión en Cuencas del Ciclo Socio-Natural del Agua para El Bien Común y la Justicia Ambiental" (Knowledge and Management in Watersheds of the Socio-Natural Water Cycle for the Common Good and Environmental Justice), part of Pronaces Agua of the Conahcyt in Mexico and created in 2020, is representative of public government institutions that generate national knowledge. The water administration in Mexico has designed a national structure with regional watershed systems, state commissions, and municipal operating agencies that act with an important level of coordination.

In contrast, in Central America, the picture is very limited with regard to the generation of their own knowledge (Bogantes 2022). For some three decades now, research on water in the isthmus has been left to international bodies and organizations, some progressive in nature, such as the Heinrich Böll Stiftung and others with a tendency to privatize public services and a vision of human rights to neoliberal water, such as the Global Water Partner Central America (GWPCAM) and the Inter-American Development Bank (IDB). Information from governments, universities, and research centers on water in Central America, particularly its lakes, is still very poor, with some important national exceptions such as the Centro para la Investigación en Recursos Acuáticos de Nicaragua (CIRA/UAN) and the Centro de Estudios Atitlán at the Universidad del Valle de Guatemala. However, there is no interuniversity network for studying water management in the isthmus. However, the emergence in Costa Rica in 1998 of the Tribunal Centroamericano del Agua (TCA), transformed in 2006 into the Tribunal Latinoamericano del Agua (TLA), a non-governmental organization that is part of a tradition of non-binding ethical tribunals, for more than twenty years has tried cases of water injustices and violations of the human right to water and sanitation in Latin America, as well as of impacts on the ecological systems of the subcontinent. The court also has a scientific and technical committee that has generated one of the few reliable data banks of what happens to water in Central America as a region. Additionally, the Waterlat-Gobacit network for water policy studies in Latin America has contributed to the production of knowledge on Central American water problems. Despite these important social and academic organizations, much remains to be done to understand water dynamics in the isthmus.

From the point of view of local water management in Mexico and Central America, municipalities have generally taken responsibility for providing drinking water, sewage, and sanitation of contaminated water. However, they face constant organizational and financial constraints that put these municipal services at serious risk, making them easy prey to privatization in the absence of sufficient public resources, an "absence" that is often fabricated and not real. Other forms of community water management in the region include Comités Locales de Agua in Mexico; Comités de Agua Potable in Guatemala; Juntas y Comités Administradores de Acueductos Rurales (Rural Aqueduct Management Boards and Committees) in El Salvador; Juntas Administrativas de Agua (JAA, Administrative Water Boards) in Honduras; Comités de Agua Potable y Saneamiento (CAPS, Drinking Water and Sanitation Committees) in Nicaragua; Asociaciones Administradoras de los Sistemas de Acueductos Comunales y Alcantarillados Comunales (ASADAS, Community Aqueduct and Sewerage Systems Management Associations) in Costa Rica; Juntas Administradoras de Acueductos Rurales (JAAR, Rural Aqueduct Management Boards) in Panama. Unidades de Riego (Irrigation Units) and Distritos de Riego (Irrigation Districts) in Mexico could be included, but they play a management role for the centralized structure, with a certain degree of local autonomy on the part of the irrigation users. It is estimated that in Central America there are more than forty thousand such forms of community water management, constituted of neighborhood and peasant associations, including local administrations of rural and peri-urban waters (TCA 2005). In total, they supply more than 15 million people, over 37 percent of the population of Central America, with water (Global Water Partnership [GWP] 2011). These community forms of management are often in tension with national public institutions as they defend their own autonomy.

The Central American Isthmus, in particular, is crossed by various transboundary rivers between its countries, which makes "sovereign" administration especially complex since these surface basins do not recognize the administrative divisions of modern nation-states. Thus, the "upstream and downstream" dynamics of transboundary rivers present a challenge for geopolitical and geostrategic collaboration in Central America. All Central American countries share at least one basin with a neighboring nation, with twenty-three shared basins in the area that spans from Guatemala to Panama (GWP 2011).

Throughout the territory of the Mexican-Central American region, there is a great lack of knowledge of how groundwater flows function and, specifically, how this water contributes to the life of lakes. It seems that groundwater has been as important or even more so than surface water. Still, it is clear that water management institutions do not have enough public data to explain the significant role that groundwater has played in Mexico and Central America. "Gravity flows of groundwater" are unknown (Kachadourian and Carrillo 2015: 180), and in Mexico, subsurface water is served under the logic of "aquifers," which represent a succession of "closed" receptacles, independent of each other as if the subsurface were divided into perfectly delimited "vessels" and not into general water flows. The form groundwater acquires in the Mexican-Central American Anthropocene is deeply unknown, and its theoretical models are under debate.

It is not far-fetched to think that Central America, because of the great abundance of water it possesses, will soon become a direct supplier of this natural element from the periphery to the disputed center, especially to supply dry territories in the United States, including through water futures listed on world stock exchanges. For example, in December 2020, the New York Stock Exchange opened its futures market for speculative trading on water by making it a "financial product" offered in the futures market. What is sold in principle is not water as such but certificates or rights that give concessions for water use to individuals (López 2021). Selling water rights involves selling the ecological function of subsoil territories that serve as significant reserves for groundwater flows and selling the channels and surface water bodies of rivers, lakes, lagoons, and wetlands; it also means selling the rainfall that occurs in the different regional climates of the planet, as well as selling the atmospheric water that through its condensation precipitates back into the Earth. Already by the beginning of the first decade of the twenty-first century, researchers Maude Barlow and Tony Clarke had spoken of the emergence of "water hunters" to describe a new caste of entrepreneurs who "mine the planet for freshwater sources to put on sale in the boutique markets of Paris and New York" (Barlow and Clarke 2004: 154).

The Desiccation of Lake Chapala and the Vast Drainage Systems of Mexico City

One of the main logics of historical water management in Mexico has been the desiccation of its lakes. This situation started during colonial rule and continues today. This long-term historical trend involves intensive intervention with modern water displacement technologies. Extensive historical studies on desiccation and resultant contemporary actions testify to this:

> [the lakes] were located at the bottom of the water hierarchy for the Spaniards [...] for them the best waters were facing east, they were located in the mountains, they were cold in the summer and hot in the winter and they were clear, sweet and light [...] the worst water was that of the lakes and lagoons, because they were thick, bilious and phlegmatic [...] hot and smelly in summer and riotous and cold in winter [...] so begins a long history that's main objective is to justify policies of drainage and disappearance of the lakes. (Tortolero 2000: 34)

And:

> We had to suppress the water that the conquerors were unable to understand or master. Thus, the canals [pre-Hispanic built in ancient Tenochtitlan] were converted into drains and the water of the lakes into garbage dumps [...] The new European empires continued the Spanish dream of draining the Valley of Mexico. In 1865, Maximilian of Habsburg authorized the start of the construction [...] the work done to displace all this water from the basin is known as the Gran Canal del Desagüe [Great Drainage Canal] and the first tunnel of Tequixquiac, completed in 1895 and inaugurated by President Porfirio Díaz [in 1900]. (Legorreta 2006a: 25–42).

