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Edited by Alberto Bardi, Pietro Daniel Omodeo, and Justas Patkauskas

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Abstract

This volume explores the historical relationship between humans and their environments from the perspective of geoanthropology. Focusing on waterscapes, the volume considers the importance of *longue durée* processes, cross-cultural perspectives, and knowledge production dynamics for understanding the complex conditions behind the Anthropocene and the current ecological crisis. The multidisciplinary contributions draw on a series of discussions conducted over several international conferences and workshops. Divided into three sections – Hydrological Frameworks, Anthropocene Questions, and Water Culture – the volume addresses such themes as the history of waterscape engineering, the politics of technological change, and the conceptual dimensions of Earth system science. The result is a multifaceted inquiry that highlights the significance of the humanities and social sciences for geoanthropological research.

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Alberto Bardi

Introduction

Alberto Bardi, Pietro Daniel Omodeo, and Justas Patkauskas

This volume reexamines the role of history in understanding the relationship between human beings and their environments, with a focus on waterscapes, *longue durée* processes from a cross-cultural perspective, and knowledge acquisition and transmission. The image that emerges is one in which historical analysis reintroduces space for the political: the present is an outcome of contingent rather than necessary developments, and the future, too, will be decided on the basis of ideas and choices rather than blind necessity. Although the perspective adopted in this volume is global in scope, it remains grounded in case studies that offer insights into exemplary contexts and are underpinned by reflections on labour, capital, and historical change of societies and their ecosystems.

The papers presented herein are the result of the international project *Cosmography of Historical Waterscapes* (June 2023–December 2024),¹ an academic collaboration between the Tsinghua University of Beijing (School of Humanities) and the Ca' Foscari University of Venice (Department of Philosophy and Cultural Heritage) supported by the Tsinghua Initiative Scientific Research Program (Grant No. 20233080008). The volume collects the research presented at two academic workshops and one conference panel on water in human civilization and the Anthropocene paradigm. The objective was to produce a comparative study of historical waterscapes in different geographical locations by investigating the connection between cosmological and ecological knowledge in water-landscape engineering. The workshops, held at Tsinghua University in November 2023 and May 2024, brought together researchers of diverse backgrounds, including China, India, Iran, Mexico, Lithuania, and Italy. The international and transdisciplinary nature of the workshops matches the values of our inquiry: historical waterscapes and their modern status, particularly in light of the Anthropocene debate on human geological agency, require global approaches to scholarship. In continuity with these workshops, the conference panel “Water and Knowledge, Heaven and Earth: Historical-epistemological Perspectives from Early Modern Sources” was held at the 11th Conference of the European Society for the History of Science (4–7 September 2024, Barcelona). The panel enlarged the research scope to include Chinese case studies. One paper presented there is included in this volume.

The papers presented in this volume belong to the framework of geoanthropology, an emerging scientific field that combines Earth system research with the theories and histories of human societies.² Broadly conceived, geoanthropology aims to bypass established disciplinary antagonisms without pretending to dissolve disciplinary distinctions in a supposedly universal ground, which usually amounts to pressuring the humanities and social sciences to adopt the research practices of the physical sciences. This methodological position mirrors the geoanthropological approach to fundamental concepts: instead of abstract dualisms or monisms, geoanthropology looks to identify and understand various concrete nexuses where different material and socio-cultural processes and bodies of knowledge interact to produce complex outcomes.³ Some instances emphasized by researchers in this field are the biosphere–technosphere nexus and the environment–politics–climate articulation. To properly investigate the relevant interactions and their outcomes, it is important to locate them in phenomena that permit multidimensional descriptions, with a key requirement being compatibility with Earth system research.⁴ Otherwise,

¹ The principal investigator (PI) of this project is Alberto Bardi and the co-PI is Yubin Shen, while the main overseas research partner is Pietro Daniel Omodeo.

² See Jürgen Renn, “From the History of Science to Geoanthropology,” *Isis* 113, no. 2 (2022): 377–85.

³ For a discussion about the natural–social nexus in the geoanthropological paradigm, see Pietro Daniel Omodeo, “Geopraxis,” *Journal of Interdisciplinary History of Ideas* 11, no. 22 (2022): 9:1–9:52.

⁴ The significance of Earth system research for geoanthropology has been strongly highlighted by Giulia Rispoli, “The Evolution of the Anthroposphere,” *Journal of Interdisciplinary History of Ideas* 11, no. 22 (2022): 10:1–10:31.



the particularity of geoanthropology as a scientific field is supplanted by a general interdisciplinary spirit, which, although laudable, is not helpful in orienting research.

Within this developing analytic vocabulary and negotiation with Earth system research, we propose that landscapes are one phenomenon where various nexuses can be localized. In particular, waterscapes have been productively examined by geoanthropological research,⁵ and our volume continues this development by experimenting with different approaches to describing historical landscapes in various geographical locations.

Although not all of our contributions adopt an explicit geoanthropological (Earth system and the Anthropocene) vocabulary, this volume is located at the heart of the current debate about the natural–cultural paradigm to come. It aims to demonstrate that geoanthropology makes room for and even *requires* contributions from multiple disciplines, from legal studies to the history of science. These disciplines do not have to be strongly connected to one another in an aprioristic, systemic manner; instead, it is enough for them to be contiguous within the bounds of the identified phenomenon, in this case, waterscapes. Given our previous hint at the isomorphism between methodology and foundational concepts, this reflection on the nature of disciplinary cohesion within geoanthropology translates to an insight into nexuses: contiguity and common boundaries supersede continuity and reduction.

This volume is arranged in three parts: Hydrological Frameworks, Anthropocene Questions, and Water Culture. In the opening paper, Pietro Daniel Omodeo considers the historical connections between proto-capitalist dynamics, knowledge-making, and landscape modification in early modern Venice over the centuries. Among the conclusions is the idea that political and economic history is inseparable from the history of physical transformations of geography, but this relationship cannot be read in simple terms, whereby the political inscribes itself in nature as if the latter were a canvas. These reflections serve as the hermeneutic key to many of the themes considered in the subsequent papers, which reveal some of the ways in which the natural–social nexus can be observed in different historical, regional, and cultural circumstances.

For instance, in the contribution by Babu Senthil D. and Shibi Nandan R., we find a *longue durée* overview of the transformations enacted around the Kaveri River basin, initially driven by agriculture centred around the caste system, and later premised on labour organization imposed by colonial governance. The complex imbrication between nature and society is revealed to have a wide range of mediators, many of which, however, involve labor and its organization. This diversity of agentic mediation is matched by the diversity of outcomes, as described in Omar Rodríguez Camarena's contribution, which surveys the anthropogenic, political causes behind the hydrological history of Mexico City, once a water city much like Venice, and Cuernavaca. These contributions highlight the significance of the diachronic and multifaceted study of landscapes in addition to the synchronic and formal considerations of the Earth system.

In the second section on Anthropocene Questions, Giovanni Fava addresses the ontological presuppositions underpinning the sense of Earth system science. The issue is not that science needs philosophy to understand its own work, or vice versa. Instead, ontology impacts how one interprets even the most empirically grounded results, along with their framing. With a similar aim to clarify the implicit and explicit preconditions of empirical and theoretical research, the contribution of Justas Patkauskas traces the genealogy of the metabolism concept, whose popularity in Anthropocene and Earth system research is high, but whose conceptual multivalence generally remains opaque.

The last section on Water Culture starts with Xenia Chiaramonte's paper on juridical landscapes and the different ways in which water uses have been framed in legal terms. An important dimension is foregrounded by

⁵ See, for example, Pietro Daniel Omodeo and Sebastiano Trevisani, "Historical Geoanthropology in Venice," *Journal of Interdisciplinary History of Ideas* 11, no. 22 (2022): 2:1–12:22; Thomas Turnbull, "Mississippi: Working River," *Journal of Interdisciplinary History of Ideas* 11, no. 22 (2022): 11:1–11:28.

this contribution: the biosphere–ergosphere–technosphere nexus is mediated not only by labour but also by jurisprudence. Historical and political treatments of the Earth system spheres overlook the significance of legal frameworks to their own detriment.

The contributions by Razieh S. Mousavi as well as Zheran Wang and Siyuan Xu indicate the deep historical and cultural roots of technology and its dependence on situated work and knowledge. In other words, the conditions of the biosphere–ergosphere–technosphere nexus mediated by the knowledge economy, which emerges in full capitalist force with the Great Acceleration in the 1950s, have been rendered operative by a long, cumulative, yet disconnected development spanning Arabic and Chinese societies, among many others.

In the closing contribution, Alberto Bardi discusses the impact of Ibn Tufayl's educational and utopic work *Hayy Ibn Yaqzan* on subsequent Arabic and European thought based on considerations of an idealized insular setting. This contribution is particularly interesting to consider together with Omodeo's opening paper – just as waterscapes inspire pragmatic reflections that bring together politics with engineering, they are also invested with abstract significance. Abstraction, in turn, generates philosophical reflection, impacting the material socio-economic valuation involved in landscape transformation. Thus, in a geoanthropological framework with theoretical and historical contributions, it may be possible to attenuate the antagonism between base and superstructure inherited from historical materialism.

More than a collection of contributions, this volume is a nexus of contiguous research showing the complexity and necessity of geoanthropology with a strong emphasis on its humanities and social sciences side. The main goal is to study water heritage as an open-ended historical geo-anthropological process, comprehend the current conjuncture marked by socio-ecological imbalances, and assess alternative pathways to a sustainable future. We believe it expedient to understand water heritage as a dynamic process influenced by both human actions and environmental factors, and to address current socio-ecological challenges. By examining philosophical and historical perspectives and drawing on case studies around the world, this volume seeks to enrich the discourse on contemporary water issues and their sustainable management. Throughout history, water has been a fundamental force shaping human societies. It has influenced cultural exchanges, economic development, and technological advancements. However, as the adage goes, “You cannot step in the same river twice,” reminding us that history is fluid and shaped by our choices.

We extend our gratitude to the institutions and individuals who have made this publication possible: the Tsinghua Research and Development Office, which provided research and travel funding through the Tsinghua Initiative Scientific Research Program (Grant no. 20233080008); the Max Planck Institute of Geoanthropology, Jena; the UNESCO Chair on *Water Heritage and Sustainable Development* at the Ca' Foscari University of Venice; the FARE project *EarlyGeoPraxis* (Grant of the Italian Ministry of University and Research, no. R184WNSTWH); the Max Planck Partner Group *The Water City* (Venice–Jena); and the NEW INSTITUTE CENTRE for Environmental Humanities (NICHE) in Venice.

Our appreciation also goes to the Tsinghua School of Humanities and the Department of History of Science, especially to Wu Guosheng, Shen Yubin, Zhang Enshuo, and Huang Zongbei for their institutional support and organizational efforts at the workshops, and to Corinna Guerra for co-organizing the panel in Barcelona.

SECTION ONE: HYDROLOGICAL FRAMEWORKS



The Historical Epistemology of Venice's Water Heritage: An Inquiry into the Connection of Hydrology and Early Capitalism¹

Pietro Daniel Omodeo

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Introduction

Venice's waterscapes can be seen as natural–cultural heritage. The water city of Venice is situated in its lagoon in the middle of a cluster of islands, perhaps “an archipelago.”² This geomorphological formation has been preserved in its liquid state through centuries of water engineering and reengineering. In particular, the diversion of rivers outside of the “inner waters” also brought the sediments outside of the lagoon and preserved it against infilling. Venice and its lagoon count today as a locality of special concern among the UNESCO World Heritage Sites because its future is threatened by the sea level rise. This anthropogenic phenomenon, coupled with subsidence that makes the ground sink, could prove fatal to Venice. As this city and its surroundings are a hybrid natural–artificial formation, they ought to be looked at through what I will term “historical hydrosociological lenses.” Indeed, a *longue durée* perspective is necessary. The perspective that I propose takes into account, as its two fundamental axes, the epistemological dimension (i.e., the techno-scientific factor of transformation) and political economy. In other words, I address the “geoanthropological” reality of Venice from the integrative perspective of the *historical epistemology* and the *political economy of water heritage*. To be sure, Venice is a paradigm of human–natural coevolution, but it also counts as a birth place of capitalism in the late Middle Ages. In the following pages, I will set the ground for an integrated perspective that enables us to assess the interrelation between the ecology and the economy of Venice at the crossroads of the histories of geoanthropology and capitalism.

Clarification of Terms and Method

Some preliminary terminological clarification is in order. It is useful to first establish a working definition of the expression “water heritage” and then clarify the meaning of “historical epistemology” as a method, which guides this investigation.

Water heritage – the core concept of the UNESCO Chair in Venice on *Water Heritage and Sustainable Development*, which I direct³ – points to both the materiality and the symbolic meaning of water, which, as a

¹ I would like to acknowledge the institutions and projects that have contributed to our research: the UNESCO Chair *Water Heritage and Sustainable Development* at the Ca' Foscari University of Venice; the FARE project *EarlyGeoPraxis* (Grant of the Italian Ministry of University and Research, no. R184WNSTWH); the Max Planck Partner Group *The Water City* (Venice–Berlin–Jena); the project *Cosmography of Historical Waterscapes* (funded by Tsinghua University, Beijing); the NEW INSTITUTE CENTRE for Environmental Humanities (NICHE) in Venice; and the Max Planck Institute of Geoanthropology in Jena. A preliminary version of this essay was delivered at the workshop *Geo-sciences, Knowledge and Capitalism* (Oslo University, Department of Archaeology, Conservation and History, 7 December 2023) under the title: “The Socio-Economic Roots of Venice's Historical Hydrosociology.” Special thanks to Justas Patkauskas for his close reading of this essay and his suggestions for improvement.

² See Ludovica Galeazzo, “The Venetian Archipelago: Society, Everyday Life, and Cultural Exchange in the Early Modern Lagoon,” in *Market Spaces, Production Sites, and Sound Landscape of European Cities: From History to Regeneration*, ed. Elena Svaldus (Padova: Università degli Studi di Padova, 2022), 69–78; Pietro Daniel Omodeo and Sebastiano Trevisani, “Historical Geoanthropology in Venice,” *Journal of Interdisciplinary History of Ideas* 11/22 (2022): 13:1–13:22.

³ For the UNESCO Chair web site, see <https://www.unive.it/web/en/5454/home> (accessed on February 9, 2024).

fundamental albeit movable component of cultural landscapes, has been crucial to the “co-creation” of human communities and their environments.⁴ As Francesco Vallerani has recently observed,

Waterscapes are [...] the prevailing foreground where both water flow and water engineering aesthetics are developed, harmonising practical needs with cultural and spiritual expectations. It follows that inner dynamics related to the shaping of human territoriality expand well beyond the idea of a landscape as a distanced object, transforming the traditional role of simple spectatorship into a more active being-in-the-world and therefore allowing a more direct engagement and participation in the ‘lifeworld’.⁵

This perspective is informed by the emergent hydro-sociological paradigm, according to which the water cycle cannot be thought in abstract insulation from human agency.⁶ Water and society are so imbricated at the planetary level (or that of world economy, in accordance with world-system perspective of Immanuel Wallerstein)⁷ that all flows on our planet are connected with anthropic and techno-scientific agency. According to the Anthropocene hypothesis, planetary disorders are caused by large societal and geopolitical processes and technological interventions, which are producing, according to some geologists, the emergence of the technosphere as one of the main spheres the Earth System (akin to the lithosphere, the hydrosphere, the atmosphere, and the biosphere).⁸ The water cycle is not excluded from this planetary anthropization.

As for human geo-interventions, they are not abstractly technological. Rather, they are social and political in the first place. According to Linton and Budds, in a paper aimed to introduce the idea of hydrosociology,

water internalizes and reflects social and power relations that might otherwise remain invisible. This, in practice, implies that we need to think differently about water, attend to the social circumstances of water circulation, and ask questions about how water, social structures, power relations, and technologies are internally related.⁹

For the sake of brevity, one can say that hydrosociology raises the question of the reciprocal making of social structures and water flows, thereby offering a dialectical key to the comprehension of waters in the current age. From this perspective, water heritage refers to a cultural legacy that is inscribed in nature.

With respect to the other key term of this working paper, historical epistemology, this method should be seen as both a historical and philosophical study of knowledge and science.¹⁰ To investigate waterscapes and geomorphological formations from the viewpoint of historical epistemology means looking at the human–natural co-creation along three entwined lines:

⁴ I owe the concept of co-creation to Veronica Strang, *Water Beings: From Nature Worship to the Environmental Crisis* (Reaktion Books, 2023), 228–42.

⁵ Francesco Vallerani, “Introduction: Flowing Consciousness and the Becoming of Waterscapes,” in *Waterways and the Cultural Landscape*, ed. Vallerani and Francesco Visentin (Routledge, 2018), 7.

⁶ Erik Swyngedouw, “The Political Economy and Political Ecology of the Hydro-Social Cycle,” *Journal of Contemporary Water Research & Education* 142 (2009): 56 – 60.

⁷ Immanuel Wallerstein, *The Modern World-System*, 4 Vols. (Academic Press, 1974, 1980, 1989, University of California Press, 2011).

⁸ Peter Haff, “The Technosphere and Its Relation to the Anthropocene,” in *The Anthropocene as a Geological Time Unit: A Guide to the Scientific Evidence and Current Debate*, ed. Jan Zalasiewicz et al. (Cambridge UP, 2019), 138–143.