This trend towards desiccation was forcefully maintained during the first half of the twentieth century, the most important examples of which were the activities and attempts to dry up much of Lake Chapala (the largest in Mexico, located between Jalisco and Michoacán, with a current total area of 1,146.59 km^2, equivalent to 114,659 hectares, and a storage capacity of up to 8,000 mm^3). Today, 60 percent of the greater Metropolitan Area of Guadalajara (MAG) (Comisión Estatal del Agua Jalisco n.d.), capital of the state of Jalisco and the country's second largest city in population, relies on this body of water for its supply needs.

In 1906, with the consent of then-President Porfirio Díaz in Mexico, a great step was taken toward the desiccation of Lake Chapala to extend the agricultural lands: in that year, the so-called La Palma-Maltaraña *bordo* (a structure built to contain water and prevent flooding) was built and resulted in the desiccation of one-third of the lake's original surface, creating the present day *ciénega* (wetland system) of the

Mexican states of Jalisco and Michoacán; the project was initiated by the Jaliscan governor Manuel Cuesta Gallardo who, later, "was able to incorporate to his lands not less than 54,000 hectares [...] of good quality alluvium" (Helbig 2003: 40; Boehm 2002: 95). The number of hectares that were dried at this time constitute today approximately 20 percent of the area of MAG. Therefore, the previously described size of Lake Chapala corresponds to what remained after this significant process of desiccation. The *bordo* was an important technical manifestation of the vision that the modern Anthropocene has on water, with the artificial creation of an irrigation area in Mexico that lasted until 1937 with the construction of drains and pumps (Rangel 2005: 334).

The most recent attempts to dry parts of Lake Chapala have been as follows: in 1953, 18,000 hectares were to be dried out between the island of Petatán (now dry) and the town El Fuerte, but this new levee was curbed due to the decline in the level of the lake and social pressure (Helbig 2003: 43; Boehm 2002: 98). In 1994, then-Governor of the State of Jalisco, Alberto Cárdenas Jiménez, attempted to set aside 38,900 hectares for such projects, and during the period of Mexican President Vicente Fox Quezada (2000–2006), intentions remained to continue its desiccation (Villagómez 2016: 16). None of these actions were realized, but they show, among others, the centuries-old trend of drying up lakes in favor of agriculture. In western Mexico, the drying of Lake Chapala has aimed to improve the efficiency of irrigation areas to supply agricultural products, mainly for the capitalist international market with vegetables, berries, and flowers. Other areas of Mexico, mainly those semi-arid, are part of this same logic of artificially forming agricultural swamps by desiccating large bodies of surface water (rivers, lakes, and lagoons).

The trend towards lake desiccation has also remained present due to the construction of large drainage spillways and networks connected to and built in different lake cities in Mexico. Among the most important hydraulic works of this type have been those carried out for Mexico City, one of the largest urbanizations in the world, which continues to have problems of flooding in rainy seasons accompanied, paradoxically, by land subsidence in the city due to being seated on a lakebed: "During the twentieth century, the city sank ten meters; today, the historic center yields 2.5 centimeters a year. Paving, which covers the land without water, is becoming more widespread and has prevented natural recharges and seepage from rain" (Legorreta 2006b: 316).

By the first decade of the twenty-first century Mexico City (pre-colonial heir to the ancient Mexica capital of Great Tenochtitlan, located on the lakes of Texcoco and Mexico) was the most sophisticated technical system of general drainage of a lake city in Latin America and had "the largest spillway in the world built for a city" (Legorreta 2006b: 317) with three major subsystems: the first consisting of closed tunnels – the most important called Tequixquiac – open collectors such as the Gran Canal and the Canal Nacional, as well as more than thirty dams and twelve storage tanks and lagoons to store and then discharge rainwater; the second subsystem formed by deep drains with a discharge capacity of 220 m^3 per second; and the third formed by treatment plants that were destined for green areas and (re)filling lakes (Romero 2002: 260).

But only what Legorreta analyzed about the drainage of Mexico City reveals the long historical continuity that the Anthropocene has had in Mexico, as by 2006, they had:

> 135 kilometers of underground tunnels between 4.5 meters in diameter running underneath the city and leading water to a tunnel called the central emitter, 6.5 meters in diameter and built at a depth of 240 meters. Such a drain inherits Spanish intentions to continue displacing water from the Mexico basin through major engineering works since only 20 percent is black or residual water and the remaining 80 percent is unused rainwater. (Legorreta 2006b: 317)

The most important drainage project in Mexico City in recent times has been the construction of the *Túnel Emisor Oriente* (East Emitter Tunnel) (which is a large tube of 7.5 meters in diameter located at a depth of 200 meters that is 60 kilometers long and ends in the State of Hidalgo, Mexico) (Diversidad Ambiental 2014). Construction began in 2008 and concluded in 2019. With its completion, it became the "largest deep drainage project in the world." (Alavez 2020). The Túnel Emisor Oriente, together with the works begun for the new Mexico City International Airport, which would have been built on part of Lake Texcoco (now canceled and replaced by Felipe Ángeles Airport) concentrated 73 percent of the federal expenditure budget for the hydraulic sector in 2018 (Mestre 2018: 10). This is only to maintain that the desiccation of lakes in Mexico has been a hydraulic policy transversal to the regional Anthropocene.

In one way or another, many of the primary lakes in Mexico – Cuitzeo and Pátzcuaro (in Michoacán), Yuriria (in Guanajuato), Tequesquitengo (in Morelos), and Nabor Carrillo (in the State of Mexico) – have suffered the pressure of historically colonial desiccation policies to create irrigated *ciénegas* for agriculture but the limited space of this chapter does not allow for deeper discussion on this topic.

Dynamics at Lake Cocibolca

Meanwhile, Lake Nicaragua in Central America, also called Lake Cocibolca, has an area of 8,144 km^2 (Salvatierra Suárez 2007: 151) (7 times larger than Lake Chapala in Mexico). It was named by the Spanish "*El Mar dulce*" (The Sweet Sea) and is the only lake in Latin America to possess freshwater sharks. Perhaps because of the abundant rain that makes up its climatic and biophysical space, which are enough to maintain the lands dedicated to agriculture, it has not come under historical pressure from desiccation policies. Lake Cocibolca belongs to an extensive watershed, the largest in Central America, which encompasses, from upstream to downstream, Lake Managua or Xolotlán, Lake Nicaragua itself, and, finally, the extensive current of the San Juan, a transboundary river that originates in Nicaragua and extends to Costa Rica (GWP 2016: 32). The average annual rainfall in this geographical and climatic area is between 4,000 and 6,000 mm in a period of between six and nine months in the wetter regions and 1,000 and 2,000 mm in the drier areas, whose rainy season lasts about seven months a year (GWP 2016: 33).

To understand the super abundance of rain in this basin it must be noted that one millimeter of rain is equivalent to one liter of water over an area of one square meter. In this Central American basin, between 4,000 and 6,000 liters of water per square meter fall during a six-to-nine-month period (out of twelve months of the year) in its humid regions. And between 1,000 and 2,000 liters of water per square meter in its "dry" areas. According to the World Meteorological Organization (WMO), less than 200 mm are insufficient rainfall; 200 to 500 mm are low rainfall; 500 to 1,000 mm are sufficient; 1,000 to 2,000 mm are abundant; and finally, more than 2,000 mm are excessive (Gleason 2014: 62). Thus, in Lake Nicaragua, rainfall is excessive even in the regions classified as "dry." This phenomenon is prevalent in many other areas of Central America, as estimates state that less than 8 percent of the total water supply is used in Central America, which amounts to about 723,072 million cubic meters (GWP 2011).

For contrast and comparison, Guadalajara (with a population of more than 4.5 million inhabitants) (Instituto de Información Estadísitica y Geográfica de Jalisco [IIEG] 2021) receives in approximately four months only about 900 liters of rainwater per square meter each year (which are sufficient rains in the best scenario), which precipitate over the entire surface of the city and Lake Chapala. In contrast, any locality in the basin near Lake Nicaragua receives more than 4,000 liters of rainwater per square meter (which is excessive rainfall in the worst-case scenario). The capital of Nicaragua, Managua, only holds 1.5 million inhabitants (Embajada de México en Reino Unido n.d.) but receives almost seven times more precipitation than Guadalajara in Mexico. The abundance of rain may then be an explanation for the reasons why many Central American lakes have not tended to dry up.

However, there have been some proposals regarding desiccation of Nicaraguan lakes. In 1983, Juan Sanz Sanz, a Spanish autodidact considered by many to be a genius, proposed the partial emptying of Lake Cocibolca and the total desiccation of Lake Xolotlán (Managua) to Nicaragua to allocate these new lands to crops that could bring the country out of the economic crisis:

> What this study proposes is to partially empty Nicaragua's lakes, lowering their level to sea level by opening a simple gap in the isthmus that separates the greater

> lake from the Pacific Ocean. Thus, most of the land at the bottom of these lakes, whose current level is several dozen meters above the sea, would be exposed and could be placed under cultivation. The tracts of lakes and swamps that this simple procedure could cultivate would total about 10,000 square kilometers or one million hectares. For a country whose arable land does not exceed 7,000 square kilometers – a figure from some years ago – it would be a considerable addition to its livelihoods. These million hectares of easy colonization, presumably fertile, of intensive use, would not only would solve the problem of the lack of food that the country suffers today [*1983], but would also create a surplus for them, the sale of which could be the economic basis of the future Nicaraguan State. (Sanz Sanz 2019)

As Lake Nicaragua has not yet been impacted by desiccation, it could become part of a transboundary strategy to solve problems of regional water scarcity elsewhere in Central America. Such was proposed by Salvador Montenegro, Director of the Center for Research in Aquatic Resources of Nicaragua of the Autonomous University of Nicaragua (CIRA/UAN), in June 2005 during the workshop "Derecho humano al agua en la agenda política centroamericana" (Human Right to Water in the Central American Political Agenda) organized by the TCA (now TLA):

> In Nicaragua, we can only have a surplus of 500 m^3 [of water] per second by draining the Great Lake. Across the country, our 5.5 million inhabitants need just 4m^3/second. That is, the surplus of water is simply huge. El Salvador, very close, less than 300 km away, has a high Gross Domestic Product, several times higher than Nicaragua, and a huge need for water, as the surface sources are contaminated and those underground are overused. The water demand of the Salvadoran people, now and in the future, is very great and has the capacity to pay. Nicaragua should use its water resources more sensibly than it does, and this includes demand for water from the neighborhood. I am not afraid to use [divert] a very small part of that surplus water via a very simple aqueduct that goes over the coast at zero meters high. The only difficulty is overcoming the Gulf of Fonseca, and that can be achieved with a few detonations. That should serve the Salvadoran people not only to solve their pressing problem but also to give them resources because it is not free. Landowners in the Lake Cocibolca basin should be funded so that forests and soils can be protected and good quality water delivered. This would be an excellent arrangement between good neighbors. (TCA 2005: 19)

Other Central American lakes that share sufficient, abundant, and excessive rainfall regimes include Atitlán, Amatitlán, Izabal, and Petén Itzá in Guatemala; Guija, Ilopango, Suchitlán, and Coatepeque in El Salvador; Lake Yojoa in Honduras; Cachí, Cote, and Arenal in Costa Rica; Alhajuela and Gatún in Panama. Belize has no lakes, only lagoons on its maritime shores.

Contaminated Lakes

The main characteristic common to Mexico-Central America lakes is pollution. This is a transversal trend and the main common impact of the Anthropocene in the region. Unlike rivers, whose waters are dynamic or "lotic," lakes possess "lentic" waters: "the term lentic connotes the unique ecological properties of a body of still waters, while the term lentic connotes ecological properties that characterize moving water systems" (RCSE and ILEC 2014: 3). Due to their lentic waters, lakes are more likely to contain pollution problems in slow processes (ILEC-UNEP 2004: 3–8).

Water quality in lakes can be affected by a variety of pollutants that are retained in the lake bottom, generating eutrophication processes (i.e., the process of contamination of lakes, rivers, and reservoirs caused by excess nutrients in the water, mainly nitrogen and phosphorus, from human activity) and an accumulation of agricultural pesticides more permanently than in rivers:

> Excessive nutrient intakes can stimulate the growth of toxic blue-green algae species that harm the health of both farm animals and humans [...] Water and sediment contamination of toxic and dangerous substances can originate from many sources. Of greatest concern to human and ecosystemic health are certain heavy metals (e.g., mercury, arsenic, cadmium, lead, chromium) and persistent organic pollutants (e.g., dioxins, polychlorinated biphenyl (PCBs), and pesticides such as DDT). These pollutants are of particular concern due to their long life, as well as their ability to accumulate in lake sediment and human, aquatic, and terrestrial organisms. Many of these are believed to cause birth defects, tumors, and cancer in humans, as well as in flora and fauna. Chemicals that mimic natural hormones ("endocrine disruptors") and pharmaceutical and medicinal residues, with potentially adverse effects on human health and reproduction, are also being detected in lakes more frequently (ILEC-UNEP 2004: 8–9).

Using official data from Conagua in Mexico, the Instituto Tecnológico y de Estudios Superiores de Occidente (ITESO, Institute of Technology and Higher Studies of the West, Jesuit University of Guadalajara) carried out a technical study in 2018 called "Reporte de Análisis de datos de Calidad del Agua del Lago de Chapala" (Analysis Report on Water Quality Data from Lake Chapala), which was part of the evidence for the case "Posible violación del derecho humano al agua, al saneamiento y a un medio ambiente sano, en la ribera de Chapala, Jalisco, México" (Possible violation of the human right to water, sanitation and a healthy environment, on the banks of Chapala, Jalisco, Mexico) that was presented before the twelfth hearing of the TLA held in Guadalajara. In this report, based on information from monitoring stations located within Lake Chapala, ITESO notes important concentrations of pollution:

> stations located in the northeastern part of the lake have been shown to have high average concentrations for the parameters Fecal Coliforms, *E-Coli*, Arsenic, Chromium, Organic Nitrogen, Chemical Oxygen Demand (COD), and Total Nitrogen; stations located in the southeastern part of the lake were found to have high averages for Fecal Coliforms, Mercury, Nitrogen in the form of Ammoniacal Nitrogen, Nitrates and Nitrites, Chromium, and Total Suspended Solids; stations located in the western part in general had high average concentrations for the parameters Arsenic, Fecal Coliforms and *E-Coli*, Biochemical Oxygen Demand (BOD), and Chromium; for the northern part of the lake, monitoring stations had high concentrations of BOD, COD, and Lead, while monitoring stations in the southern part identified Fecal Coliforms, *E-Coli*, Chromium, and Phosphorus. (Sanchez et al. 2018: 91)