⁹ Jamie Linton and Jessica Budds, “The Hydrosocial Cycle: Defining and Mobilizing a Relational-Dialectical Approach to Water,” *Geoforum* 57 (2014): 170–180, 178. See also Giorgio Osti, “Acque interne e società,” in *Introduzione all'ecologia politica*, ed. Luigi Pellizzoni (Il Mulino, 2013), 297–313.

¹⁰ Gerardo Ienna and Massimiliano Badino, *Epistemologia storica: Correnti, temi e problemi* (Carocci, 2022).

1. the social practices of water uses and labour,
2. the instruments mediating the human interaction with the ecosystem,
3. and the forms of knowledge and scientific abstraction that emerge and are mobilized.

I take this formulation of the epistemological triad from a definition of historical epistemology offered by Matteo Pasquinelli but reinterpret it in an environmental direction.¹¹ This triad ultimately refers to the socio-economic approach that was first presented by Soviet historian of physics Boris Hessen in 1931 as a specifically Marxist perspective on science: an investigation of the socio-economic roots of science.¹² Henryk Grossmann, a Polish economist and historian of mechanics and mechanic philosophy, embraced a similar standpoint in his studies of René Descartes's early natural conceptions and capitalism in the age of the Scientific Revolution.¹³ Gideon Freudenthal and Peter McLaughlin recently summarized the historical-epistemological approach of these historical-materialist thinkers of the last century as the "Hessen–Grossman thesis." This is the formula looks as follows:

1. Economics *presents* demands,
2. which *pose* technical problems,
3. which *generate* scientific problems.¹⁴

In extreme synthesis, the three components of the organic exchange – or metabolism – between societies and their surroundings (to use Marx's biological metaphor)¹⁵ can be reduced to the dynamic articulation of:

1. economy,
2. technology,
3. science.

Some examples taken from the environmental-epistemological history of Venice can offer an illustration of the areas covered by the above points:

1. The economic component: drinking, fishing, traveling, energy production for industry (mills and proto-industrial water-powered engines), fields irrigation, etc.
2. The technological component: transportation, fishing instruments, machines, and agricultural activities, but also surveying, mapping, measuring, etc.
3. The scientific component: navigation, tidal knowledge, ecosystem knowledge, ichthyology, and mechanics (also the medieval and early-modern science of machines), as well as physics (earlier "natural philosophy"), hydrology, statics, mechanics, mathematics, astronomy.

The Political-Epistemological Question: The Economy and Culture of an Early Capitalist Formation

A political perspectivation – that of political epistemology, which focuses on the question of the function or goals of science – expands the above triad of historical epistemology (genesis, validity and goals of the labour-

¹¹ Matteo Pasquinelli, *The Eye of the Master: A Social History of Artificial Intelligence* (Verso, 2023), 13: "Historical epistemology is concerned with the dialectical unfolding of social praxis, instruments of labour, and scientific abstractions within a global economic dynamic."

¹² Boris Hessen, "The Social and Economic Roots of Newton's *Principia*," in *Science at the Cross Roads* (Kniga, 1931), 147–212.

¹³ Henryk Grossman, "The Social Foundation of Mechanistic Philosophy and Manufacture," in *The Social and Economic Roots of the Scientific Revolution; Texts by Boris Hessen and Henryk Grossmann*, ed. Gideon Freudenthal and Peter McLaughlin (Springer, 2009), 103–156.

¹⁴ Gideon Freudenthal and Peter McLaughlin, *The Social and Economic Roots of the Scientific Revolution*, 4.

¹⁵ See John Bellamy Foster, *Marx's Ecology: Materialism and Nature* (Monthly Review Press, 2000) and Dario Padovan, "The Concept of Social Metabolism in Classical Sociology," *Revista Theoria/Theoria Journal* 2 (2003): 26–40.

technology-science nexus) to consider their dependency and impact on forms of governance, power relations, and decision-making. In *Political Epistemology: The Problem of Ideology in Science Studies*, I indicated the following two main areas of inquiry of such a perspective:

1. the political economy of science, and
2. the cultural politics of science (or, more plainly, ideology).¹⁶

In relation to the specific case study of this essay, I have recently emphasized the importance of the republican settings of early modern water knowledge in Venice as a common good to be understood through a communal form of knowledge with various socio-epistemological components, including the expertise of water officers and policy makers as well as the practical knowledge of the labouring people. I called the Venetian knowledge of the common waters an “epistemology from below.” Indeed, during early modernity, waterscape engineering was not a mere technical issue in the service of governmental politics or a purely top-down mechanism but rather a negotiated decision process in which various societal components interacted, including the fishermen’s community. A prescription from a Renaissance regulation of the water officers (*savi alle acque*) of Venice in 1536 is telling of this multilayered knowledge culture at the basis of decision processes that have shaped the geomorphology of this place:

Since no one understands better the course and the movements of the waters of our lagoon than the fishermen who travel through it by day and by night, the Gastaldo [community chief] and the school of fishermen of San Nicolò shall choose two of the most sensible and practical elderly fishermen, or former fishermen [...] the choice of another person must be made by the Gastaldo and the fishermen of Sant’Agnese; another will be chosen by the fishermen of Murano, two by those of Burano and two by those of Chioggia. All eight of them, when we deal with matters related to this lagoon, should be called to this College to share their opinions and recollections about the matter proposed, for the benefit of our lagoon.¹⁷

All of these aspects relate to the geo-anthropological question of the human–natural transformative nexus (perhaps to be termed “co-evolution”). The inscription of human labour, technology, and knowledge in the territory (i.e. waterscapes) is not a unique feature of modern societies, although the Anthropocene debate has forcefully brought it to the fore.¹⁸

A vivid example of geo-anthropomorphization is the Roman centuriations. This ancient social method of land organization and irrigation according to a square grid is still visible in the landscape from satellites after more than two thousand years. It documents the lasting inscription of human labour and technique upon the territory.¹⁹

Modern societies have developed specific technological and economic relations with their environments (eventually leading to a “metabolic rift” and an environmental crisis that deepens the ecological imbalance between cities and countryside at the cosmological level of planet Earth). Arguably, this rift is triggered by societal formations that have been guided, in modernity, by capitalism, its principles and mechanisms.

¹⁶ Pietro Daniel Omodeo, *Political Epistemology: The Problem of Ideology in Science Studies* (Springer, 2019).

¹⁷ Quoted from Gianni Scarpa, “Premessa,” in Mariiegola della Scuola di Sant’Andrea de’ Pescadori 1569–1791, (Il Leggio, 1996), 9–44.

¹⁸ The standard reference is Dipesh Chakrabarty, *The Climate of History in a Planetary Age* (The University of Chicago Press, 2021). See also Christophe Bonneuil, “Der Historiker und der Planet: Planetaritätsregimes an der Schnittstelle von Welt-Ökologien, ökologischen Reflexivitäten und Geo-Mächten,” in *Gesellschaftstheorie im Anthropozän*, ed. Frank Adloff and Sighard Neckel (Campus, 2020), 55–92.

¹⁹ See, among other readings on these topics, Cristina Mengotti and Sante Bortolami (eds), *Antico e sempre nuovo: l’agro centuriato a nord-est di Padova dalle origini all’età contemporanea* (Cierre, 2012) and Jeremia Pelgrom, *The Renaissance of Roman Colonization: Carlo Sigonio and the Making of Legal Colonial Discourse* (Oxford University Press, 2020).

The crucial principle of capitalist “civilization” (to use Fernand Braudel’s expression) is money accumulation (resting on so-called “primitive accumulation”), investment, and growth (in terms of capital). The standard formula of the capitalist imperative is:

$$M-C-M'$$

But how recent is this development? This question about the origins of capitalism has been variously addressed by historians (often in connection with the question about the *end* of capitalism, as was the case with the studies of Grossmann and Rosa Luxemburg approximately one hundred years ago).

Let me add that the standard formula, which captures the logic of capital, is also the intrinsic marker of *capitalist* social metabolism. In my view, the specific logic of capitalism and, accordingly, of the metabolism of capitalist societies is that of accumulation (M–C–M’) pace recent attempts to reinterpret capitalism as a semiotic (i.e. essentially symbolic) mechanism (e.g. according to Felix Guattari’s *plan sur la planète* and Moore’s *capitalocene*).²⁰ By reducing capitalism to the expansive articulation of the M–C–M’ principle (from economy to culture and nature), I do not intend to propagate a historical oversimplification. Rather, I think that capitalism itself, as a societal formation, brutally strives to reduce everything to its economic logic. Thus, it is not my analysis but capitalism itself that is reductivist. Its logic affects or can affect all realms of social life and its relationship with nature, transformed into a reservoir of resources for (economic) value-making.²¹

A crucial factor that allows capitalist accumulation to operate is the process of separation of those who produce wealth from the means of production, that is, the so-called “primitive accumulation.” In the words of Marx,

The so-called primitive accumulation [...] is nothing else than the historical process of divorcing the producer from the means of production.²²

Although primitive accumulation – that is, the alienation (maybe better, expropriation) of the means of production for the sake of capital accumulation – is not historically located in a mythical beginning (its “original sin” as Marx ironically called it),²³ its understanding calls for historical investigation. Marx especially looked at early modern enclosures as the paradigm of the expropriation of the commons that made capitalism develop in Great Britain, beginning in the 16th century. Still, he also detected earlier phases of capitalism (as it were, of “capitalism before its original sin”). He considered the time of medieval maritime republics and later European colonialism to be decisive factors for the beginning and unfolding of capitalism in its early phases, a process that reached its first global expansion in the 16th century (see Chapter 31 of Volume 1 of *Capital*). According to Marx, the level of evolution of a capitalist civilization could be measured by the degree of debt on the part of states (i.e. the dependency of the state on private bankers that was functional to foster capitalist investments). He considered Genoa and Venice to be the sites where this process began:

The system of public credit, i.e., of national debts, whose origin we discover in Genoa and Venice as early as the Middle Ages, took possession of Europe generally during the manufacturing period. The colonial

²⁰ On Félix Guattari’s *Plan pour la planète*, see Franco Berardi, “Introduzione: Dalla simulazione della guerra mondiale alla realtà della globalizzazione,” in Félix Guattari *Piano sul pianeta: Capitale mondiale integrato e globalizzazione* (Ombre corte edizioni), vii–xiv, and Jason W. Moore, “Anthropocene, Capitalocene and the Flight from World History: Dialectical Universalism & the Geographies of Class Power in the Capitalist World-Ecology, 1492–2022,” *Nordia Geographical Publications* 51/2 (2022): 123–146.

²¹ Foster, *Capitalism in the Anthropocene: Ecological Ruin or Ecological Revolution* (Monthly Review Press, 2022). See also Kohei Saito, *Marx in the Anthropocene: Towards the Idea of Degrowth Communism* (Cambridge University Press, 2022).

²² Karl Marx, *Capital: A Critic of Political Economy* (Vol. 1) (Progress Publishers, revised 2015: <https://www.marxists.org/archive/marx/works/download/pdf/Capital-Volume-I.pdf>), 506.

²³ Ian Angus, “The Meaning of ‘So-Called Primitive Accumulation,’” *Monthly Review* 74/11 (2023): 54–58, reprinted in *The War Against the Commons: Dispossession and Resistance in the Making of Capitalism* (Monthly Review Press, 2023), 204–209.

system with its maritime trade and commercial wars served as a forcing-house for it. Thus, it first took root in Holland.²⁴

Another quotation of Marx's on early Italian capitalism here follows (which I propose to read by keeping in mind the question of early Venetian capitalism):

In Italy, where capitalistic production developed earliest, the dissolution of [feudal] serfdom also took place earlier than elsewhere. The [feudal] serf was emancipated in that country before he had acquired any prescriptive right to the soil. His emancipation at once transformed him into a free proletarian, who, moreover, found his master ready waiting for him in the towns, for the most part handed down as legacies from the Roman time. When the revolution of the world-market, about the end of the 15th century, annihilated Northern Italy's commercial supremacy, a movement in the reverse direction set in. The labourers of the towns were driven *en masse* into the country, and gave an impulse, never before seen, to the *petite culture*, carried on in the form of gardening.²⁵

Although the first of these two quotations points to finance as an instrument of capitalist expansion, the second one indicates the relationship between cities and the countryside, which is today the crux of eco-Marxist analysis of social metabolism. However, Venice's massive investments in the countryside, in the time of its commercial decline, is not to be connected with *petite culture* (small-size agriculture activities) but rather with a form of internal colonialism, which often required great state and private investments, as Fernand Braudel has clearly noted in his masterwork *La Méditerranée et le Monde méditerranéen à l'époque de Philippe II, L'espace et l'histoire*:

The internal colonization which was carried out throughout the Mediterranean in the sixteenth century also took its toll. It was particularly marked in Italy. If Italy took no part in the great movement of colonization of distant territories the reason is perhaps partly to be sought in her preoccupation with reclaiming all available land within her own frontiers, from the flooded plains to the mountain peaks. [...]

Mediterranean man has always had to fight against the swamps. Far more demanding than the problem of forest and scrubland, this colonization is the distinguishing feature of his rural history. In the same way that northern Europe established itself or at any rate expanded to the detriment of its forest marches, so the Mediterranean found its New World, its own Americas in the plains.²⁶

Given the historical relevance of Venice for the reconstruction of early phases of capitalism (in the Middle Ages and early modernity), its environmental metabolism – the historical epistemology of its hydro-culture – could offer a crucial testcase to study the environmental history of capitalism, bringing it back to times that predate the fossil age on which much eco-critique has focused.²⁷

In this sense, it could be worthwhile to reconnect Venice's hydrosocial history with that of capitalist civilization; that is, to connect a historical epistemological inquiry with its socio-political conditions and consequences. The first step of this reconnection could be made by adopting Braudel's multilayered understanding of capitalism qua civilization and applying his lenses to examine Venetian water culture. Braudel's work itself makes such connection plausible: he presents Venice as a synthesis of Mediterranean capitalist accumulation throughout the Middle Ages up to modernity. His insights are particularly interesting because they pointed to the environmental conditions of civilization, although he did not expand on the retro-action of society on the environment, which is so

²⁴ Marx, *Capital*, 533. On the function of debt in the development of civilizations in general, see David Graeber, *Debt: The First 5000 Years* (Melville House, 2011).

²⁵ Marx, *Capital*, 534.

²⁶ Fernand Braudel, *The Mediterranean and the Mediterranean World in The Age of Philip II* (Vol. 1), transl. Sian Reynolds (Harper & Row, 1972), 66–7.

²⁷ See Andreas Malm, *Fossil Capital: The Rise of Steam-Power and the Roots of Global Warming* (Verso, 2016).

relevant from the viewpoint of the Anthropocene question (the geological agency of human societies by technoscientific means).²⁸

Capitalist Aquaformation of Venice

This reflection on capitalism and the environment in early modern Venice particularly draws on the analytical tools offered by Braudel in *Capitalism and Material Life (1400–1800)*. In this work, he defined “capitalist civilization” a three-layered socio-environmental stratigraphy that has slowly emerged in history:

Nascent capitalism clearly does not cover the whole of economic life. There are at least three levels and three spheres: everyday material life, very widespread, concerned with basic necessities and short-range; economic life, calculated, articulated, emerging as a system of rules and almost natural necessities; and finally the more sophisticated capitalist mechanism, which encroaches on all forms of life whether economic or material, however little they lend themselves to its manoeuvres.²⁹

In summary, the three layers concern

1. everyday material life,
2. economic life, and
3. the full-fledged capitalist system.

The distinction of these three levels can shed light on the socio-environmental stratigraphy of Anthropocene Venice and its waterscapes. In my past and present research, I have especially focused on the 16th and 17th centuries because they were decisive centuries in the history of the territory and the lagoon of Venice. At that time, massive interventions were started and accomplished that transformed the lagoon in an enduring manner. I call this process “aquaformation,” although it very much relates to territorial transformations, such as “terraformation” through land reclamation. This concept bridges a socio-economic understanding of capitalist conditions in terms of specific societal formations with ecological transformations.

Bottom Layer: Material Practices of Watery Life

At the ground level of Venice’s capitalist aquaformation, one should first consider some relevant material practices connected to labour, the extraction of practical knowledge, and their institutional settings.³⁰ I would like to mention three examples of material practices that count as technological and scientific practices:

1. fishermen’s labour and its valorization for water politics;³¹
2. land reclamation, technology and labour as a process of inner colonization of land;³²

²⁸ I discuss these aspects in Pietro Daniel Omodeo, “History of Science and History of the Earth in the Anthropocene,” *Physis* 57 (2022): 171–88.

²⁹ Fernand Braudel, *Capitalism and Material Life: 1400–1800* (Weidenfeld and Nicolson, 1967), xiii.

³⁰ For such an inquiry, literature on practical knowledge is precious. See Pamela Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (The University of Chicago Press, 2004); Pamela O. Long, *Artisan, Practitioners and the Rise of the New Sciences, 1400–1600* (Oregon State University Press, 2011); Matteo Valleriani (ed.), *The Structures of Practical Knowledge* (Springer, 2017).

³¹ Omodeo, “The Invisible Fisherman: The Economy of Water Knowledge in Early-modern Venice,” in *Ichthyology in Context (1500–1880)*, ed. Paul J. Smith and Florike Egmond (Brill, 2023), 362–91.

³² Pietro Daniel Omodeo, Sebastiano Trevisani and Senthil Babu D., “Benedetto Castelli’s Considerations on the Lagoon of Venice: Mathematical Expertise and Hydro-Geomorphological Transformations in Seventeenth-Century Venice,” *Earth Sciences History* 39/2 (2020): 420–46.

3. and the arsenal as a place of experimental knowledge, as stressed by Galileo Galilei in his remarks at the very beginning of the *Discorsi e dimostrazioni matematiche intorno a due nuove scienze* (*Discourses and Mathematical Demonstrations Relating to Two New Sciences*, 1638):

SALVIATI. The constant activity which you Venetians display in your famous arsenal suggests to the studious mind a large field for investigation, especially that part of the work which involves mechanics; for in this department, all types of instruments and machines are constantly being constructed by many artisans, among whom there must be some who, partly by inherited experience and partly by their own observations, have become highly expert and clever in explanation.

SAGREDO. You are quite right. Indeed, I myself, being curious by nature, frequently visit this place for the mere pleasure of observing the work of those who, on account of their superiority over other artisans, we call "first rank men." Conference with them has often helped me in the investigation of certain effects including not only those which are striking, but also those which are recondite and almost incredible.³³

Second Layer of Braudel's Stratigraphy of Capitalist Civilization, Related to Economic Practices

At the level of the economic life of capitalism, one should consider mercantile investments in the territory. In their study of the Palladian Villa as *Herrschaftsstruktur* (culture of domination), first published in 1971, Reinhard Bentmann and Michael Müller remarked the indissoluble connection of aesthetics, economy and politics in the creation of this specific economic-cultural units of early-modern agriculture. The development of the *Ville* as colonial units is an economic process that is tightly connected with cultural developments, most notably new forms of architecture (symbolized by Palladio) and bucolic nostalgia. As the two social historians of architecture write,

The dialectic of the villa is one in several dimensions. The question that raises is the following. To what extent is the villa as an aesthetic phenomenon encased in economy, as an economic appearance encased in aesthetics, and to what extent are both – the idea of the 'beautiful' villa and the idea of the 'economic' villa – encased in politics? The parallelogram of forces between aesthetics, economics, politics and philosophy in the villa ultimately gives rise to the question that lies at the heart of this investigation: the overarching question of the 'villa as ideology'.³⁴

Maybe one could rephrase this thesis in terms of the villa as *material* ideology. Indeed, the reorganization of cultivated spaces has nothing to do with pure ideas but rather with power relations crystallized in the landscapes and waters management.

Upper Layer of Braudel's Material History in Relation to Capitalist Civilization

Third, can one consider the transformation of territory, the Venetian waterscapes, to be the embodiment of a capitalist civilization? Is this something that reaches beyond habits/practices and economic activities proper to any form of social metabolism? These questions deserve careful consideration. For the time being, I will limit myself to

³³ Galileo Galilei, *Dialogues Concerning Two New Sciences*, trans. Henry Crew and Alfonso de Salvio (Dover Publications, 1954), 1. See Boris Hessen, *Manuscripts and Documents on the History of Physics: A Historical Materialist Textbook*, ed. Pietro Daniel Omodeo and Sean Winkler (Verum Factum, 2022), 211–2.

³⁴ Reinhard Bentmann and Michael Müller, *Die Villa als Herrschaftsarchitektur: Versuch einer kunst- und sozialgeschichtlichen Analyse* (Europäische Verlagsanstalt, 1992), 15: "Die Dialektik der Villa ist eine in mehreren Dimensionen. Die Frage muß also weiter lauten: Inwieweit wird die Villa als ästhetische Erscheinung ummantelt von Ökonomie, als ökonomische Erscheinung von Ästhetik, und inwieweit wird beides – die Vorstellung der 'schönen' Villa wie die Vorstellung der 'wirtschaftlichen' Villa – ummantelt von Politik? Aus dem Kräfteparallelogramm von Ästhetik, Ökonomie, Politik und Philosophie in der Villa ergibt sich schließlich die Frage, die über dieser Untersuchung steht: die übergreifende Frage nach der 'Villa als Ideologie'."

acknowledging that the thesis of the capitalist aquaformation of Venice looks plausible, especially in the light of much historical-theoretical work on this site, seen as the cradle of early capitalism. I should here consider some instances but also mention one contrasting interpretation.

Giovanni Arrighi, for one, has stressed the unique character of Venice as “an enclave of capitalist rule within the medieval system,” that is, as a prototype of capitalist practices and governance. In *The Long Twentieth Century* (also drawing on Braudel’s work), he argued that Venice’s “cycle of accumulation” anticipated (even superseded in its “purity”) later hegemonies in world economy – the Dutch, the English, and the US American (and, in the perspective of Arrighi’s most recent work, the Chinese hegemony):

Venice is the true prototype of the capitalist state, in the double sense of ‘perfect example’ and ‘model for future instances’ of such a state. A merchant capitalist oligarchy firmly held state power in its grip. Territorial acquisitions were subjected to careful cost-benefit analyses and, as a rule, were undertaken only as the means to the end of increasing the profitability of the traffics of the capitalist oligarchy that at exercised state power [...].

If there has ever been a state whose executive met the *Communist Manifesto*’s standards of the capitalist state (“but a committee for managing the common affairs of the whole bourgeoisie” [according to] Marx and Engels [...]), it was fifteenth-century Venice. From this standpoint, the leading capitalist states of future epochs (the United Provinces, the United Kingdom, the United States) appear as increasingly diluted versions of the ideotypical standards realized by Venice centuries earlier.³⁵

Moreover, in *Building on Water*, Salvatore Ciriaco brings forward the thesis that the process of appropriation of the countryside and its agricultural development is comparable to the phenomenon of the British enclosures. In other words, Ciriaco sees it as a case of primitive accumulation:

The reclamation of marshy or under-used land, as well as the irrigation of terrain suitable for improvement, was one of the most important ways in which capitalism penetrated into the countryside (quite as important as the much-discussed question of ‘enclosures’).³⁶

As for the enclosures, the expropriation of the commons in Venice is an ambivalent story. It may apply to rivers and countryside, but not to the lagoon as a common.

In historical documents, the common character of the waters and the sovereignty of the Republic over them as a public domain is constantly reaffirmed in the sources; for example, in a very important proclamation of 1684, in which the interests of the Senate, the fishermen of San Nicolò, and the Magistrate of Waters converge in the common defence of the public good. On that occasion, the program of a general mapping of the lagoon was outlined, aimed to contrast claims made by private parties on certain areas, particularly the areas of the fish farming (*valli da pesca*).³⁷ For the Senate, it was a matter of asserting territorial sovereignty, particularly over the waters; for the fishermen, it was a matter of guaranteeing their right to mobility and fishing; and for the water officers, the water

³⁵ Giovanni Arrighi, *The Long Twentieth Century: Money, Power, and the Origins of Our Times* (Verso, 1994), 37. See also Giovanni Arrighi, *Adam Smith in Beijing: Lineages of the Twenty-First Century* (Verso, 2007).

³⁶ Salvatore Ciriaco, *Building on Water: Venice, Holland and the Construction of the European Landscape in Early Modern Times* (Berghahn Books, 2006), 16.

³⁷ Archivio di Stato di Venezia, *Compilazione leggi Pesca, Pescaria, Pescatori, Pesce (1314–1786)*, 1050r: “Nelli riflessi debiti alla soddisfazione dell’incombenze del Magistrato con la mira d’obbedire alli Decreti dell’Eccellentissimo Senato 19 Agosto e 13 Novembre decorsi seguiti a supplicatione anco del fedel Popolo di S. Nicolò, suo Gastaldo, e Compagni per poner li confini all’Acque Pubbliche col zelo verso la Patria nella Materia importantissima della Laguna, e Porti, da che dipende la preservatione, salute, e Libertà della medesima.”

technicians of the republic of Venice, it was a matter of monitoring the state of the lagoon and preserving it.³⁸ The historical case of the mapping of the public waters opens up the political-epistemological question of governance and the relation between water management, knowledge and political regimes.

Historical epistemologist and economist Grossmann presented his own views on the succession of economic hegemonies in *Das Akkumulations und Zusammenbruchsgesetz des kapitalistischen Systems* (i.e. The Law of Accumulation and Collapse of the Capitalist System). There, he looked at the medieval maritime republics in order to detect the roots of the present and anticipate the future. He was as much interested to trace the origins of capitalism as to anticipate its end – just like his fellow countrywoman Luxemburg, with whom he debated on the tendencies of capitalist society. As one reads with respect to the liaison between war and capitalism:

[Wars] have always accompanied capitalism since its first appearance on the historical stage [...]. From its historical birth, originally in the form of commercial capital C–M–C, and then in the form of the final subordination of all production and sales relations to industrial capital M–C–M, up to the present day – capitalism has always been belligerent, and the history of capitalism is at the same time the history of uninterrupted commercial and economic wars. [...].

Amalfi, which of all Italian cities was the first to show the beginnings of capitalist development and entered into trade relations with Syria, Palestine and Egypt, lost its independence as early as 1130 and its fleet in 1135: its rivals, the Pisans, attacked Amalfi, destroyed its fleet and plundered the city. From the 12th century onwards, the battles between the victorious Pisa and its new opponent, Genoa, continued uninterrupted. Both powers tried to oust each other from Syria and Palestine, robbing each other of goods and setting fire to their factories until Pisa, economically weakened, was also defeated militarily at the Battle of Meloria in 1284. In 1290, the Genoese destroyed the port of Pisa, Portopisano, and buried the mouth of the Arno River. But as soon as Pisa was no longer a rival, Genoa began a new, long-lasting war. A new economic struggle began between Genoa and Venice. Both cities dominated the markets through their trading fleets, the establishment of factories and the concentration of banking and financial transactions in their own hands. They destroyed each other's factories, looted goods and blockaded the ports. As early as the 13th century, a bloody colonial war began between the two cities, which drew the whole of Syria and the Mediterranean into the battle, and this only stopped when the common enemy, the Saracens, had already conquered Antioch and Tripoli.

With the emergence of the modern territorial great states in the 16th century, the same policy continued [...].³⁹

³⁸ See Solène Rivoal, "Agir en être collectif: L'État, la communauté des Nicolotti et l'approvisionnement de Venise à l'époque moderne," *Tracés: Revue de Sciences humaines* 29/2 (2015): 65–84; Solène Rivoal, *Les marchés de la mer ; Une histoire sociale et environnementale de Venise au XVIIIe siècle* (Publications de l'École française de Rome, 2022).

³⁹ Henryk Grossmann, *Das Akkumulations und Zusammenbruchsgesetz des kapitalistischen Systems* (Hirschfeld, 1929), 48–49: "[Kriege haben] den Kapitalismus tatsächlich seit seinem ersten Erscheinen auf der historischen Bühne stets begleitet [...]. Von seiner historischen Geburt an, ursprünglich in der Form des Handelskapitals W–G–W, und dann in der Form der endgültigen Unterordnung aller Produktions- und Absatzverhältnisse unter das Industriekapital G–W–G, bis auf den heutigen Tag – immer war der Kapitalismus kriegerisch, und die Geschichte des Kapitalismus ist zugleich die Geschichte der ununterbrochenen Handels- und Wirtschaftskriege. [...]"

Amalfi, das von allen italienischen Städten zuerst die Anfänge der kapitalistischen Entwicklung zeigte und in Handelsverbindungen mit Syrien, Palästina und Ägypten getreten ist, hat bereits 1130 seine Unabhängigkeit und 1135 seine Flotte verloren: seine Konkurrenten, die Pisaner, überfielen Amalfi, vernichteten seine Flotte und plünderten die Stadt. Vom 12. Jahrhundert an ziehen sich ununterbrochen die Kämpfe zwischen dem siegreichen Pisa und dem neuen Gegner, Genua hin. Beide Mächte bemühen sich, einander aus Syrien und Palästina zu verdrängen, rauben sich die Waren, setzen ihre Faktoreien in Brand, bis Pisa, wirtschaftlich entkräftet, in der Schlacht bei Meloria 1284 auch militärisch besiegt wird. Die Genueser zerstören 1290 den Hafen von Pisa, Portopisano, und verschütten die Mündung des Arno-Flusses. Aber kaum der Konkurrenz Pisas ledig, beginnt Genua einen neuen langdauernden Krieg. Es beginnt ein neuer Wirtschaftskampf zwischen Genua und Venedig. Beide Städte beherrschten die Märkte durch ihre Handelsflotten, durch die Gründung von Faktoreien, aber auch durch die

To sum up, according to historians of capitalism, such as Grossmann and Arrighi, Venice is one of the most significant sites to consider for a reconstruction of successive phases of the development of capitalism according to a reenactment of the narrative of the *translatio imperii*, which is understood in economic terms rather than as a succession of suzerain rulers.

From the viewpoint of the global history of capitalism and its cycles, it is interesting to consider the passage of capitalist hegemony from Venice/Genoa to the Netherlands (e.g., according to Arrighi) in connection with the history of technology and the Scientific Revolution, in its migration (as it were) from Renaissance Italy to northern Europe, in particular the Netherlands, France, and England.⁴⁰ The comparison with the Netherlands is particularly interesting as both republics were deeply engaged in politics of water management and control. Ciriaco Ciriaco calls them *civilizations d'eau*. Indeed, Venice and the Low Countries have been paradigmatic for the study of territory transformation and hydraulic engineering in early modernity.

Moreover, Ciriaco argues that the degree of development of the capitalist background marks a significant difference between Venice and the Netherlands:

A comparison of Dutch *regenten* and Venetian *rentiers* immediately brings out the differences between the situations in the two states. [...] Here one must look at the way the drainage operations were carried out [...]. In the Low Countries, owners determined to reclaim new land for agriculture, while in the Venetian Republic they were carried out by patricians, who could be said to have imposed relations of productions that were much more feudalistic than capitalistic.⁴¹

Thus, this interpretation questions the capitalist essence of Venice's aquaformation vis-à-vis later social formations, in contrast with the interpretations of Braudel and Arrighi. This triggers further inquiries into the capitalist economic-ecological interface of Venice. For the time being, I should limit myself to addressing the problem and presenting relevant historiographic perspectives. It can be added though – in line with Wallerstein and others' reflections on global interdependencies and unequal exchange between imperial/capitalist centres and peripheries – that capitalism and feudalism are not incompatible but rather coexisted for long time and were mutually supportive on many occasions, especially in terms of making the exploitation of unpaid labour possible, together with colonialism and slavery. Venice's internal colonialism could represent an instance of capitalist-feudal relations.⁴²

Conclusion: Venice's Water Civilization as a Paradigm of Capitalist Aquaformation

Water in early modern Venetian hydrology is a complex issue. One would be tempted to talk about a totality in motion or a holistic phenomenon since hydrology can be never isolated from its ecological and social contexts.⁴³ Of course, contextualism goes counter widespread engineering delusions about the absolute validity of abstract

Konzentration der Bank- und Geldgeschäfte in eigenen Händen. Sie zerstörten sich gegenseitig die Faktoreien, raubten die Waren, blockierten die Häfen. Bereits im 13. Jahrhundert begann zwischen beiden Städten ein blutiger Kolonialkrieg, welcher ganz Syrien und das Mittelmeer in den Kampf hineingezogen hat, und dieser hörte erst auf, als der gemeinsame Feind, die Sarazenen, bereits Antiochien und Tripolis eroberte.

Mit der Herausbildung der modernen territorialen Großstaaten im 16. Jahrhundert wird dieselbe Politik fortgesetzt [...]."

⁴⁰ Pietro Daniel Omodeo, "Scientific Revolution, Ideologies of the," in *Encyclopedia of Early Modern Philosophy and the Sciences*, ed. Dana Jalobeanu and Charles T. Wolfe (Springer Online, 2020): 1–10.

⁴¹ Salvatore Ciriaco, *Building on Water: Venice, Holland and the Construction of the European Landscape in Early Modern Times* (Berghahn Books, 2006), 171.

⁴² On this, see also Silvia Federici on early-modern capitalism, patriarchy, biopolitics, and colonialism: Silvia Federici, *Caliban and the Witch: Women, the Body and Primitive Accumulation* (Autonomedia, 2004).

⁴³ See Jeremy Schmidt, *Water: Abundance, Scarcity, and Security in the Age of Humanity* (New York University Press, 2017), 4: "Water was the agent that connected Earth's geological processes to social life. To manage water, then, was to manage the conditions that made social life possible."

models of water flow and the technocratic ideal of problem-solving management detached from all interests and values. In this sense, Venetian water heritage is a geoanthropological issue par excellence. It closely connects knowledge of the territory and its social management. This working paper has considered the possibility of developing an adequate approach to hydrosocial contexts by examining the case of the Lagoon of Venice as a cultural–natural artefact from the intertwined perspective of environmental history, economic history, and historical-political epistemology. It takes clues from externalist history of science (in particular Hessen's), *longue durée* history (in particular Braudel's), world systems theory (in particular Arrighi's) in order to understand early modern processes of aquaformation; that is, the anthropic transformation of the watery territory of Venice, capitalism, and their connection with emergent socio-ecological formations in the late Middle Ages and the modern era.