Lake Nicaragua and its basin also present pollution problems that have scarcely been researched (GWP 2016: 34), although they are still minor compared to what has happened in Chapala:

> Lake Xolotlán has so far been Managua's dumping ground and cesspool, and its waters have run over into Cocibolca twice in the last decades of the last century, bringing with it pollution. The engineer Norwin Estrada told La Prensa that the worst enemy of Xolotlán is the tons of lead deposited by a pesticide factory. "Lead is poisonous and will deposit at the bottom of the lake where it can be ingested by fish and passed to the population in their contaminated meat. It is known to be deposited at the bottom of Miraflores Bay, which means that it has not yet been transferred to Cocibolca but continues to poison the population that relies on the Xolotlán's fishery," said the expert. Although, to a lesser extent, the same is happening in Cocibolca; most of the surrounding populations pour their sewage and waste into the lake. Moreover, clothes are washed in its waters and the inhabitants of the humblest neighborhoods use it for their everyday needs and as a bathroom. Solid waste covers the basin. Though not all of this is organic, as plastics, metals, glass, and other waste will remain unchanged, hindering the natural processes of the Great Lake. The use of fertilizers in extensive livestock farming and of agrochemicals in crops such as rice also leave their mark on water quality. And yet it still has great potential as a source of drinking water. Some 200,000 people consume water from Cocibolca, and it is estimated that it could supply the entire country at its current level for fifty-five and a half years. (Fuente 2015)

In aggregate terms, despite the historical differences in their management (Chapala with a tendency toward desiccation and Lake Nicaragua with its overabundance of rain), a unified conception of proper lake management is advancing worldwide, entailing a comprehensive vision of what should happen is these robust regional lake bodies in the rest of the twenty-first century. This contrasts with the vision of the modern capitalist Anthropocene, exemplified in what has happened to the lakebed of Mexico City, and points to another form of anthropocenic management that recognizes nature as an ecosystem factor, participating actively in the human project as more than just a bank of water "resources."

Conclusions: Climate Change and Sustainable Lake Management

Technical Paper VI of the Intergovernmental Panel on Climate Change (IPCC), entitled "Climate Change and Water" on the world's freshwater, provides scientific findings and policy conclusions on the current management crisis. Considering that "observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems" (Bates et al. 2008), the IPCC scientists draw, among others the following conclusions I briefly summarize here:

- Current water management practices may not be robust enough to counter the effects of climate change on water supply reliability, flood risk, health, agriculture, energy, or aquatic ecosystems.
- Water resources management clearly affects many other policy areas, for example, energy, health, food security, or nature conservation. Therefore, adaptation and mitigation measures must involve multiple sectors that depend on water.
- Climate change challenges the traditional hypothesis that past hydrological experience is an appropriate background for future conditions. The consequences of climate change may alter the reliability of existing water management systems and water-related infrastructure.
- Climate change affects the role and use of existing water infrastructures – in particular, hydropower, structural flood protections, drainage, and irrigation systems – as well as water management practices.
- Knowledge and modeling of climate change in relation to the hydrological cycle at scales useful for decision-making need to be improved. Information on climate change's impact on water is inadequate, especially with regard to water quality, aquatic ecosystems, and groundwater, particularly in its socioeconomic dimensions (Bates et al. 2008: 3–4).

That is, climate change calls for a complete paradigm shift in the world's freshwater management within the Anthropocene, in which previous experience, installed infrastructure, and previous knowledge do not guarantee an adequate capacity to adapt to the new challenges that entail, among other things, global warming. In the context of these scientific warnings, the United Nations (UN), through the Assembly of the United Nations Environment Programme (UNEP), adopted the "Resolution on the Sustainable Management of Lakes" in 2022, which offers a global perspective capable of illustrating proper lake management for the region of Mexico and Central America.

As part of the resolution, it calls upon "all Member States and members of specialized agencies and invites relevant international organizations [...] to develop international networking and collaboration for integrated sustainable and climate-resilient lake management and regularly exchange data and information between States that share a transboundary lake, as provided for in international agreements" and "to facilitate collaboration among Member States and members of specialized agencies in research, capacity-building and the sharing of knowledge, information and best practices, including through North-South, South-South and triangular cooperation" (UN 2022: 2–3).

In this regard, the management of the region's lakes faces several challenges. The first is to establish a new way of understanding the role lakes play in supplying water to the city and the countryside, breaking the linear causal relationship according to which *the water supply for the city and the countryside depends on the amount of water in a lake*. It is necessary to add cyclical and recursive complexity to this linear vision, complementing it with the contingent fact that *the amount of water also depends on the type of water supply with which the city and the countryside pressure the lake*. In other words, while the water supply depends on the lake, the lake depends on the type of supply it is required to provide. A lake must be assembled and managed in a co-responsible, co-evolving systemic relationship, in a sustainable pact between society and nature.

A second challenge is considering lakes as users or consumers, needing a certain amount of water to be living lakes. Just as distribution rules are established for users in human activities, whether agricultural, urban, or industrial, lakes also need water. Understanding the ecological flows for a lake to live in is a scientific, political, and administrative challenge of the utmost importance in the region. It is not simply a question of allocating volumes but of understanding the slow pace at which the lake in question flows: its relationship to regimes of rainfall and baseflow (the minimum water level during the drought season), i.e., how much water does a lake need to contain during the various seasons? And what of the relationship with the biophysical ecosystems on which it depends and which it maintains its functioning, including the dynamics with its flora and fauna and with the composition of its soil and beds, as well as the relationship with the gravity flows of its groundwater.

A third challenge is to have a responsible impact on the climate of lakes. This involves learning to manage evaporation (evapotranspiration, more properly) and humidity, i.e., water vapor produced by lakes and not only its liquid state. If the lakes are seen as reservoirs only of water in a liquid state, their capacity to produce moisture is left out of their management. Thus, the lake's integral relationship to the socio-natural cycle is fragmented. Finally, there is the challenge of sanitation to guarantee the quality of water for human consumption and other living things through the installation of suitable treatment systems for both biological contaminants and heavy metals, as well as those compounds that arise from the chemical relationships that develop when contaminants are combined within the lake itself.

These challenges signal the way forward for lake management in the Mexican-Central American region, where the idea that water is a resource is transformed by the recognition that water is a process integrating human and ecosystemic dynamics into a single socio-natural cycle. It goes beyond the conceptions of the Anthropocene that emerged from global capitalist modernity. This new vision represents a condition of the future.

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Water in the Caribbean from 1950 to the Present

A Paradigm Shift towards Integrated Water Resources Management

Paulette Bynoe and Jewel Liddell

Water underpins all life-forms and influences natural, social, and economic systems. It is the fundamental link between human society, the climate system, and the environment (CARDI 2012). This vital but finite resource is central to sustainable human development as demonstrated by the interconnectedness of the United Nation's seventeen Sustainable Development Goals (United Nations n.d.).