The literature on Venice as the medieval cradle of capitalist civilization, from Marx onwards, and on the same city as the paradigm of the Anthropocene, is extensive, but the two aspects have been hardly studied together. By dealing with Venice's waters as a cultural heritage, I here thematize the historicity of a fluid landscape that is rooted in societal processes of capitalist accumulation and, at the same time, I point to the sense of urgency of preserving this geoanthropological environment for future generations in view of both ecological sustainability and social sustainability. However, as reality is historical and marked by agency, the interaction between societies and their settings, preservation means redirecting and guiding future transformations according to visions and ideals that need to be established, negotiated, agreed upon, or affirmed through struggles. From history, one can learn about republican forms of management of Venice's waters as a common. Even though we must avoid the temptation of idealizing the past, it is important to take inspiration from it to rethink the manners in which society can address and manage the commons, first of all waters, in more socialized and democratic ways.

In short, the main historical-critical points concerning the historical epistemology of Venice here raised are the following:

1. Human labour is inscribed in waterscapes as is witnessed by the case of Renaissance Venice and its comparison with the distant past (the Roman centuriation) and later developments (e.g. in the Golden age of Dutch hydraulics).
2. The transformative metabolism of society in its relationship with territory is linked to technological practices (engineering, machines, etc., their mobilization and uses), which ought to be understood in connection with scientific codifications and societal values.
3. Waterscapes are a document of economic processes and ecological changes which are in reciprocal transformative relation.
4. A political question looms large over the ecological-economic issues relative to water management. It relates to the institutions, political conditions and actors who took the decisions that constitute material path-dependencies visible in waterscapes.
5. Processes that involve the transformation of ecosystems have an aesthetic and epistemological dimension that can be termed a dialectics of economic interests and cultural politics. Indeed, the question of the function of environmental agency has, besides the economic and technological dimension, also an ideological component, which needs further exploration in the realms of belief systems, metaphysics, and cosmology. I here mentioned the Palladian villa as a case of material ideology linked with developments in the organization of the territory and agriculture.
6. The question of scientific abstraction and the political question of sufficient abstraction also needs to be furthered. This problematic relates the efficacy of science to societal goals, guided by hegemonies and

power relations, which determines the level of abstraction that is adequate to the political a priori that sets the meaning and objectives, that is, the criteria of the efficacy of knowledge.⁴⁴

To summarise, the historical epistemology of water heritage in Venice is here discussed as a socio-ecological history of territorial transformation triggered by economic interests, political agendas, cultural imaginaries, social and technological practices, and forms of knowledge. All of these lines have been here considered in relation to the macro-question of the relation between water management and the emergence of a “capitalist civilization” in Braudel’s understanding of this expression. Venice is a paradigm of cultural-natural transformations including from the viewpoint of the ecology of capitalism.

⁴⁴ I explore this topic together with Justas Patkauskas in the forthcoming paper “Water Knowledge Economy in Early Modern Venice,” in *Natural Resources in Early Modern Economies of Knowledge*, ed. Pietro Daniel Omodeo and Helge Wendt (Harrassowitz, in print).

Land, Labour, Water and Crop in the Kaveri Delta of South India

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Introduction

In this article, we draw on the emerging fields of environmental history and the history of science. Historians such as Fernand Braudel have shown such a possibility of studying economic systems of a particular landscape. Our attempt involves the study of four distinct moments in south Indian history that have shaped the landscape of the Kaveri Delta. The objective is to consider the changing forms of value, and how new forms of extraction altered the social relations in this landscape. We use the *longue durée* approach to our advantage to span our study over a millennium. However, we dwell deeper into each particular moment so that the *longue durée* shines even better, almost as if we stop at each station, linger and zoom in, and not just pass on to the next station. Second, there is the distinct advantage that a very strong empirical inquiry offers when we are at the beginning of this intersection between environmental history and history of science. Because, if environmental history foregrounds the relationship between land, crop, and water in this landscape, to us, labour becomes the prism to understand the historical transformations.

However, in the relationships between labour, land, water, and crop, we need to see how knowledge practices do not necessarily manifest only in the management practices of this relationship but are also grounded in the very way these objects of knowledge were conceived, conceptualized, and then reshaped continuously. In this essay, we will briefly go through a very long historical period from the medieval to the contemporary, situated in one particular landscape. First, a medieval South Indian moment from about the 9th century to the 12th century, when the core deltaic area becomes the seat of the Chola empire, fundamentally constituting this landscape as one of extensively canal irrigated wetland rice cultivation and the consolidation of society entrenched in hierarchies of social relations. Second, the British colonial period, when an apparatus of water management emerged to cater to the needs of the growing empire. Third, the postcolonial moment, when the newly independent Indian nation-state reengineered the same landscapes to fulfil its planning for food security of its people. The fourth moment is the current climate change period, when another round of re-engineering is being undertaken in the guise of climate adaptation programmes.

River Kaveri and Its Delta

Like for most rivers in south Asia, the monsoon cycle is the lifeline of Kaveri. Its deltaic region located in the south eastern part of India has been historically shaped by alternating floods and droughts. Kaveri and its many tributaries, carrying the flood that the South West monsoon pours on the western highlands, along with the silt congregate to form one stream, the main river Kaveri. This, then, divides into many distributaries meandering through the plains as they settle the sediments, to form a fan shaped delta, when it drains into the Bay of Bengal on the eastern coast. The cyclical flow of winds and precipitation has shaped the delta significantly and has kept people's life in the region amphibious, for thousands of years.

The Kaveri delta is one of the few landscapes to have witnessed continuous transformations for over a millennium, leaving their footprints as visible traces on its land, rivers, canals, wetlands and on its people. As climate change makes itself felt in the rivers and deltas of the world, it has become important to study landscapes such as the Kaveri delta. We need to understand the changing ways in which humans and natural systems have shaped each other, to help us imagine alternative and better possibilities.



The Medieval Moment in the Delta

The first moment spans the period between the 8th and 14th centuries. During this period, the Kaveri delta served as the core region of the Chola empire.¹ This empire intensified rice cultivation, creating a centralized revenue administration that would control this canal irrigated wetland rice fields through slave labour, which remained the foundation of production in this time.

Labour and Canal Infrastructure

Controlling a meandering river has been one of the greatest tasks of the Chola rulers. The heavy silt content of the river deposits on the beds of these water bodies, making them shallower, and may eventually change the course of the channel and render them unfit for irrigation. Hence, as much as larger infrastructures such as embankments are crucial in preventing the river from breaching, so was the annual maintenance of channels and rivers. Looking at the taxation system of the Chola state would show us how labour was organized for this grand task.

There were two mandatory taxes that were to be paid by a landowner seasonally. One in the form of paddy, paid to the king called the *kaṭamai*; the other was paid in the form of labour called *kuṭimai*. The latter consisted of a cluster of taxes that were administered at the local level by village administrative bodies. They were generally paid by the tenant cultivators, who cultivated lands owned by the Brahmins, the Vellala landlords and the temples.² It is also clear through several inscriptional evidence that the tenant cultivators had rights to own slaves.³ This slave labour was used to fulfil the labour tax obligations of the tenant cultivators and land owners.

One of the common terms that is used to denote the compulsory labour tax is *vetti*, which is a transformation of the Sanskrit word *viṣṭi*. According to Uma Chakravati,⁴ the term found across India has denoted forced labour that is demanded from the poor and extracted through debt bondage, and “the earliest reference to *viṣṭi* as used in agriculture dates back to 8th century AD.” The Tamil term of *vetti* in the Chola inscriptions appears with the prefix *cennīr* (fresh water in the literal sense) denoting the labour tax that is being demanded from the tenants for the purpose of canal maintenance and irrigation expansion. There also other labour taxes such as *āḷamañci* and *kōḷarai* that denote irrigation related manual labour. This form of control over labor becomes integral to the emergence of a canal-irrigated infrastructure, making the expansion possible.

We find remnants of these expansion efforts both in physical forms as well as in social practices. Sluice heads constructed in the 12th century under the Cholas found on the northern and southern banks of the Kaveri river in modern day Tiruchirapalli district are still being used as structures of water regulations.⁵ A practice that was followed in a village in the western part of the delta in 1950s that is similar to *kōḷarai* (the practice of desilting the riverbed with each group or person given a measured stretch to desilt) has been documented by anthropologist

¹ Y. Subbarayalu, “Changes in Agrarian Relations in the Kaveri Delta, c. 900–1300,” *Social Scientist* 38, no. 7/8 (2010): 44–52.

² Land ownership in the Chola society was concentrated among the two groups of people. One, the priestly upper caste Brahmins, who were prevented from indulging in any physical work. They received land through various donations made by the King and nobility. Second were the Vellalas, who generally were agriculturalists, but were part of the power structure. Vast amount of land also accumulated with temple, again through land donations by the nobility and royalty over the period of the Chola rule. All land owned by Brahmins and Temples were cultivated by tenants who were mostly Vellalas. While some of the Vellalas cultivated their own land, large estates were cultivated by tenant cultivators.

³ *Annual Report on Epigraphy, 1918* (Archaeological Survey of India, 1986), no. 538 (1177 CE).

⁴ Uma Chakravarti, *Everyday Lives, Everyday Histories: Beyond the Kings and Brahmanas of Ancient India* (Tulika Books, 2006), 84.

⁵ H. Krishna Sastri, eds., *South Indian Inscriptions, Vol. 4* (Archaeological Survey of India, 1986), no. 394, 395, 396.

Kathleen Gough⁶, where at the wake of the arrival of water in the river, landless dalit labourers are employed by the Brahmin village head to desilt the canal, with each group of labourers assigned with one measure of the stretch to be desilted.

Brahmadeya Expansion and the Square Grid

This expansion in irrigation and establishment of control over labour happened along with the creation of a new kind of settlements called the Brahmadeyas, which are exclusively Brahmin settlements. Settling Brahmins in villages and donating them land with complete tax waiver or concession has been practiced in Tamil region since at least the fifth century. During the Chola rule, this creation of exclusive Brahmin villages was carried out at a large scale, concentrated heavily in the Kaveri delta region where irrigated wet paddy cultivation was possible.

At many instances these donations of a whole village or a piece of land meant bringing new land under cultivation. One example is the land donation that was made to the Tirunallam temple in the year 980 CE by a member of the royal family. This grant inscription explains in detail how the land that was donated to the temple was demarcated.

we, the residents of the district, saw the royal order (*coming*), went to meet (*it*) worshipped, and placed (*the order*) on our heads, marked out the boundary, led round the female elephant and circumambulated the hamlets of the land of *Kiladakuvilai* of which the boundaries are: ...⁷

Having explained the boundaries of the land that is to be donated in great detail, the inscription goes on to say that all the land in these two villages.

village sites, houses, house-sites, open spaces, wasteland where cattle graze, tanks, threshing floors, anthills, halls (?), jungle, pidiligai, barren grounds, saltish grounds, hollow grounds, reservoirs, dykes, creeks, rivers, river-beds, pits where fish exist, hollows where honey is gathered, trees growing up and wells sunk below, with every kind of land where the iguanas run and the tortoise crawls, without excluding any portion of land (included in the boundary) replacing its previous owners and removing its tenants, were granted tax free as devadana, nandavanapparru (garden land), and salaboga including Karanmai (right to cultivate) and Miyatchi (right over ownership).⁸

While the description of the various landscapes and ecological elements that signify wilderness are included in this, similar passages have been used elsewhere in Chola inscriptions across various regions to signify bringing new regions into cultivation and to establish the complete ownership of the land which is being transferred to the beneficiary, in this case the God. The existing owners or users of the land are uprooted from the land, or their right over land is being transferred to the Brahmins or to the temple.

The inscription further explains the digging of a new canal to irrigate all these lands, and “others shall not cut and dig out diversions from these channels, nor put up small picotas, nor bail water by basket, nor obstruct the flow with crossbanks,” establishing exclusive right over the water for purpose of temple alone.

⁶ Kathleen Gough, *Rural Society in Southeast India* (University of British Columbia, 1981), 221.

⁷ H. Krishna Sastri, eds., *South Indian Inscriptions, Vol. 3, Parts III and IV* (Government of India, 1929), no. 151, 308 (980 CE).

⁸ H. Krishna Sastri, eds., *South Indian Inscriptions, Vol. 3, Parts III and IV* (Government of India, 1929), no. 151, 310 (980 CE).

Agricultural land in these villages were reoriented in the shape of square grids, with canals running east to west and drains running north to south intersecting the canals. Traces of these square-grid patterns are still visible in some of these brahmadeyas. A modern map of Devarayanpettai, a village near Kumbakonam shows us this grid pattern quite clearly.⁹

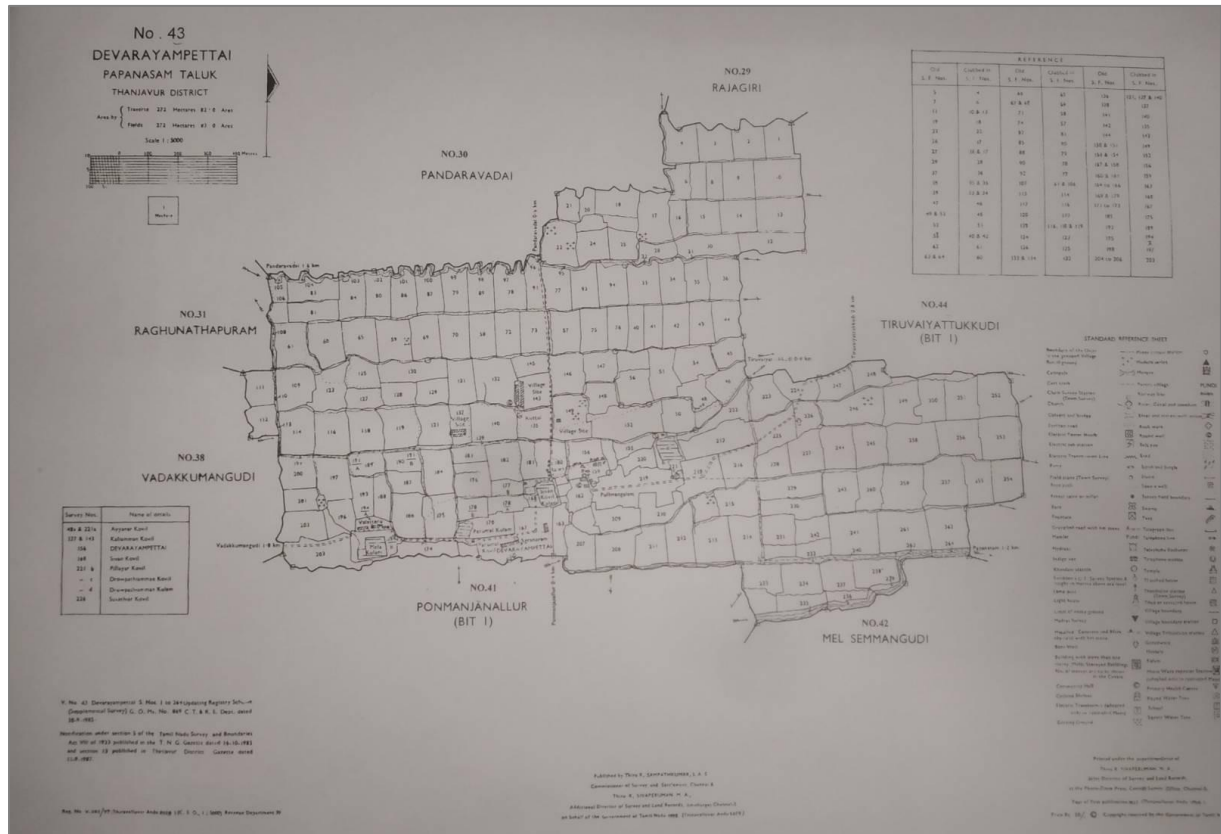


Figure 1. Village map of Devarayampettai in modern day Thanjavur District, showing the square grid organisation of irrigation canals and drains (Source: Commissionerate of Survey and Settlement, Government of Tamil Nadu).

These patterns could be found in inscriptions since at least the 10th century, where in, each square is numbered, and each canal and drain are named and all the land is graded. “6 mā of land in the 8th kaṇṇāru (branch canal) to the west of caṇṭēsvara vati(drain), and 4th kaṇṇāru to the south of cōlacūlāmaṇi vāykkāl (canal).”¹⁰ One could observe an expansion of this meticulous addressing of even a very small piece of land in relation with the canal that irrigates the land and the drain that empties it within the square grid. In contrast to this, we find a very vague addressing system for a dry or waste land that is yet to be converted to cultivable land, mentioning just the natural landmarks that form its boundary and the area of the land. This expansion of irrigation networks along with the creation of Brahmadeyas brought new areas of land under cultivation and reorganized the landscapes, aligning a particular relationship between rice cultivation, water infrastructure and labour relations to make it all seem perpetual, under the constant watch of the ruling elite.

⁹ H. J. Nitz “Order in Land Organisation: Historical Spatial Planning in Rural Areas in the Medieval Kingdoms of South India,” *Explorations in the Tropics. Prof. KR Dikshit Felicitation Volume Committee, Pune* (1987), 258–79.

¹⁰ G. V. Srinivasa Rao, eds., *South Indian Inscriptions, Vol. 19* (Archaeological Survey of India, 1970), 66.

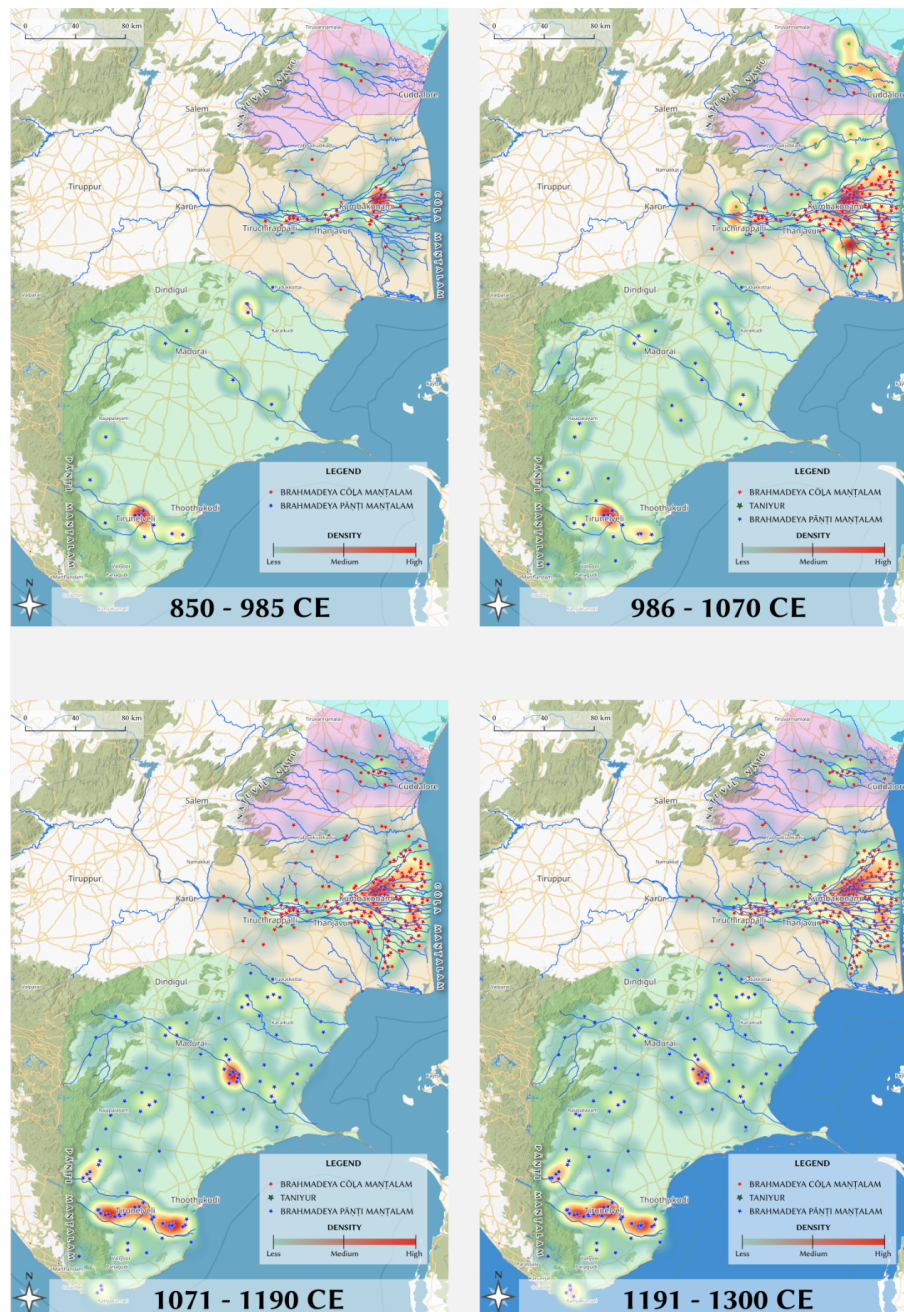


Figure 2. Expansion of Brahmadeya settlements under the Cholas. Source: Map designed by Ganesh Gopal, based on data collected from epigraphic sources by Y. Subbarayalu

Brahmadeya land grants were a crucial mechanism by which canal irrigation infrastructure was reshaped, along with the strengthening of existing labour control mechanisms. This map shows the expansion of Brahmadeya land grants under the Chola rule over a span of four centuries, divided into four phases of the Chola empire's duration. During the pre-imperial chola phase, the concentration of Brahmadeyas is on the western side of the Kaveri delta. This is where the early inscriptions of labour control and infrastructure expansion are found. Such efforts ensured continuous rice cultivation in an economy where rice was paid as tax, as wages and as a means of exchange in society. Information about rice as means to fulfil the needs of hunger and for consumption by the labourers or even by the tenants and how did they allocate for tax or rent is not clear from the evidence available.

During the imperial phase, we see further expansion of the new Brahmadeyas, spreading into the south and eastern part of the Delta. We can also see how the number of Brahmadeyas around other river basins both in the South and North of the Kaveri Delta increases. By about the 14th century, a vast network of canal infrastructure and rice cultivation was institutionalized and consolidated. Evidence from this period helps us in understanding the relationship between crop, labour, and water when a hegemonic model of water management through the utilization of slave labour reorganized land relations. This mechanism was instituted, legitimized, and normalized to such an extent that everybody else who arrived into the delta, had to contend with this infrastructure, that was as much administrative as it was social.

The British Colonial Intervention in the Delta

Following the decline of Cholas around the 13th,¹¹ there comes a century of a no powerful state until the Vijayanagara empire takes over the Tamil speaking regions, including the Kaveri Delta in the 14th century.¹² However, for the Vijayanagara empire, Kaveri delta did not constitute the core region. Fragmentation of the Vijayanagara empire in the 17th century led to the formation of smaller kingdoms, and the Kaveri delta region came under the Thanjavur Nayakas, who were soon replaced by the Thanjavur Marathas.¹³ There has been little study done on the social and geographical changes that take place in the Kaveri Delta region during these long periods of transformations. The number of temple inscriptions available from these periods are also much lesser in comparison with inscriptions from the Chola period. Though existing studies point out to the emergence of new caste groups and new alliances among different caste groups during the Vijayanagara rule.¹⁴ The Nayaka and Maratha periods are marked by the rise of large-scale land owners, which include individual landowners from both Brahmin and non-Brahmin castes¹⁵ and religious institutions like Mutts and Temples.

Extraction of resources and labour was prevalent in Thanjavur even when the British took over the region, as noted by one early report of an East India Company officer, where he talks about the existing disparity among different cultivators.¹⁶ Similarly paddy continued to remain the major crop, while compulsory and customary labour was used for canal maintenance works.

While the British East India Company took over Tanjore in 1799, after almost half a century of instability and occupations, it was not in the ideal state of generating increased revenue. The company had to make significant interventions. One of the important ways in which the British attempted to intervene in revenue extraction is through the institution of private property rights on paper. Several rounds of experiments were made by the early colonial officers such as the Mirasdari, Mittadari and village lease system. Each of them failed in effective collection of revenue, and eventually the Ryotwari system of taxation was established. According to the Ryotwari system, every

¹¹ Noboru Karashima, "Landholding in Chola Times," in *History and Society in South India: The Cholas to Vijayanagar* (Oxford University Press, 2001): 3.

¹² Noboru Karashima, "The Emergence of Medieval State and Social Formation in South India," *International Journal of South Asian Studies* 1 (2008): 11–29.

¹³ S. Chinnaiyan, "Tax Structure in Tanjore Kingdom under the Nayaks and Marathas (AD 1532–1799)," in *Proceedings of the Indian History Congress*, vol. 66 (Indian History Congress, 2005): 456–9.

¹⁴ Noboru Karashima, *Towards a New Formation: South Indian Society under Vijayanagar Rule* (Oxford University Press, 1992), 155.

¹⁵ Saraswathi Menon, "Historical Development of Thanjavur Kisan Movement: Interplay of Class and Caste Factors," *Economic and Political Weekly* (1979): 403–8.

¹⁶ C. Harris, "A New System to Secure Tanjour Against The Invasion of the People – 60% for Government, 40% for the People (1800)."

direct cultivator of the land would be given a title deed of the land that they directly cultivate. This way, they become the direct tax payer to the state, thus eliminating intermediaries.¹⁷

Land relations were reorganized in relation to a system of tax revenue from land as they introduced private property relations. The British considered cultivation as the major means to source revenue from land, and forms of labour control were aligned to this particular objective. Because of this shift in the meaning of relations between taxation and land relations, we find a very distinct regime of irrigation shaping up under the British colonial rule.

The urgent motive of the British irrigation management in the early half of the 19th century, was to prevent siltation in the bed of river Kaveri, in the early decades of gaining control over Thanjavur, the core area of the Kaveri Delta. Colonial engineers feared that heavy siltation at Kallanai¹⁸ (the point where the river enters the delta) might eventually divert the course of the river. Several attempts were made to desilt the river, all going in vain as the new floods in the subsequent year would again silt up the bed. A permanent solution was provided by a military Engineer Arthur Cotton. He built a Dam in the upstream distributary of the river thus diverting more water into the main channel, and ensuring more inflow into the deltaic irrigation network. Though this was never a permanent solution, more and more improvisations had to be made to the infrastructure in the following decades, to keep tackling siltation.¹⁹ This relationship that the colonial water managers had with silt, would continue to shape their understanding of rivers, as silt became a huge liability for modern water irrigation management instituted by the colonial powers.

Once the issue of siltation at Kallanai was tackled, irrigation in the deltaic region was expanded, resulting in better returns to the colonial state in terms of land revenue. This led to the construction of more such regulatory infrastructures, diverting floods and excess water to water deficient regions thus not only expanding irrigated regions within the delta but also expanding the number of seasons in which paddy was cultivated. Lands that produced a single crop of paddy per year were quickly converted to double cropping, again resulting in increased revenue. Arrival of hydraulic cement and geared shutters refined this control over the flow of water further.²⁰ Dams were built at every nodal point where the river further divided, thus ensuring greater control over the flow of water. Such an infrastructure marked by different kinds of regulators of water flow, such as the head-regulator, tail-end-regulator, cross-regulator, etc., catered to the needs of the colonial engineering. By the second half of the 19th century the promotion of rice cultivation into two crops almost became normalized.

In order to attain further control over the river and the delta, and to further expand both the irrigated area and number of crops, a large multipurpose dam project was designed and built in the early 20th century. This project called the Mettur Dam Project, built farther upstream, intended to store excess water thus preventing floods and letting water during drier seasons, also was meant to be preventing droughts.²¹ The storage and meticulous regulation of water made sure by precise measurement at every node, gave rise to a discourse of wastage that

¹⁷ Sarada Raju, "The Agrarian Structure of the Madras Presidency: Impact of British Administration," in *Proceedings of the Indian History Congress*, vol. 35, 265–72 (Indian History Congress, 1974).

¹⁸ Kallanai is a pre-colonial infrastructure that is built to regulate the flow of water into the Kaveri delta irrigation system. It sits between Kaveri and Ullaar. Ullar is a small branch river that connects Kaveri and its major tributary Kollidam. Regulating water that flows into Kollidam becomes crucial because Kollidam runs straight into the sea, while Kaveri expands into a large network of canals irrigating a vast landscape. Kollidam acts as a major drain during the times of flooding, also water needs to be prevented from flowing into Kollidam during drier seasons to ensure cultivation within the delta. Subramanian, C. N. *Aspects of the History of Agriculture in the Kaveri Delta C. 850 to C. 1600*, M. Phil Dissertation submitted to the Centre for Historical Studies, Jawaharlal Nehru University (1983).

¹⁹ Aditya Ramesh, "Indian Rivers, 'Productive Works', and the Emergence of Large Dams in Nineteenth-Century Madras," *The Historical Journal* 64, no. 2 (2021): 281–309.

²⁰ Rohan D'Souza, "Supply-Side Hydrology in India: The Last Gasp," *Economic and Political Weekly* (2003): 3785–90.

²¹ C. G. Barber, *History of Cauvery-Mettur Project* (Government Press, 1940), 7.

branded any water that was let out into the sea as waste. This discourse dominates the political discourses on Kaveri River water usage, and it becomes the moral duty of the Engineer to ensure every drop of water is being used, and not “wasted” into the sea. This wasteful flow of water and the prevention of wasteful siltation in the riverbed, continues to remain two big liabilities for modern water engineering and finds its origin in British colonial engineering.

This colonial engineering of the landscape and its agrarian practices, made rice as one of its chief commodities. Rice of Thanjavur was exported to the new frontiers of the British empire, to feed the labourers who helped expand the empire by transforming tropical forests in places like Burma, Malaya and Ceylon into plantations.²² The labour which became skilful and expert in rice cultivation in deltaic areas, became equal commodity to be exported into new areas where the British colonial state was expanding the rice cultivation, such as the lower Burmese delta.²³

The Independent Indian Nation-State and the Delta

The third moment under our consideration is when the independent Indian nation state intervened in the Delta. In terms of irrigation development, the modern Indian state took up the practice of building large dams to serve storage and to feed cultivation to ensure food security to its people, as well as to feed the growing nation with electricity.²⁴ Kaveri basin, particularly the Tamil Nadu portion of it, was dotted with several large-scale and small-scale multi-purpose dam projects in the first few decades of independence.²⁵

Attempts to modernize agriculture by introducing chemical fertilisers and machinery, led the Indian Nation state to introduce the Intensive Agricultural District Program in the 1960s. Several districts from across the nation were selected to pilot this modernisation and thereby expand it throughout the country. Thanjavur was one among the many. This intervention was done with international aid, from aid through organizations such as the Ford Foundation and the MacArthur Foundation, in the days before the Bretton Woods institution. This project intensified paddy cultivation in Thanjavur not by expanding the area of cultivation, but by developing and introducing seeds that could mature earlier, thus shrinking the crop seasons to accommodate one more crop within the existing climatic conditions.²⁶ The archives of these aid agencies are opening slowly, and more work needs to be done in these archives.

In about less than two decades, under the IADP program, the credit, the consumption of pesticide, chemical fertilizers, proportion of land under the high yielding varieties, and filter point wells dramatically increased into the same landscape. While the other transformations that were discussed earlier took place in centuries, the post-colonial independent nation state with foreign aid brought changes at a massive scale.

²² Kathleen Gough, “Agrarian Relations in Southeast India, 1750–1976,” Review (Fernand Braudel Center) (1978), 25–53.

²³ Ritesh Kumar Jaiswal, “Indian Labour Emigration to Burma (c. 1880–1940): Rethinking Indian Migratory Patterns,” in *Proceedings of the Indian History Congress*, vol. 75 (Indian History Congress, 2014), 911–919.

²⁴ Rohan D’Souza, “Framing India’s Hydraulic Crises: The Politics of the Modern Large Dam,” *Monthly Review* 60, no. 3 (2008): 112.

²⁵ NRSC, CWC, “Cauvery Basin Report,” (2014).

²⁶ M. D. Gopalakrishnan, “Productivity and Profitability of ADT-27 in Thanjavur District,” *Indian Journal of Agricultural Economics* 23, no. 4 (1968): 65–9.

Table 1. Elements of Green Revolution in the Kaveri Delta²⁷

Year	Newly constructed filterpoint wells	Proportion of lands under HYV	Consumption of chemical fertilizers (tonnes)	Consumption of pesticides (tonnes)	Co-op. credit (Rs. in thousands)
1960/61	243	negligible	31034	271	1481
1968/69	1532	35.5	164263	8225	45107
1969/70	1557	76.9	183229	8111	49894
1970/71	956	83.4	212536	10050	58438
1971/72	1400	92.8	247375	12134	78927
1972/73	1503	91.6	267704	13305	95837
1973/74	1548	95	272439	10596	120479
1974/75	685	93.5	218304	5305	155805
1975/76	1857	94.6	314825	17037	203812

Source: Kathleen Gough, "Rural change in southeast India 1950s to 1980s" (1989).

It is important to note that the focus of the state shifted from expanding control over water to that of agricultural practices. Precise measurements and control over the new agricultural practices, fertilizers, pesticides and other chemical supplements and a whole army of officers to monitor and regulate the same are brought upon to bear on the delta. This resulted in the forking of the landscape into administrative divisions, divided into the agricultural district and the water/irrigation district. These two became two different departments under the state administration. The Public Works Department controlled water, while the Department of Agriculture controlled rice cultivation. And both failed to speak to each other concurrently. This forking away from two different disciplines instituted different systems of labour control.

As a result of this, the existing large-scale ownership of land continued and thrived, as these interventions benefited the large landowners directly and not the tenants and landless labourers. This also meant control of labour prevailed and was reinforced through caste hegemonies. The IADP introduced new kinds of control by traders and rice-mill owners, who till today continue to control the localized agrarian economy. This forking of the division between agriculture and water management also reflected in how traders and the millers, were gaining control over the agrarian society.