Over the past few decades, there has been increasing concern about global water security and a growing recognition and acceptance of the urgent need for a paradigm shift in the current approach to water management, given the increasing and competing demands placed on water by agriculture, tourism, as well as the existential threats posed by climate change and climate variability. The Intergovernmental Panel on Climate Change (2007) has predicted drier days and more intense single precipitation events; moreover, a rapid decrease in precipitation would directly impact river flows, resulting in basin-scale shifts from regulated to unregulated. Undoubtedly, the growing competition for water among different users, in terms of quantity and quality, can only be resolved by reconciling diverse interests through an integrated management system.

In the Caribbean, the typical problems and critical situations arising from the Anthropocene as the current global crisis acquire particular characteristics related to the variability in water availability and access in each of the different countries that make up the region. From the second half of the twentieth century to the present day, in the global period of the "Great Acceleration," the increase of anthropogenic interventions, whether in infrastructure or the management or spreading of pollution, together with the increasing demand for water from agriculture, industrial production, and tourism, has given way to transformation and imbalances that suggest challenges for a possible paradigm shift in the relationship between society and water in the region. All of this impacts the feasibility of an integrated management system, which would guarantee the availability of sufficient, high-quality water for various sectors of the population within Caribbean nations.

This chapter discusses water resource endowment, traditional approaches to water resource management and the need for a more integrated approach, challenges to a paradigm shift, and a way forward to build a resilient water sector in the Caribbean region.

Water Resources in the Caribbean: Critical Issues

The primary source of freshwater in the Caribbean is rainfall (except for the Bahamas and Antigua and Barbuda), which provides the three basic water types: direct rain, groundwater, and surface water (ICS 2002). Researchers have divided the Caribbean into six zones based on similar climates, weather patterns, humidity, etc. Rainfall during the wet season accounts for approximately 70 percent of each zone's total precipitation. Generally, in the Caribbean, the distribution and availability of water resources are highly variable. The region includes some of the world's most water-scarce countries, such as Barbados and the Bahamas, with Barbados ranked as the fifteenth most water-scarce nation globally (United Nations Environment Programme [UNEP] 2012). Conversely, neighboring countries like Guyana, Suriname, and Belize have abundant freshwater resources (Global Water Partnership [GWP] 2014). These disparities arise from the Caribbean's diverse topography, geology, and climate. For example, Antigua and Barbuda's geographic position and topographic features contribute to its water-scarce status. The low levels of rainfall combined with highly erratic rainfall distribution, high evaporation rates, and porous limestone geology make the islands vulnerable to hydrological drought. Between 70 and 100 percent of Antigua's daily water supply during the wet years and the arid periods, respectively, is obtained from desalinated water. Table 1 provides more information on the islands' water resources.

Rainwater harvesting (RWH) is an ancient method currently utilized to fulfill some of the goals outlined in the United Nations 2030 Agenda for Sustainable Development. It also serves as a resilience device against climate change within the Caribbean and as a supplemental water source (Peters 2016). The adoption rates of rainwater harvesting as a supplemental water source are highlighted in Peters' (2016) article. Participants who were residents of the Eastern Caribbean States were questioned on the success or usage of RWH. It was found that 53 percent of the participants utilized the captured rainwater for domestic purposes, 44 percent for domestic and agricultural purposes, and 3 percent solely for agricultural use (Peters 2016). In a study by Roopnarine and Mycoo (2024), the prevalence of over-extraction of groundwater resources in the Caribbean is driven by population increase, leading to greater demand for domestic use and urbanization (Ekuwe 2010). Cashman (2014) noted that the situation across the region is compounded by high levels of unaccounted-for water, e.g., 67 percent in Jamaica, 40 percent in Trinidad, and 50 percent in Barbados; paradoxically, many of these countries have sufficient water resources to meet demand but not the infrastructure or institutional frameworks to close the supply-demand gap. Undoubtedly, effective policies, legislation, organizational structures, and participatory processes play a vital role in the integrated management of water resources. Further, in Georgetown, "there is a demand for 20 million gallons of water per day, with about 8 million being furnished from surface water sources and 12 million from groundwater" (United Nations Development Programme [UNDP] 2016: 214).

Table 1: Renewable Water Resources in Antigua and Barbuda

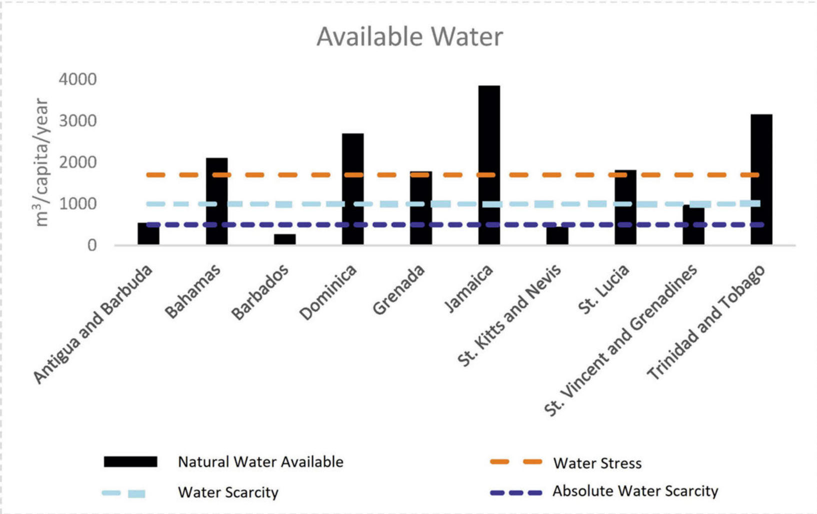
Renewable Water Resources		
Total average annual rainfall	mm/year	1,030
Total average annual rainfall	million m^3/year	453
Total renewable water resources	million m^3/year	52
Total renewable water resources per capita (2013)	m^3/year	571.4
Total dam capacity (2013)	million m^3	6

Source: GWP (2014)

Caribbean countries such as Barbados, the Bahamas, and Jamaica heavily depend on groundwater resources for their water supply. Unsustainable anthropogenic activities such as prolonged extraction, low rainfall within the Caribbean Region, urbanization, etc., have contributed significantly to the depletion of this resource, creating scarcity as seen in Figure 1 (Cashman 2014; Roopnarine and Mycoo 2024).

Rivers, streams, creeks, and other similar natural surface water structures account for only 1 percent of freshwater worldwide. These natural formations depend on precipitation to keep them from drying up. Owing to variations in the geological structures, geomorphology, rock types, and precipitation, countries like Haiti and the Dominican Republic have limited access to groundwater (U.S. Army Corps of Engineers 1999). With areas of low permeability, some regions of land are less ideal than others for groundwater collection, making an already finite source of freshwater even more scarce and forcing the populace to focus on surface water. Despite having sufficient annual precipitation levels to accommodate the population, the region still suffers from water scarcity (UNEP n.d.).

Figure 1: Water Scarcity Based on Available Water in the Caribbean



Source: Mycoo and Roopnarine (2024)

Despite thirty surface water sources, abundant underground aquifers, and sufficient annual rainfall, anthropogenic activities have plagued the countries' water supply (Adamson et al. 2016). Lack of sanitation and proper sewage disposal periodically contaminate groundwater and surface water sources. As of 2020, only some areas of the larger cities, such as Port-Au-Prince, had limited and inefficient drainage networks. Additionally, since no wastewater treatment plant exists, most wastewater enters open rivers and seas (UNEP n.d.).