The labour movement of landless labourers and tenants of the delta which had started in the 1940s intensified during this time. This mobilization of labour, went along with the promotion of rice cultivation from a two-crop to a three-crop region and became a very highly dynamic radical political movement led by agricultural labourers, whose demands were of redistribution of land as much as increase in wages.²⁸ This moment shows how a distinct regime of labour in relation to a regime of three-crop rice cultivation, while letting control of water management entirely to the purview of the state, creates a different regime of ownership in land, as well as control over labour and rice.

²⁷ Kathleen Gough, *Rural Change in Southeast India 1950s to 1980s* (Oxford University Press, 1989).

²⁸ Saraswathi Menon, "Historical Development of Thanjavur Kisan Movement: Interplay of Class and Caste Factors," *Economic and Political Weekly* (1979): 403–8.

The Current Climate Adaptation Intervention in the Delta

As outlined so far, the deltaic landscape had undergone a regime of water control where siltation was considered a liability, floods had to be prevented by all costs by creating large tracts of canal networks connecting the river directly to the sea to drain, and at the same time preventing water from reaching the sea during drier years through its numerous sluices and gates.

Several factors such as mono-cropping of rice, prevention of siltation, increased number of cropping seasons, uncontrolled extraction of groundwater resources are contributing to the increased salinity in the aquifers of this landscape. This growing movement of salinity into the rice growing area is one of the chief concerns of water engineers. A new project was designed and implemented with the aid of about \$100 million US dollars in over five years from the Asian Development Bank. This project was intended to improve the canal infrastructure, both in the hinterlands and in the coastal part of the delta in order to prevent seawater intrusion. Several new Tail-End-Regulators were constructed at points where the rivers meet the sea. These are places where the rivers naturally interact with the sea forming brackish wetlands ecosystems. Over two centuries of infrastructure intervention by the colonial water management regime to drain floods into the sea, had already altered the ecosystem.²⁹ The new infrastructure funded in the name of climate adaptation further alters the landscape by rendering the wetlands less brackish. The rhythmic relationship between the river and the sea, a constitutive feature of the delta was consistently disrupted over 150 years, and now once again by the climate engineers.

Regulators can be thought of as machines. What was now previously done by agricultural labour using spades and crowbars and simple devices through human labour, through the working body, now has to be mimicked by the tail-end regulators in such a way that the sea water and the flow of the tides can now be controlled through such new devices.

Other important intervention that the climate adaptation project has implemented is raising embankments and lining the banks with concrete. In this process, there has been extraction of silt deposits in the riverbed by implementing agencies, to be sold illegally to feed the growing construction industry in nearby urban centres. This has caused the deepening of river. Farmers also complain that years of regulation and intervention in the river through construction of infrastructure caused increased erosion, complicating the scenario and resulting in the further deepening of the river bed. This deepened riverbed prevents water from entering the agricultural fields. Due to constant demand from farmers to tackle the issue of deepening river bed, the Water Resources Department, which is a branch of the Public Works Department that administers irrigation, has come up with another new device called the “Bed Dam.” A shallow horizontal column of concrete wall is constructed perpendicular to the flow of the water. This blocks the flow of water to raise to as necessary to let the water into the fields.

This history of water can also be seen as a history of silt and sediments. The sediments have been for the past few decades taken away by the contractors who implement the construction of these infrastructures to be sold illegally. This illegal money has been used to fuel election campaigns both at the local level and at the state level. In this process the relationship between the local political class, and the river are altered completely, while the river gets degraded where at least four-to-six feet depth of the soil is being taken away³⁰ and a new relationship between the sea and the river is being forged, where the sea itself becomes a liability.

There is a new tension emerging between the rice farmers who lose out because of salinity, which is encroaching on them, and the new set of capital that emerges from the same landscape by exploiting its resources,

²⁹ Aditya Ramesh, “Deltas after Rice: Agrarian Pasts, Environmental Futures,” *Environment and History* 9 (2021): <https://blog.history.ac.uk/2021/03/deltas-after-rice-agrarian-pasts-environmental-futures/>.

³⁰ J. Jeyaranjan, “Sand and the Politics of Plunder in Tamil Nadu, India,” in *The Wild East: Criminal Political Economies in South Asia*, ed. L. Michelutti and B. Harriss-White (UCL Press, 2019), 92–114.

where they see salinity as the resource for cultivating export-based shrimps. Similar to the emergence of paddy as a commodity in the 19th century, as result of new infrastructure development in the delta, we now witness the emergence of shrimp as the new commodity with the emergence of new forms of infrastructure that are built around the discourse of salinity such as the tail-end-regulator and the bed-dam.

These different moments through the prism of water, labour and the crop, helps us ask connected questions. They bring into focus how scientific interventions and bureaucratic control through the execution of disciplinary fields on site, through engineering, water management, sciences of rice cultivation and the knowledge that makes markets operate. Such interventions are articulated through structures of power in the landscape, which sustain and articulate the social relations between resources and the working people. The long-term historical analysis is a way by which we can identify and learn from the patterns of such a changing relationship. It helps us learn the moments that inhered possibilities of a different relationship and ways in which they were subverted, removing the possibility of justice to the same working people, who sustain the land and water and produce through their hard labour.

The New World of the Anthropocene

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Introduction: The Anthropocene in the City of Eternal Spring

In 2000, at a meeting of the International Geosphere–Biosphere Program (IGBP) in Cuernavaca, Mexico, Paul Crutzen interrupted a conventional discussion on the Holocene to propose a new geological epoch: the Anthropocene. It is almost paradoxical that the proposal of this new concept was in Cuernavaca, a favourite getaway from the highly urbanized Valley of Mexico. Already at the beginning of 19th century, Alexander von Humboldt spoke of that “happy region” of Cuernavaca, commonly called “the reign of perpetual spring” since it was a quite “temperate region.”¹ This expression highlights its temperance throughout the year and it assumes its continuity over a long time. Even earlier, however, similar notions were applied to New Spain in general² and to Mexico City in particular; for instance, in the *Grandeza Mexicana* (1604), Bernardo de Balbuena spoke about a perennial Mexican spring which does not suffer the vicissitudes of time because there “the whole year is May and April.”³

Nonetheless, throughout Spanish rule, the watershed of Mexico was drastically altered, as Humboldt could already testify. He explained this natural change by cultural preferences, affirming that it “would appear that the first conquerors wished the beautiful valley of Tenochtitlán to resemble the Castilian soil, which is dry and destitute of vegetation.”⁴ They tried to reverse “the order of nature” by felling the trees of the basin, but mainly they constructed a drainage of its lakes, decreasing their water levels, which made the soil sterile and increased health problems. It is not surprising, then, that by the time of Humboldt’s visit, the title of perennial spring had been transferred from Mexico City to Cuernavaca and that later, this warmer and quieter city with plenty of vegetation became one of the favourite places to escape from the bustle of the capital.

In the years since Crutzen’s proposal, however, anthropogenic changes have also reached Cuernavaca, altering its climate and its perennially pleasant spring and springs. Heat waves have increased, and temperatures have reached historic records, while groundwater levels have dropped.⁵ This is due to global warming as well as a lack of adequate policies in the face of increasing urbanization, water exploitation, and the loss of the green areas for which the city was known. Thus, this refuge from the metropolitan area runs the risk of facing the deterioration of its environment due to human action and negligence. I maintain that this socio-natural history is exemplary of the human impact on the environment not only at a global level but mainly in terms of its local disparities, whereby even highly closed spaces can experience contrasting processes and temporalities. Some places have been strongly affected since the beginning of globalization, while others have not suffered negative anthropogenic impacts on their environments until recently; such disparities should affect the ways in which the Anthropocene is understood and historicized.

¹ Alexander von Humboldt, *Researches Concerning the Institutions and Monuments of the Ancient Inhabitants of America: With Descriptions and Views of Some of the Most Striking Scenes in the Cordilleras* (London, 1814), 108.

² For example, in the first text of natural philosophy printed in America, the *Physica speculatio* (Mexico, 1557) by Alonso de la Vera Cruz, in the book “On the Heavens,” contrary to hegemonic ideas, it is said that New Spain was the most temperate region.

³ Bernardo de Balbuena, *Grandeza mexicana* (Sociedad de Bibliófilos Mexicanos, 1927), 91v–92r.

⁴ Alexander von Humboldt, *Political Essay on the Kingdom of New Spain*, vol. II (London, 1811), 31.

⁵ *Diario de Morelos*, May 16, 2024, <https://www.diariodemorelos.com/noticias/rompe-otro-r-cord-el-calor-en-cuernavaca>; Cuernavaca Municipal Government, June 19, 2023, <https://cuernavaca.gob.mx/?p=29491>.

Transdisciplinarity and Diversity in the Anthropocene

The Cuernavaca meeting in 2000 during which the Anthropocene was proposed as a new geological epoch was part of the IGBP. This program focused on Earth system science and global change, taking into account biological, physicochemical, and human factors. Thus, the approach of the IGBP was already inter- and transdisciplinary, but it focused on global change as a whole.⁶ In a similar vein, Crutzen developed his important studies on anthropogenic alterations in the atmosphere, mainly on the impact of chlorofluorocarbons on the degradation of the ozone layer.⁷ These studies gave rise to the implementation of the Montreal Protocol (1989), which aimed to protect the ozone layer; this was the first international agreement to solve a global anthropogenic environmental problem. Therefore, the Anthropocene studies had already adopted a transdisciplinary approach from the beginning, focusing on global alterations such as changes in the chemical composition of the atmosphere and climate change. At the same time, it was proposed in a context with successful examples of human possibilities for dealing with anthropogenic environmental problems at a global level.

The proposal of the Anthropocene as a geological epoch meant that its pertinence was evaluated by the International Union of Geological Sciences, mainly in terms of analysing its stratigraphical traces. After several proposals and discussions, in March 2024, the Union voted against accepting the Anthropocene as a geological epoch. However, they clarified that with this decision, they did not pretend to dismiss the current social impact on the planet. In this way, rather than closing the discussion, its rejection as a geological epoch could promote the multidisciplinary approach implied by the Anthropocene and by the studies on the anthropogenic impact on the environment in general.⁸

The growing negative effects of humans on the environment in the last decades have motivated the development of several studies with distinct disciplinary approaches. Despite the consensus about the utility and necessity of multi-, inter-, and transdisciplinary approaches to study the Anthropocene, in practice, compared with traditional disciplinary studies, this implies several difficulties. One issue is the contrasting approaches by different disciplines, which makes it more complicated to try to univocally define what should be understood by the Anthropocene. In addition, various alternative concepts have been proposed.⁹ Although this could be considered a problem, it has also prevented the confinement of the Anthropocene to univocal definitions and disciplinary constraints, especially because it necessarily conjoined natural and social issues. In this way, for example, even if now it would not be accurate to study the Anthropocene as a geological epoch, it seems quite pertinent to comprehend it as a historical period.¹⁰

⁶ Sybil P. Seitzinger, Owen Gaffney, Guy Brasseur, Wendy Broadgate, Phillipe Ciais, Martin Claussen, Jan Willem Erisman et al., "International Geosphere–Biosphere Programme and Earth System Science: Three Decades of Co-evolution," *Anthropocene* 12 (2015): 3–16.

⁷ Studies that resulted in him being awarded, together with Mario Molina and Sherwood Rowland, the Nobel Prize in 1995.

⁸ As Pietro Daniel Omodeo argues, "far from being a technical question, or the exclusive prerogative of an isolated community of scientists, the Anthropocene is a still unsolved dilemma requiring adequate philosophical tools to orient us on both the epistemological and the ontological level" ("Geopraxis: A Concept for the Anthropocene," *Journal of Interdisciplinary History of Ideas* 11 (2022), no. 22: 9:1–9:52).

⁹ Donna Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities* 6 (2015); Jason W. Moore, "The Rise of Cheap Nature," *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism* (PM Press, 2016). In this same volume, Justin McBrien proposed the Necrocene as "a fundamental biogeological moment" of the Capitalocene ("Accumulating Extinction Planetary Catastrophism in the Necrocene," in *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism* [PM Press, 2016]).

¹⁰ "A potential difference between geological and historical Anthropocene concepts might reflect different, and equally valid, disciplinary epistemologies and temporal conceptualizations" (John L. Brooke and Christopher Otter, "Concluding Remarks: The Organic Anthropocene," *Eighteenth-Century Studies* 49, no. 2 [Winter 2016], 296). Andreas Malm and Alf Hornborg affirm that "'the geology of mankind' must have its roots in the properties of that being," not abstractly but in the "sociogenic" sense, that is,

Omodeo, Garau, and Rispoli have proposed to study the Anthropocene using an “historical geoanthropological approach” because, to understand its origin, it is necessary to encompass “methods deriving from the historical and cultural, disciplines, socio-economic history, and the history and philosophy of technology.”¹¹ If we want to understand how humans have become a geomorphic force throughout the planet, it is not enough to start when anthropogenic impacts reach effectively all the world at once, as is the case with contemporary climate change. More than identifying a precise point and time in which the world as a whole has entered a new epoch, it is necessary to recover the complexity of human, but also natural, history. To accomplish this, we must go beyond tracing the Anthropocene’s consolidated effects, as in the case of geological stratigraphy,¹² to discover its dynamics and causes. In other words, if we assume that this epoch is marked by human action, it is not sufficient to study it in terms of geological strata; instead, it is necessary to recover the historical inception of this process in which humans are becoming a geological force.¹³ We need to connect human history to geological times in a *longue durée* history.

Comparative Geo-histories in the Anthropocene

Despite the huge scope of the *longue durée* history in which humans have become a geological force, we must question the utility of another universal history that conceives a homogeneous and shared process for the whole globe. If we propose an idea of the Anthropocene as a global process whose timing and impacts are the same everywhere, we run the risk, as modern thinking used to do, of once again imposing dynamics and conceptions generated in particular places as universal processes. Although the Anthropocene is usually studied from a global perspective, since this process is initiated by humans, we should recover their environmental impact not as an abstract universal and homogeneous agent but as they developed their practices in concrete spaces. As in planetary physics, air and water flows move from some places to others with different geographical and climatic conditions, the Anthropocene system should consider not only these physical data but also the economic, commercial, production, and exploitation practices that mobilize throughout the globe natural, social, and economic resources, generating contrast anthropogenic impacts in different places.

Anthropocene studies generally propose the idea of the earth as a system, but many times they adopt a homogenous view instead of trying to understand how the different parts of the system interact and differ from one another. Contrary to this trend, it is necessary to rethink whether the Anthropocene has developed in the same way and with the same temporalities all over the world. In order to analyse these questions, comparative studies can be very useful, particularly the evaluation of exemplary cases marked by anthropogenic intervention.¹⁴ Venice has been proposed as one such significant case, having been called a “city of the Anthropocene”¹⁵ not only because of the current problems of rising sea levels but also because of its *longue durée* history, according to which it has been built and reinvented in constant tension with its aquatic environment to try to preserve both the city and the

it arises within a “specific social structure” (“The Geology of Mankind? A Critique of the Anthropocene Narrative,” *The Anthropocene Review* 1, no. 1 [2014]: 63, 67).

¹¹ Pietro Daniel Omodeo, Rodolfo Garau, and Giulia Rispoli, “Historical Geoanthropology,” *Journal of Interdisciplinary History of Ideas* 11, no. 22 (2022): 8:1–8:12.

¹² Such as the Global Boundary Stratotype Section and Point.

¹³ As Malm and Hornborg affirm, it is necessary to invert the actual approach to the Anthropocene that departs from the natural sciences to study its social inception: “in climate change, social relations determine natural conditions; [but] in Anthropocene thinking, natural scientists extend their world-views to society” (“The Geology of Mankind? A Critique of the Anthropocene Narrative,” *The Anthropocene Review* 1, no. 1 [2014]: 66).

¹⁴ As Donna Haraway says, these changes are produced by “historically situated people” (“Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin,” *Environmental Humanities* 6 [2015], 159).

¹⁵ Pietro Daniel Omodeo, “Venice. City of the Anthropocene,” Anthropocene Curriculum (2022), <https://www.anthropocene-curriculum.org/>.

lagoon.¹⁶ If Venice can be proposed as an early example of the Anthropocene, something similar – or better, specular (with the inversion that implies) – can be affirmed for another water city: Mexico-Tenochtitlan. Similar to Venetians, the Aztecs built their city over land reclaimed from water, in this case, within a high plain lake. However, in the long term, human interventions in both cases have diverged, producing highly contrasting socio-natural environments. Thus, contrary to Venice, where the lagoon has been preserved, in the watershed of Mexico, the lakes have almost disappeared, giving space to a huge metropolitan area.

To understand these different outcomes and their respective dynamics, we need to study the different roles played by diverse places and groups within the global system as a whole. This implies that some places and some people are more negatively affected while others, instead, accrue the benefits. Given this diversity of outcomes, another question arises: Can general patterns be proposed as a part of the same world system? Or, on the contrary, has the Anthropocene developed through diverse and even contrasting forms and rhythms in different parts of the world? Despite the global character that the anthropic impact on the environment has reached, we must not disregard the fact that this impact is not homogeneous across the world; it acquires diverse dynamics, intensities, and temporalities in different places.¹⁷ Just as early modern imperialism and spoliation, current anthropogenic environmental problems (such as climate change and waste management as well as the continuity of extractive practices) have clearly had highly diverse impacts in different places.

In this way, for instance, to understand the contrasting historical paths of Venice and the Mexico watershed, and in general the complexity and diversity within the Anthropocene, it is necessary to recover the differences between places with divergent roles within the development of the modern world system, in which the integration of local social groups and natural resources can involve quite dissimilar dynamics, affecting local landscapes in different, and even contrasting, ways. Nonetheless, despite these contrasting outcomes, they can be seen as part of the same system that integrates different places around the world not homogeneously but extremely unequally.

An Early Anthropocene: The Invention of a New World

One of the earliest but usually forgotten examples of human impact on the environment in its modern form was the rise of Ibero-America. The inception of the New World implied a mixture of cultures as well as of natures, which would shape the world as we know it, including imperialism and colonial practices. Thus, some alternative interpretations to the Anthropocene, such as the one developed by Donna Haraway, have pointed out the necessity to “at least include the great market and commodity reworlding of the long sixteenth and seventeenth centuries.”¹⁸ To understand the historical development of the Anthropocene, it is necessary to recover the role of Ibero-America in the constitution of the modern world, taking into consideration both its biological and environmental aspect at the same time as its implementation of colonization and imperial dynamics.

One of the main historiographical problems with proposals about the Anthropocene is the moment in which it began. Although the industrial revolution and the so-called “Great Acceleration” have been proposed as starting points of the Anthropocene,¹⁹ alternative studies have located its origin earlier in connection with the inception of the modern world, early globalization, and the first modern empires. More than 50 years ago, Alfred Crosby studied not only the cultural but also the biological consequences of what he called the “Columbian

¹⁶ Cristina Baldacci, Shaul Bassi, Lucio Capitani, and Pietro Daniel Omodeo (eds.), *Venice and the Anthropocene: An Ecocritical Guide* (Wetlands, 2022).

¹⁷ Brooke and Otter, “Concluding Remarks,” 284.

¹⁸ Donna Haraway, *Staying with the Problem: Making Kin in the Cthulucene* (Duke University Press, 2016), 48.

¹⁹ Steffen Will, Broadgate Wendy, Deutsch Lisa et al., “The Trajectory of the Anthropocene: The Great Acceleration,” *The Anthropocene Review* 2/1 (2015), 1–18.

Exchange.” He affirmed that the introduction of animals and plants by Europeans was probably “the greatest biological revolution in the Americas since the end of the Pleistocene.”²⁰ Thus, if we aim to study the Anthropocene from an American perspective, the Columbian exchange would be the more important turning point during the Holocene in that continent.

More recently, John Brooke and Christopher Otter, drawing on Crosby, have discussed an “early organic Anthropocene” characterized by “the reshaping, manipulation, destruction, and global redistribution of the bodies of countless living species.” Brooke and Otter link this early Anthropocene with “the increased human exploitation of global planetary resources” and with the “destruction and reconstruction of multiple ecologies.”²¹ Similarly, Helge Wendt prefers to speak about a proto-Anthropocene linked with the “Iberian colonial world” characterized by “an enlargement of the perspective of human transformative action in its natural environment.”²² Although species moved in both directions, given that this early globalization was implemented mainly by Hispanics, the species and resources exchange was achieved with the goal to impose their ways of life and economic interests. Therefore, the social and environmental impacts were quite different on both sides of the Atlantic.

Although the introduction of new species in the New World could be many times involuntary, since the beginning this process was mainly directed with a conscious intent to transform the environment to adjust it to European conceptions. Accordingly, Brooke and Otter characterize the organic Anthropocene by the following two key processes: (1) “the active and even calculated shaping of global landscapes”; and (2) “the reshaping, manipulation, destruction, and global redistribution of the bodies of countless living species.”²³ Already in the early *History of the Invention of the Indies* by Fernán Pérez de Oliva, it is clear that since Columbus’s second voyage, the colonizers were aware that colonization implies both of these processes – the introduction of species and the Spanish way of life to modify the landscape – within the early European imperialism:

The kings, grateful for the great service they had received from Columbus, wanted him to be admiral of all his navigation and ordered that he be furnished with three ships and fifteen caravels, and in them one thousand two hundred armed foot soldiers and some on horseback, and with them all the craftsmen necessary for the building and use of a city. On those ships were all the seeds of herbs, plants and animals that we use most, so that they would multiply in that strange land and be coveted by our sailors, if the gold ran out there at some point. Columbus then, with many other men of authority – who followed him eager to see the great novelties that he in Spain had told – left Spain the year after the first navigation to mix the world and give those strange lands the shape of ours.²⁴

The success of this introduction of European species in the New World was well documented by the chroniclers of the time. Gonzalo Fernandez de Oviedo, for one, mentioned that in the Caribbean islands and New Spain there were

²⁰ Alfred Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Praeger, 2003), 66.

²¹ Brooke and Otter, “Concluding Remarks,” 284.

²² Helge Wendt, “Epilogue: The Iberian Way into the Anthropocene,” in *The Globalization of Knowledge in the Iberian Colonial World* (Berlin 2016), 297–314.

²³ Brooke and Otter, “Concluding Remarks,” 284.

²⁴ “Los reyes, agradeciendo el gran servicio que de Colón habían recebido, quisieron que fuese almirante de toda su navegación y mandaron adornalle tres naves y quince carabelas, y en ellas mil y docientos peones armados y algunos a caballo, y con ellos todos los artífices que para el edificio y uso de una ciudad es menester. En aquellas naves iban todas las simientes de yerbas, plantas y animales que nosotros más usamos, para que en aquella tierra estraña se multiplicasen y fuese codiciosa a nuestros navegantes, si en ella el oro algún tiempo hobiese fin. Colón entonces, con otros muchos hombres de autoridad -que le siguieron movidos de ver las novedades grandes que él en España había contado-, partió de España año siguiente de la primera navegación, a mezclar el mundo y a dar a aquellas tierras estrañas forma de la nuestra” (Hernán Pérez de Oliva, *Historia de la Invención de las Indias* [Mexico 1991], 50).

great quantities of horses, cows, sheep, and pigs, and “every day they increase wherever Christians populate.”²⁵ Oviedo narrated that some people owned cows in such large numbers that they even killed them without using their meat, only to sell their leather in Spain.²⁶ In addition, the introduction of European species became a governmental policy; for instance, the Ordinances (*Ordenanzas*) of the Indies of 1573 ordered the settlers to bring with them all the seeds and livestock they could in order to multiply them.²⁷

Crosby continued his research in this area, publishing another work entitled *Ecological Imperialism: The Biological Expansion of Europe, 900–1900*, in which he claimed that in the New World, “colonizing plants had not had such an opportunity since the invention of agriculture.”²⁸ Although, in many cases, the introduction of these alien species was a human decision, their resulting proliferation was also wild.²⁹ In the case of animals, since America lacked native ruminants, the introduction of various grazing animals had particularly strong impacts on the environment.³⁰ Crosby even affirms that if the Europeans had arrived with 20th-century technology, their environmental impact would not have been as great due to the self-reproducing capacity of animals brought to the New World.³¹

Clearly, Spanish colonization focused not only on the transformation of American fauna and landscapes but, mainly, of its societies and populations. Conquest wars, followed by exploitation and epidemics, diminished drastically the local peoples, something that was particularly dramatic in the Caribbean islands, as Bartolomé de las Casas reports in his *Brief Account of the Destruction of the Indies*.³² However, the decline of the native population also continued in mainland. For instance, in today’s central Mexico, it has been estimated that depopulation surpassed 90 percent.³³ Perhaps the latest pandemic can help us better imagine what these figures meant for the life of local societies and the scope that anthropogenic impact can have not only on the environment and animal extinction but also on human life itself. We can hope to learn from previous population tragedies to address today anthropogenic impact with the social and environmental risks that it implies. Some authors have even connected the depopulation of the New World with an unexpected consequence in the medium term linked to the global climate. More specifically, Lewis and Maslin affirm that the reduction of human activity implied by the high mortality in the Americas allowed the recuperation of over 50 million hectares of forests and vegetation. They connect this process with an increase in the capture of CO₂ – thus, by 1610, the presence of CO₂ in the atmosphere had reached a low point in parts per million. Consequently, they propose this as an appropriate Global Stratotype Section and Point marker for defining the beginning of the Anthropocene.³⁴ Regardless, beyond the search for stratigraphic markers, it is more important to understand how the complex dynamics of anthropogenic environmental impacts historically emerged in their modern form.

²⁵ Gonzalo Fernández de Oviedo, *Historia general y natural de las indias, islas y tierra firme del mar océano* (Vol. 1) (Imprenta de la Real Academia de la Historia, 1851), 300.

²⁶ Oviedo mentioned that in La Española Island, there used to be owners with several thousand heads of cattle, even up to twenty-five thousand (*Historia general y natural de las indias*, 399–400).

²⁷ Ordinance number 131.

²⁸ Crosby, *Ecological Imperialism*, 151–52.

²⁹ However, this does not imply that this process was completely autonomous and independent of human decisions, as is nowadays being proposed for the “techno-sphere” (see Omodeo, “Geopraxis,” 9:7–9:8).

³⁰ For example, Elinor Melville studied this process in the Mezquital Valley – to the north of the Basin of Mexico – where, already in the 16th century, the proliferation of sheep had degraded the endemic vegetation, transforming the land. See Elinor Melville, *A Plague of Sheep. Environmental Consequences of the Conquest of Mexico* (Cambridge UP, 1990).

³¹ Crosby, *Ecological Imperialism*, 173.

³² Bartolomé de las Casas, *Brevísima relación de la destrucción de las Indias* (1552).

³³ Borah and Cook, *The Aboriginal Population of Central Mexico on the Eve of the Spanish Conquest* (University of California Press, 1963).

³⁴ Simon L. Lewis and Mark A. Maslin, “Defining the Anthropocene,” *Nature* 519, no. 7542 (2015): 171–80.

Colonization of the Life-world and Originary Accumulation

The process of American colonization was both natural and social and had important political and economic implications for the formation of the global system.³⁵ By mixing “previously separate biotas,” the Columbus exchange generated a “radical reorganization of life on Earth without geological precedent.”³⁶ This exchange was not only biological but involved the establishment of the first global trade networks that altered the forms of production and consumption with important economic implications, beginning to affect those *longue durée* patterns that Fernand Braudel related to the material civilization and the structures of everyday life.³⁷ Enrique Dussel speaks about the “colonization of the life-world” in America, which implied “the beginning of the domestication, structuring, colonization of the ‘way’ in which those people lived and reproduced their human life.”³⁸ Meanwhile, Jason W. Moore speaks of a *world-ecology*, which he links with the emergence of capitalism, in which “capital and power – and countless other strategic relations – do not act *upon* nature, but develop *through* the web of life,” resulting in new patterns of environment-making.³⁹ In fact, by Philip II’s time, these changes were not so slow and unnoticeable as Braudel proposed. Already in the early Americas, we can see that Braudel’s different levels mix and affect one another as well as their respective dynamics and timing.

By generating an early biological and commercial globalization, the Columbian exchange altered the biota and the economic and productive dynamics of different socio-geographical environments, with deep impacts not only in the New World but also in the Old World. Since this exchange concerned species, resources, and products, it can be located within what Jürgen Renn calls the “ergosphere” or the “sphere of work,” with reference to labour which, as Marx proposed, has the power to transform humanity and environment at the same time.⁴⁰ This connection between the transformation of the biosphere and work-production is even clearer in material culture interchanges, as in the case of the introduction of the plough in America, as well as in the new international division and organization of work, with all its asymmetries and injustices, with important environmental impacts in some places and high exploitation of local people and resources, as with slavery and plantations.⁴¹ In this way, together with the Anthropocene, the Capitalocene and the Plantationocene⁴² have been proposed as more adequate names for our epoch. In his proposal, Moore describes the Capitalocene, starting from the 16th century, as “successive waves of global conquest and the worldwide appropriations of Cheap Nature” together with cheap work.⁴³

³⁵ Davis and Todd affirm that it is necessary to decolonize the Anthropocene by locating its origins in the course of the process of colonization of the Americas, highlighting the context of violence and power relations implied. Heather Davis and Zoe Todd, “On the Importance of a Date, or Decolonizing the Anthropocene,” *ACME: An International Journal for Critical Geographies* 16, no. 4 (2017): 761–80.

³⁶ Lewis and Maslin, “Defining the Anthropocene,” 174.

³⁷ Fernand Braudel, *Civilization and Capitalism 15th–18th Century: Volume I, The Structure of Everyday Life* (Butler & Tanner, 1985).

³⁸ Enrique Dussel, *El encubrimiento del Otro. Hacia el origen del “mito de la Modernidad”* (La Paz, 1994), 49–50. My translation.

³⁹ Moore, “The Rise of Cheap Nature,” 97–8.

⁴⁰ Jürgen Renn, *The Evolution of Knowledge: Rethinking Science for the Anthropocene* (Princeton University Press, 2020), 382. For eco-Marxist considerations, see John Bellamy Foster, *Capitalism in the Anthropocene: Ecological Ruin or Ecological Revolution* (NYU Press, 2022).

⁴¹ In his proposal, Immanuel Wallerstein defined “a world-system” as “one in which there is extensive division of labor [...] World-economies then are divided into core-states and *peripheral areas*.” In this way, in the 16th century, the “Americas became the *Periphery* of the European world-economy” (Immanuel Wallerstein, *The Modern World-System I: Capitalist Agriculture and the Origins of the European World-Economy in the Sixteenth Century* [1974], 336 and 349).

⁴² “The Plantationocene makes one pay attention to the historical relocations of the substances of living and dying around the Earth as a necessary prerequisite to their extraction... The plantation system depends on the relocation of the generative units: plants, animals, microbes, people” (Donna Haraway, “Anthropologists are Talking About the Anthropocene,” *Ethnos* vol. 81 [2016], 557).

⁴³ Moore, “The Rise of Cheap Nature,” 81.

Returning to Marx, although he focused mainly on developments in England, he also considered the role of the expansion of the known world and the colonial extraction of resources and labour in his explanation of original accumulation in capitalism. He clarified that it is called original because this accumulation is “not the result of the capitalistic mode of production, but its starting point.”⁴⁴ As Marx pointed out, in political economy, primitive accumulation plays the role of an original sign. But unlike the theological myth that affected all humans equally, this secular sin of capital served, instead, to differentiate them. “In times long gone by there were two sorts of people; one, the diligent, intelligent, and, above all, frugal élite; the other, lazy rascals, spending their substance, and more, in riotous living.”⁴⁵ This narrative was intended to explain current economic inequalities and the justification of economic system. “And from this original sin dates the poverty of the great majority that, despite all its labour, has up to now nothing to sell but itself, and the wealth of the few that increases constantly although they have long ceased to work.”⁴⁶

Beyond this myth, which is still narrated untiringly, Marx discusses the historical role that early modern imperialism played in the process of original accumulation in early globalization:

The discovery of gold and silver in America, the extirpation, enslavement and entombment in mines of the aboriginal population, the beginning of the conquest and looting of the East Indies, the turning of Africa into a warren for the commercial hunting of black-skins, signalled the rosy dawn of the era of capitalist production. These idyllic proceedings are the chief momenta of primitive accumulation. On their heels treads the commercial war of the European nations, with the globe for a theatre.⁴⁷

Primitive accumulation began with the Iberian empires⁴⁸ and was implemented with violence. “Force is the midwife of every old society pregnant with a new one. It is itself an economic power.”⁴⁹ Although opposed to the analogy between force and midwife, Silvia Federici has recovered the role of force as the “the main lever, the main economic power in the process of primitive accumulation.” Federici characterizes primitive accumulation as “an immense accumulation of labor-power – ‘dead labor’ in the form of stolen goods, and ‘living labor’ in the form of human beings made available exploitation – realized on a scale never before matched in the course of history.”⁵⁰

Rosa Luxemburg proposed to expand the idea of original accumulation not as a moment of the beginning of capitalism but as a constant and necessary element for its continued development. Thus, she asserts that cheap elements that are not strictly capitalist must be continually incorporated to ensure the growth of capitalism: “capitalist production, by its very nature, cannot be restricted to such means of production as are produced by capitalist methods. Cheap elements of constant capital are essential to the individual capitalist who strives to increase his rate of profit.” Luxemburg affirmed that if capitalism were restricted to its own elements of production,

⁴⁴ Marx, *Capital, Volume I* (Chicago, 1909), 784.

⁴⁵ Marx, *Capital*, 784.

⁴⁶ Marx, *Capital*, 785.

⁴⁷ Marx, *Capital*, 823.

⁴⁸ “The different moments of primitive accumulation distribute themselves now, more or less in chronological order, particularly over Spain, Portugal, Holland, France, and England.” But it was in England where it acquired a more systematic development, both at a national and colonial level. “In England at the end of the 17th century, they arrive at a systematical combination, embracing the colonies, the national debt, the modern mode of taxation, and the protectionist system. These methods depend in part on brute force, e.g., the colonial system. But they all employ the power of the State, the concentrated and organised force of society, to hasten, hothouse fashion, the process of transformation of the feudal mode of production into the capitalist mode, and to shorten the transition.” Marx, *Capital*, 823–4.

⁴⁹ Marx, *Capital*, 824.

⁵⁰ Silvia Federici, *Caliban and the Witch: Women, the Body and Primitive Accumulation* (Antonomedio, 2009), 64.