Freshwater is essential for agriculture and other commercial production systems in the region. Villasol and Beltrán (2004) posit that

> Demand for freshwater has grown rapidly in the region as a result of demographic growth and industrial, agricultural, and tourism expansion. These activities have also polluted existing water supplies. [Thus,] the economic success of the region is highly dependent on freshwater supplies, particularly for agriculture and tourism. (32–33)

Likewise, deforestation has contributed to the region's water scarcity. According to a report by Sustainable Water Partnership, at the beginning of the twentieth century, Haiti had approximately 60 percent forest coverage. As of 2016, it was only 1.5 percent. This has caused heavy soil erosion at approximately 1,319 tons/km^2 annually. Consequently, soil erosion in and around basins has hindered the flow of surface water by causing uneven flows, sedimentation in dams and along the coasts, as well as more frequent floods in cities. One such example is the sedimentation in Lake Péligre, which has reduced the reservoir's storage capacity by 58 percent since 1952, while total sediments in the lake have increased by 7.6 percent. Lake Peligre has seen an increase in turbidity 30 percent higher than the recommended limit to support aquatic life, thus killing many of its inhabitants (Sustainable Water Partnership n.d.).

Although fresh water is a valued resource in the Caribbean, it faces significant environmental challenges that affect its quality. In countries like Guyana and Trinidad and Tobago, industrial and municipal effluents have severely impacted surface water quality, limiting its usability (ICS 2002). In Jamaica, groundwater resources have been compromised by pollutants originating from mining minerals such as bauxite and improper sewage disposal. High nitrate levels have also been recorded within the country's Liguanea aquifer in St. Andrews, making the water unsuitable for human consumption unless treated. In Barbados, groundwater resources have also been polluted, with agricultural sources being a contributing factor (Cashman 2014). In Guyana, surface water must undergo extensive treatment to remove sediment, organic matter, and potential contaminants. Additionally, human activities contribute to contaminating both surface and groundwater sources. Upstream water quality degradation, combined with saltwater intrusion at the coast and local water usage, exacerbates water scarcity in coastal communities across many Caribbean nations (Williams and Thomas 2012). Furthermore, a few studies show saltwater intrusion's impact on groundwater in the Caribbean. However, other studies indicate that domestic demand and urbanization have prompted the increased usage (pumping) of aquifers in densely populated areas below sea level. These aquifers are subjected to saltwater (saline) intrusion, which can increase salinity and deplete the quality of groundwater (Basack et al. 2022).

Variations in water availability, quality, and effective water resource management are common challenges across Caribbean nations. CARDI (2012) has emphasized that global climate change severely impacts the hydrological cycle and water resource management, threatening the Caribbean's progress toward poverty reduction and sustainable development across economic, social, and environmental dimensions. Justifiably, there has been a growing concern about the competition for water (quality and quality) and, importantly, the capacity of Caribbean governments to ensure prudent management and provision of water without jeopardizing economic growth and the maintenance of social well-being (GWP 2014).

An Early Fragmented Approach

The region's history shapes the current water management practices. European colonization, coupled with the growth of urban centers and the demand for water to provide various services, created divergent legislative arrangements in the middle and late nineteenth century (Cashman 2012). Government-owned water utility companies in most Caribbean Islands except Barbados, Jamaica, and Trinidad and Tobago are responsible for water resources. Consequently, the lines of responsibility regarding demand versus supply are blurred. This situation has presented several challenges to managing water in a sustainable manner.

Notwithstanding, Farrell, Nurse, and Moseley (2007) noted that many Caribbean islands lack adequate water resource management. However, increasing concerns about freshwater availability have led to the establishment of policy and institutional frameworks for water conservation. GWP (2014) reported that numerous policy initiatives supporting "integrated water resource management" (IWRM) have emerged at regional and national levels over the past six years.

Some of the significant challenges hindering the implementation of IWRM include interagency/intersectoral collaboration and coordination; a lack of both human and financial resources and updated legislation and a proper implementation structure; overlaps in the responsibilities of government organizations; access to sustainable financing; land use, land use change, and tenure issues; an aging infrastructure network and inadequate storage; vulnerability to the impacts of climate variability and change; and inadequacies in data collection and availability.

A water policy and a revamp of institutional arrangements were identified as priorities for Caribbean countries to address the vulnerability of their aquifers to pollution and seawater intrusion, inadequate wastewater management, water infrastructure, and institutional and regulatory capacities.

Case Study 1: Antigua and Barbuda

Since the development of extensive naval facilities in Antigua during the Napoleonic period, Antigua has had better physical facilities than many neighboring islands. Domestic water shortages such as those of the 1980s have been replaced by an expensive, more reliable water generation system that relies heavily on desalination. Barbuda's infrastructure lags significantly behind that of Antigua but is currently being upgraded. In the Caribbean, water distribution infrastructure built in the nineteenth and early twentieth centuries did not anticipate this growth. This has led to many cases of water stress and scarcity, particularly in Antigua and Barbuda.

The 1945 Watercourses and Waterworks Ordinance placed all ponds, springs, streams, and wells in Antigua (and Barbuda), in principle, under direct government control. Its successor, the 1973 Public Utilities Act, introduced the Antigua Public Utilities Authorities (APUA), which merged with the Electricity, Water and Telephone Department. This gave APUA the right to supply, distribute, maintain, and sell water services in the State of Antigua and Barbuda, among other things. The APUA has legal control over all water resources in the country and is mandated to provide water supplies to meet the country's municipal needs. It is also responsible for water quality testing, hydrological surveys, planning and digging wells, and the construction of dams.

While the APUA has legislative oversight to regulate the use of water sources, the agency does not manage or regulate the disposal of wastewater. Instead, this is managed by the Central Board of Health under the Public Health Act (Cap 353). Additionally, APUA does not handle agricultural water needs. Agriculture is considered a commercial activity, and irrigation generally does not have a special preference for water allocation. The Ministry of Agriculture, Lands, Fisheries and Barbuda Affairs is responsible for technical assistance to farmers on irrigation, drainage, soil, and water conservation.

In 2011, Antigua and Barbuda completed the preparation of an IWRM Policy and Roadmap. The policy document focused on coordination, integration, inclusion, cost reduction, and increasing benefits across stakeholders. As a general policy statement rather than a water sector policy, it focuses on integrating strategies and activities to improve water, wastewater, land management, and disaster preparedness. The IWRM policy was submitted to the government for approval but is not in effect. The draft documents were further revised. The IWRM Road Map envisioned that APUA would not be in charge of water nationally. Instead, there is the need to create a separate department within the government or IWRM infrastructure with representatives that deal with water resources.

No single authority has an explicit mandate for watershed management, and several agencies are involved in watersheds, water harvesting and treatment, and management of the marine and coastal zones. The enactment of the Environmental Management and Protection Act 2015 (EMPA) provides an improved legal status for watersheds, including the establishment of a multi-stakeholder Watershed and Wetland Management Committee and the designation of critical wetlands and watersheds.

Case Study 2: Saint Kitts and Nevis

Unlike other small states in the Caribbean, most of the country's settlements and critical social and economic infrastructure are located within 0.5 km from the coast at "normal" mean high water. The 1956 Water Courses and Water Works Ordinance provides for the establishment of the Water Board with powers to control, manage, maintain, and supervise all watercourses and waterworks and provide an adequate water supply to consumers. Water Service Departments on Saint Kitts and Nevis manage the water resources on the respective islands. departments are responsible for identifying, maintaining, and protecting water supply sources for human consumption. They, however, do not manage or regulate wastewater disposal. Instead, under the 1969 Public Health Act, the Environmental Health Department manages this. The Environmental Health Department is responsible for monitoring the quality of water harnessed for human consumption.

The Department of Agriculture traditionally has been responsible for preserving forests, which protect surface and groundwater resources. In addition, the National Conservation and Environmental Protection Act (NCEPA) 1987 makes provisions for the efficient management of watersheds in Saint Kitts and Nevis, and the Conservation Commission is responsible for enforcing the NCEPA.

A limited number of management systems have been established for pollution control and managing water-related ecosystems. The need for a water policy and a revamp of the institutional arrangements was identified as a priority by the Water Services Departments as a result of a policy and legislative review carried out in 2010. Water resource management focuses on the vulnerability of aquifers on both islands to pollution and seawater intrusion. Other concerns include inadequate wastewater management, water infrastructure, and institutional and regulatory capacities. Under the Global Environment Facility – Integrating Watershed and Coastal Area Management Project, a strategic plan for the Water Resources Management Agency was developed, which emerged from developing a national water policy. However, there is little progress in implementing the provisions.

The Organisation of Eastern Caribbean States (OECS) drafted a Mode Water Policy and Legislation in 2013, which would have some bearing on the IWRM policy of Saint Kitts and Nevis as a member of the OECS. Nevis also adopted a Strategic Framework for Water Resources Management in 2016. This framework and the White Paper on Governance and Climate Resilience in the Water Sector in the Caribbean provide detailed recommendations for restructuring the water sector to gain resilience, efficiency, and effectiveness.

Challenges to Traditional Water Resources Management

Several challenges are posed to promoting a more integrated approach to water management in the Caribbean. Those challenges include (i) Lack of integration between sectoral water-related policies, which leads to fragmented programs and inefficient utilization of technical capacities and financial resources; (ii) Lack of decentralization and efficient local administrative structures, coupled with low capacity in end-users, which minimizes the opportunities to operationalize IWRM at the base level; (iii) Many Small Island Developing States (SIDS) have traditional or customary systems of land tenure, poor land use and management practices, and inadequate land-use policies, which continue to have an impact on their water resources; (iv) The prevailing erroneous notion that the provision of water is a social service and not an economic good and vital ingredient for national development; (v) Various authorities often lack coordination regarding data collection and management, resulting in inefficient utilization of available technical and financial resources. Decisions are also often made without using the available data because it has not been analyzed and interpreted; (vi) The existing water strategies and policies require investments that are not affordable for many SIDS governments; many island governments face difficulties in allocating the necessary budget to finance the operation and maintenance of the water infrastructure; (vii) Where available, water-related legislation is often inadequate, technically inappropriate, and/or unaffordable. The inadequacy of legal and regulatory frameworks also makes it challenging to apply economic instruments such as fines or incentives for good practices; and (viii) Regional approaches are challenging due to the diversity within the Caribbean region. The paragraphs that follow will detail a few of these challenges.

One of the critical challenges of institutions with direct or indirect responsibility for water resources management is human capital flight, which leads to severe shortages in managerial and technical capacity in water resource management institutions. A rapid survey of water-related agencies in Guyana conducted by Bynoe in 2022 revealed that the number of persons requiring training in IWRM ranged between 63 and 80. Survey respondents reported that the most critical areas for capacity building to support IWRM in Guyana include mapping, monitoring, and modeling technologies; governance approaches, policies, and laws; the data sharing and the development of standards for inland and coastal water quality; and management of water resources, urban planning, and land use.

Equally concerning is population growth and economic development, which will add more significant pressure to the current infrastructure, considering that the distribution infrastructure was built many decades ago and could not have accounted for these changes. For example, the agricultural sector's water and land demands put additional pressure on limited water resources and contribute to the destabilization of marginal lands, creating conflict between the agricultural sector and other stakeholders in Antigua and Barbuda (Carpenter 2011) Consequently, the tourism industry, essential to Antigua and Barbuda's economy, might therefore suffer from inadequate water resources management, water supply management, and wastewater management: both directly through water shortages, poor drinking water quality, and flooding; and indirectly through the pollution of the nearshore environment (Carpenter 2011).

Another challenge is the lack of adequate and timely scientific data, often rooted in inadequate monitoring of water quality and quantity. More often than not, piecemeal data collected by one agency are not always readily available to other agencies for various reasons. Notably, the paucity of data is affected by human resource capacity, a function of the current remuneration package, as noted by stakeholders in Guyana. A related challenge is the absence of water resource information systems that promote shared digital data-sharing platforms. In many instances, water management institutions are unaware of previous studies on water resources or the "location" of these study reports.

There is also an urgent need to change behaviors and attitudes, dispelling misconceptions (for example, the notion of water as a "limitless" resource) by increasing public awareness of the actual costs of providing water, one of the most undervalued natural resources (Farrell, Nurse, and Moseley 2007). Unarguably, poorly informed public perception of the quality and quantity of water resources has influenced public practices that present severe threats to watersheds. Therefore, the task is to engage in a process that will effect lasting changes in public behavior by promoting collective and social responsibility at every level of Guyanese society. Furthermore, Caribbean consumers frequently resist change and tend to oppose privatization or new contracts, believing that access to fundamental services such as water and sanitation can only be guaranteed by governments (Batley 2004). The provision of water services is monopolistic, which restricts consumer influence and accountability. This is made more difficult by corporate structures that isolate the public from officials, legislators, and service providers. Ineffective consumer protection laws and a lack of public awareness of service privileges further hamper reform initiatives. Several countries are beginning to address these issues; for instance, Cuba has developed educational campaigns that provide practical, everyday examples to engage the public in conservation activities, making them seem achievable and easy to follow (Scalley 2012). Such educational initiatives are essential for replicating behavioral change in the English-speaking Caribbean.

Significantly, the success of IWRM heavily depends on the genuine participation of all stakeholders at different levels: planners, local water users, including farmers, the private sector, women, local communities, Indigenous peoples, nongovernmental organizations, and state agencies and ministries. In most cases, stakeholder participation is characterized by seminars, workshops, or consultations since there are no formal mechanisms to truly democratize and decentralize decision-making regarding sustainable resource management and protection. Table 2 illustrates the range of stakeholders for water resources management.

Table 2: Water Management Stakeholders' Perceived Roles in Guyana

Stakeholder	**Perceived Role(s) in IWRM**
Civil Defence Commission	Preparing for and managing disasters
East Demerara Water Conservancy Board of Commissioners	Managing, controlling, and administering the conservancy, especially water levels during torrential rainfall
Environmental Protection Agency	Monitoring and managing the environment
Guyana Geology and Mines Commission	Monitoring of mining's impact
Ministry of Housing and Water – Guyana Water Incorporated	Distributing water for commercial and domestic use
Local Communities/Groups, for example, Water Users Association	Protecting water resources (e.g. preventing the dumping of garbage) Protecting interior waterways for domestic and other purposes Implementing conservation measures; manage the use of water resources
International Agencies: WWF, UNICEF, PAHO, FAO, UNDP, Global Water Partnership-Caribbean	Funding of action plans and initiatives for river basin water resource management
Media	Distributing information Creating a high level of public awareness
Ministry of Agriculture: National Drainage and Irrigation Authority, and the Hydrometeorological Division	Regulation of pesticides Monitoring weather variability Issuing licenses for drilling wells

Stakeholder	**Perceived Role(s) in IWRM**
Ministry of Health	Ensuring water safety based on regulations and standards Maintaining water quality
National Drainage and Irrigation Authority	Caring for surface water
Office of Climate Change	Ensuring integration of water resource management policies and action plans in light of global climate change
University of Guyana	Researching and training; developing capacity
Regional Democratic Council of Guayana	Managing water resources in the various regions

Source: Interviews conducted by Bynoe in 2012

In Guyana, farmers are the primary beneficiaries of drainage and irrigation systems. Thus, the decision was made to get them involved in their management. Farmers were allowed to establish themselves in the Water Users' Associations to actively participate in the planning, design, management, operation, and maintenance of the drainage and irrigation systems. This will ensure that farmers play a direct and integral role in the sustainable use of water within their communities.

Apart from the above-mentioned institutional issues, the existential threat of climate change demands a shift from business as usual to a more precautionary, proactive, and risk-based approach to managing regional water resources. Dore (2005) notes that rising temperatures have been potentially linked to alterations in precipitation patterns due to the changes in circulation and the increase in the humidity of the atmosphere. Moreover, the atmosphere's water-holding capacity is known to increase by "7 percent per 1×." This increase of water vapor within the atmosphere, thus, has produced more rainfall. Indeed,

the ability of freshwater systems to cope with current and future stresses is vital to any prospect of sustainable development. Our continuing wasteful use of freshwater, degradation of aquatic ecosystems, and disruption of critical freshwater services pose a serious challenge to our shared future, as water underpins the resilience of natural and human systems. (Holmgren et al. 2018)

Moving Forward with IWRM

IWRM is a holistic, cross-sectoral policy approach designed to replace the traditional, fragmented sectoral water resource use and management method, leading to poor services and unsustainable resource use. In so doing, IWRM gives recognition to different water use interests and objectives (ecological, social, economic, cultural, and political) and promotes an uncompromising participatory process inclusive of the private sector, women, Indigenous and local communities and farmers, among others being a key stakeholder in the decision-making process regarding water use and management (Holmgren et al. 2018).

IWRM is crucial for sustainable governance and healthy aquatic ecosystems (Mattheiss et al. 2010) since it is "a process that promotes coordinated development and management of water, land and related resources to maximize the resultant economic and social welfare equitably without compromising the sustainability of vital ecosystems." The concept of IWRM is based on the understanding that water resources are an integral component of the ecosystem, a natural resource, and a social and economic good (Global Water Partnership 2014). Notably, the IWRM approach is flexible and can be adapted to local, national, and regional contexts. Moreover, the success of IWRM depends mainly on the input and involvement of a range of stakeholders at different levels: local water users, the private sector, women state agencies and ministries, and nongovernmental organizations, among others.

The Dublin Principles remain the standard for considering water resource use and protection issues. The principles are listed below:

> **Principle No. 1**: Freshwater is a finite and vulnerable resource essential to sustaining life, development, and the environment. [...]
>
> **Principle No. 2**: Water development and management should be participatory, involving users, planners and policy-makers at all levels. [...]
>
> **Principle No. 3**: Women are central in providing, managing, and safeguarding water. [...]
>
> **Principle No. 4**: Water has an economic value in all its competing uses and should be recognized as an economic good. [...]. (United Nations 1992)

For IWRM to become a reality, eight imperatives must be adhered to: First, citizens must appreciate the value of a clean and safe water supply. Such a transformation requires (i) sound pricing, (ii) valuation of sector financing, and (iii) conservation ethics. Second, the sustainability of water resources must be based on five additional building blocks: (iv) wise use of water resources by other sectors, (v) harmonization of laws, regulations, and guidelines about water quality and water quantity, (vi) water efficiency through reduced demands on, and less pollution of, water resources by households, communities, and the private sector; (vii) green infrastructure through rainwater harvesting techniques and building codes, reforestation of degraded watersheds; (viii) climate change adaptation techniques such as drip irrigation for farmers. Last but not least, a reorganization of institutional structures to prevent any organizational or legislative silos and to improve stakeholder collaboration in water resources management will also be necessary.

Conclusion

Competing water demands will continue to increase even as supplies remain limited and inadequate, and climate variability and anthropogenic climate change will continue posing existential threats to the quantity and quality of the resource. Business as usual is not an option. Water resources should be prioritized in all socio-economic development plans to mainstream their protection. Water must become the substratum for social and economic development to allow for the holistic integration of various objectives: ecological, economic, social, cultural, and political. The time is now for Caribbean governments to transform rhetoric into action by demonstrating political will and commitment to create and support an enabling framework for a more coordinated approach to sustainable water resources management through Integrated Water Resource Management.

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Appendix

Biographical Notes

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Diana Birrichaga has been Professor and Researcher at the Faculty of Humanities, *Universidad Autónoma del Estado de México* since April 2006. Previously, she was a researcher at *El Colegio Mexiquense, A.C.*, from 2000 to 2006. She has held positions as coordinator of the Bachelor's in Information Science, head of the digitalization laboratory, and head of the Professional Evaluation Department. She earned her PhD in History from *El Colegio de México* (2003). As a specialist in the history of water use and Indigenous peoples in Mexico, her research focuses on the management of natural resources and the social history of local communities. She is a member of Mexico's National System of Researchers and has received national awards for her doctoral thesis. In 2008, she became a regular member of the Mexican Academy of Sciences. She has published numerous articles and books, both nationally and internationally. Her recent publications include the book chapters "Fiscalidad y propiedad territorial. Los repartos de bienes comunales en el distrito de Zinapécuaro, Michoacán, 1868–1880" (CIESAS, 2023) and "La administración de bienes de santos en el Estado de México, 1850–1880" (El Colegio Mexiquense, 2023).

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Rocío Bustamante Zenteno has a background in Law and Political Sciences, an MSc. in Management of Agricultural Knowledge Systems (MAKS) at Wageningen University, and a PhD studies in Irrigation and Water Engineering at the same institution. Her work has been focused mainly on the fields of Public Policy, Legal Anthropology, and Legal Sociology. She is currently Researcher and Lecturer at the Andean Centre for Water Use and Water Management (Centro AGUA) of the University of San Simón (UMSS), Cochabamba, Bolivia. Most of her work experience deals with the field of (customary, local, Indigenous) water rights formalization processes, as well as interlegality, public policies, institutions, and legislation on water resources and water utilities in the Andean region. She is also a member of academic networks such as WATERLAT and Water Justice and was the manager of the UMSS Water Observatory until 2023. Her most recent research is about the rights of nature and relational ontologies in the Bolivian Andes, as well as studies on water economics and the water commons. One of her latest papers, "Paisajes Hídricos y Ontologías del agua, el caso de las fuentes Ph'iña en los valles de Cochabamba," was presented at the *XII Congreso de la Asociación de Estudios Bolivianos* in July 2023.

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