"its development in general would have been impossible."⁵¹ Therefore, it "requires inevitably free access to ever new areas of raw materials"; in this way, it depends on colonialism and increasing globalization.

From the very beginning, the forms and laws of capitalist production aim to comprise the entire globe as a store of productive forces. Capital, impelled to appropriate productive forces for purposes of exploitation, ransacks the whole world, it procures its means of production from all corners of the earth, seizing them, if necessary by force, from all levels of civilisation and from all forms of society.⁵²

This process was not only the initial booster of capitalism but is a continuous and necessary element of its expansion and reproduction. "It becomes necessary for capital progressively to dispose ever more fully of the whole globe, to acquire an unlimited choice of means of production, with regard to both quality and quantity, so as to find productive employment for the surplus value it has realised."⁵³ Similarly, Federici affirms that until now, "systematically, whenever the capitalist system is threatened by a major economic crisis, the capitalist class has to launch a process of 'primitive accumulation', that is, a process of large-scale colonization and enslavement."⁵⁴

Modern Imperialism in Debate and in Practice

Since the beginning, European expansion in early modernity was based on imperialism and plunder. The abuses by colonial Spaniards of indigenous populations were already denounced by friar Antonio Montesinos in his famous sermon in the Hispaniola Island in 1511, in which he criticized the right of their conquest and exploitation, asking the settlers:

Tell me, by what right and with what justice do you hold these Indians in such cruel and horrible servitude? With what authority have you waged such detestable wars on these people who were in their quiet and peaceful lands, where you have consumed so infinite number of them, with death and unheard havoc? ... These, are they not men?⁵⁵

We can see that from the beginning, the problem was not the question of whether indigenous peoples were human, as some traditional historiography used to say, or as contemporary literature on the Anthropocene claims that human status was attributed only to some people, while others were placed on the side of nature and not culture.⁵⁶ Despite explorers and conquerors offering several reasons and strategies justifying the American conquest, it was John Maier who first developed these imperial arguments within the natural philosophy of the time. Maier did not separate nature and culture; nature and culture were connected, and humans and societies could have different natures. It is precisely these "natural" distinctions that justified the imposition of some people over others. In this way, he affirmed that indigenous peoples were "by nature" slaves. To assert this, he claimed to follow not only classical authors, mainly Ptolemy and Aristotle, but also more contemporary experience:

⁵¹ Rosa Luxemburg, *The Accumulation of Capital*, "Chapter 26: The Reproduction of Capital and Its Social Setting," (Routledge & Kegan Paul Limited, 1951), 357–8.

⁵² Luxemburg, *Accumulation of Capital*, 358.

⁵³ Luxemburg, *Accumulation of Capital*, 358.

⁵⁴ Federici, *Caliban and the Witch*, 103–4.

⁵⁵ 'Decid, ¿con qué derecho y con qué justicia tenéis en tan cruel y horrible servidumbre aquestos indios? ¿Con qué autoridad habeis hecho tan detestables guerras a estas gentes que estaban en sus tierras mansas y pacíficas, donde tan infinitas dellas, con muerte y estragos nunca oídos habeis consumido? ... ¿Estos no son hombres?' Quoted in Bartolomé de las Casas, *Historia De Las Indias*, vol. III (Ayacucho, 1956), 13–14.

⁵⁶ For example, Jason W. Moore affirms the following: "At the core of the new thought structures was a mode of distinction that presumed separation. The most fundamental of these separations was Humanity/Nature. Some people became Humans, who were members of something called Civilization, or Society, or both (...) From the beginning of capitalism, however, most humans were either excluded from Humanity – indigenous Americans, for example – or were designated as *only partly* Human, as were virtually all European women" ("Rise of Cheap Nature," 87).

These people live like beasts on this and that side of the equator; and wild men live, as Ptolemy says in his *Quadripartitum*. And this has now been demonstrated by experience, wherefore the first person to conquer them, rules over them because they are by nature, clearly, slaves (...). On this account the Philosopher says in the first chapter of the said book [*Politics*] that this is the reason why the Greeks should be masters over the barbarians because, by nature, barbarians and slaves are the same.⁵⁷

In this manner, John Maier provided early European imperialism with a justification for the conquest of America and for indigenous exploitation based on natural philosophy. Later, Juan Ginés de Sepúlveda, following Maier, also affirmed that since they were barbarians, indigenous people could be conquered, adding other arguments such as that they deserved be punished for their crimes like human sacrifices, thus preventing injustice and spreading evangelization.⁵⁸ The first and main reason why the war waged by the Spanish against them was fair, according to Sepúlveda, was that

being by nature servants, barbaric, uncultured and inhuman men refuse to admit the domination of those who are more prudent, powerful and perfect than them; domination that would bring them great benefits, but also a just thing by natural right that matter obey the form, the body to the soul, the appetite to reason, the brutes to the man, the woman to the husband, the children to the father, the imperfect to the perfect, the worst to the best, for the universal good of all things. This is the natural order that the divine and eternal law commands to always be observed.⁵⁹

Despite the dichotomies enumerated, the distinction was not between men or not men, but between men of different status.⁶⁰ It was not a distinction between nature and culture; rather, the natural order implied a social arrangement. With these socio-natural arguments, Europeans claimed superiority over others, and even more importantly the right to determine what is convenient for others.⁶¹ Ambrosio Velasco calls “epistemocracy” this “justification of political dominance based on a supposed superior rationality and true knowledge.” The epistemocratic view attributes to the ruler the capacity to distinguish what is fair and true, which “is placed above any other justification of political dominance, such as the will of the community itself.”⁶² This logic, established first in early Ibero-America, would become a fundamental premise of the modern justifications of imperialism and the transformation of colonized countries.

In the famous controversy of Valladolid (1550–1551), Bartolomé de las Casas offered a counter-argument to each of the statements that Sepúlveda brought forward to justify the war and conquest of indigenous peoples.

⁵⁷ Quoted in Nicolás Wey Gómez, *The Tropics of Empire: Why Columbus Sailed South to the Indies* (MIT Press, 2008), 102.

⁵⁸ As Immanuel Wallerstein argues, these arguments, with some modifications, were developed throughout all modernity to justify their “interventions” (“Whose Right to Intervene? Universal Values Against Barbarism,” in *European Universalism: The Rhetoric of Power* [2006], 4–6).

⁵⁹ “Siendo por naturaleza siervos, los hombres bárbaros, incultos e inhumanos se niegan a admitir la dominación de los que son más prudentes, poderosos y perfectos que ellos; dominación que les traería grandísimas utilidades, sino además cosa justa por derecho natural que la materia obedezca a la forma, el cuerpo al alma, el apetito a la razón, los brutos al hombre, la mujer al marido, los hijos al padre, lo imperfecto a lo perfecto, lo peor a lo mejor, para bien universal de todas las cosas. Este es el orden natural que la ley divina y eterna manda observar siempre” (Ginés de Sepúlveda, *Tratado sobre las justas causas de la guerra*, [1987], 153).

⁶⁰ Giuliano Gliozzi, *Adamo e il novo mondo. La nascita dell’antropologia come ideologia coloniale: dalle genealogie bibliche alle teorie razziali (1500–1700)* (La Nuova Italia, 1977), III.1. At the same time, as we can see, there was a strong gender distinction focused solely on men.

⁶¹ On the interconnection between American nature and the political inferiority of its inhabitants within European thought, see the classic works of Antonello Gerbi: *Nature in the New World: From Christopher Columbus to Gonzalo Fernández de Oviedo* (University of Pittsburgh Press, 1985) and *The Dispute of the New World: The History of a Polemic, 1750-1900* (University of Pittsburgh Press, 2010).

⁶² Ambrosio Velasco, “Republicanism indiano y crítica a la epistemocracia colonial,” *Cuyo. Anuario de Filosofía Argentina y Americana* 42 (2023): 30–1.

Due to the depth and radicality of this controversy, Enrique Dussel claims that this early philosophical debate was, perhaps, the most serious one about modern imperialism until now.⁶³ Like the pro-imperialists, Las Casas did not distinguish between nature and culture; instead, he made use of both natural and human (and even divine) law to argue that the Spaniards had no right to deprive indigenous rulers of their lordship:

From this also arose not having had scruple or fear of depriving and overthrowing the natural kings and lords of their lordships and states and dignities, which God and nature and the common law of the people made lords and kings, and which confirmed and authorized the same divine law, also ignoring natural, divine and human law.⁶⁴

The work of Bartolomé de las Casas was continued by other authors, such as Alonso de la Veracruz, who in the nascent university also defended indigenous people from Spaniards' dispossession, with both natural and political philosophy arguments.⁶⁵ Thus, since the beginning of the modern world, along with the justification of imperialist practices and colonialism, some authors developed arguments, including natural claims, against conquest and exploitation. Still, the confrontation between those who were in favour of colonialism and those who were against it would not be resolved through arguments but in practice. As Immanuel Wallerstein affirms, beyond the philosophical and moral aspect of these arguments, the imperial visions "were greatly reinforced by the immediate material benefits the conquests brought to the conquerors."⁶⁶ In this way, the conquest and colonization were justified by their benefits for the few not by arguments, and despite their negative consequences for most. Thus, the critical reason of authors such as De las Casas and De la Veracruz "was buried by strategic reason."

⁶³ Enrique Dussel, *The Invention of the Americas: Eclipse of "the Other" and the Myth of Modernity* (1995), 64.

⁶⁴ "De aquí también ha nacido no haber tenido escrúpulo ni temor de despojar y derribar los naturales reyes y señores de sus señoríos y estados y dignidades, que Dios y la naturaleza y el derecho común de las gentes hizo señores y reyes, y que confirmó y autorizó la misma ley divina. Ignorando también el derecho natural, divino y humano." Bartolomé de las Casas, *Historia de las Indias*, vol. I (Ayacucho, 1956), 16.

⁶⁵ Ambrosio Velasco, "Fray de la Alonso de la Veracruz: humanista, crítico del Estado imperial y del poder de la Iglesia," in *Fray de la Alonso de la Veracruz: universitario, humanista, científico y republicano* (UNAM, 2009) 291–303. Omar Rodríguez Camarena, "The American *De coelo*: Heaven and Earth in the New World's First Printed Work on Natural Philosophy," *Journal of Early Modern Studies* 12 (2023): 151–4.

⁶⁶ Wallerstein, "Whose Right to Intervene?," 6.

SECTION TWO: ANTHROPOCENE QUESTIONS



From the Anthropocene to the Water Cycle and Back: Some Philosophical Remarks

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Introduction: One or Many Anthropocenes?

Since the publication of Paul Crutzen and Eugene Stoermer's seminal article,¹ the concept of the Anthropocene – a new epoch in the history of the Earth in which humans have modified the overall parameters that defined the functioning of the previous geological epoch, the Holocene – has rapidly spread across various disciplinary domains, ranging from geology and ecology to aesthetics and environmental philosophy.² With this diffusion, the Anthropocene has not only faced criticism from multiple perspectives but has also undergone subtle yet recognizable reconceptualizations, influenced by the specific domains in which, from time to time, it has been integrated. As a result, just to quote a few examples, we have witnessed the emergence of philosophical, sociological, postcolonial, and media studies interpretations of the Anthropocene³. This diversity of perspectives, rather than indicating a theoretical weakness, highlights the concept's richness in illuminating the scale of the anthropogenic transformations of the Earth System, comparable, as Crutzen and Stoermer affirmed, to a "force of nature." Moreover, it points to the necessity of an approach capable of framing human and natural components of the Earth as integrated elements.

Needless to say, this multiplication of meaning extends beyond the social and human sciences. Indeed, it has also influenced the natural sciences, leading to a wide variety of conceptualizations even within its discipline of origin – geology. As Jan Zalasiewicz, the former leader of the Anthropocene Working Group, observed, "there are many Anthropocenes out there, used for different purposes along different lines of logic in different disciplines."⁴ Zalasiewicz and his collaborators, part of a working group established by the International Commission on Stratigraphy, likely represent the most prominent and widely discussed conception of the Anthropocene within the natural sciences – at least since 2006⁵ – which we will refer to as the "stratigraphic" conception of the Anthropocene. From this perspective, the Anthropocene is seen as a unit of time and sediment within the Geological Time Scale, which must be validated through the identification of material traces.⁶ This is informally known as the "Golden Spike," or formally as the Global Stratigraphic Section and Point, capable of confirming its existence. To do so, the primary marker (i.e., the material trace) must be isochronous: it has to delineate a layer that simultaneously covers the entire Earth, forming a stratum that is globally distributed at the same point in time⁷. According to the

¹ Paul J. Crutzen and Eugene F. Stoermer, "The 'Anthropocene,'" *Global Change Newsletter* 41 (May 2000): 17–18.

² See Jan Zalasiewicz et al., "The Anthropocene: Comparing Its Meaning in Geology (Chronostratigraphy) with Conceptual Approaches Arising in Other Disciplines," *Earth's Future*, 9, 1–25.

³ See Jason W. Moore (ed.), *Anthropocene or Capitalocene? Nature, History and the Crisis of Capitalism* (PM Press, 2016).

⁴ Jan Zalasiewicz, "The Extraordinary Strata of the Anthropocene," in S. Opperman and S. Iovino (eds.), *Environmental Humanities: Voices from the Anthropocene* (Rowan and Littlefield, 2017), 115.

⁵ As Luciano says, in 2006, we witnessed a real "stratigraphic turn" within the debates on the Anthropocene. See. Eugenio Luciano, "Is 'Anthropocene' a Suitable Chronostratigraphic Term?," *Anthropocene Review*, 1 (2022): 33.

⁶ Jan Zalasiewicz et al. (eds.), *The Anthropocene as a Geological Time Unit* (Cambridge University Press, 2019).

⁷ In July 2023, the Anthropocene Working Group proposed identifying the Golden Spike within a lake in Ontario, Canada, where particularly evident anthropogenic sediments were found. However, this official proposal was recently rejected by the International Commission on Stratigraphy, thereby invalidating the stratigraphic conception of the Anthropocene.

stratigraphic definition, the “Anthropos” of the Anthropocene lacks substantive content; it merely labels a new stratum in Earth’s history. Furthermore, it refers to the tangible, material effects recorded in sediments rather than the underlying causes of this historical and geological transformation. Although stratigraphy has been the primary focus of the concept in the past fifteen years within geology, it was not the first discipline to address the idea of Anthropocene. In fact, the development of the concept owes much to a field that was just consolidating in the early 2000s: Earth System science (ESS).⁸ We find here another interpretation of the Anthropocene, which we will refer to as the “systemic” Anthropocene. In this field of study, the Anthropocene is not concerned with a material stratum in Earth’s sediments but with a global alteration of the parameters that define a “state” of the Earth. In other words, each state of the Earth is characterized by parameters that describe its functioning within a particular time span – what is commonly known as a “regime.” From this perspective, the Anthropocene represents the shift from one regime – the Holocenic regime – to a new one, the Anthropocenic regime. Zalasiewicz has summarized the key differences between these two approaches as follows:

There is a difference between the research styles and philosophies of the communities that deal with formal stratigraphy and with ESS. The former have a long pedigree [...] while the latter is a relatively new discipline, just a few decades old. The former are focused on the classification of rock and of geological time from an Earth perspective [...]. The latter are primarily concerned with researching the modes and mechanisms of Earth System change. The former are overwhelmingly concerned with ancient, pre-human rock and time, while the latter have, as a strong central focus, the analysis and understanding of contemporary global change.⁹

The Archive and the System

Behind this differing characterization of the Anthropocene lies what we might call a different “plane of reference,” as constructed by stratigraphy and ESS. In other words, the two “Earths” they refer to are not the same. In stratigraphy, the Earth is framed as a *layered archive*. Its defining tools are “strata,” “sediments,” “markers,” and the law of superposition, which governs the evolution of its variables. There is no space, here, for an integration of human and natural sciences, since the conceptions, methodologies and tools that define the discipline aim at investigating the history of the Earth as a layered archive. This conception of the Earth is fundamentally different from that of ESS, according to which the Earth is treated as a *system*.¹⁰ As one of the main figures in this field, Timothy Linton, wrote, the aim of ESS is to study

how our planet functions as a whole system. The scope of Earth system science is broad. It spans 4.5 billion years of Earth history, how the system functions now, projections of its future state, and ultimate fate. It considers how a world in which humans could evolve was created, how as a species we are now reshaping that world, and what a sustainable future for humanity within the Earth system might look like. Earth system science is thus a deeply interdisciplinary field, which synthesizes elements of geology, biology, chemistry, physics, and mathematics. It is a young, integrative science that is part of a wider 21st-century intellectual trend towards trying to understand complex systems, and predict their behavior.¹¹

What, then, is a system in this specific field? Condie defines a system as “an entity composed of diverse but interrelated parts that function as a whole. The individual parts, often called components, interact with each other

⁸ Clive Hamilton and Jacques Grinevald, “Was the Anthropocene Anticipated?,” *The Anthropocene Review* 2, no. 1 (2015): 59–72.

⁹ Jan Zalasiewicz et al., “Petrifying Earth Process: The Stratigraphic Imprint of Key Earth System Parameters in the Anthropocene,” *Theory, Culture & Society* 34, no. 2–3 (2017): 83–104.

¹⁰ See Will Steffen et al., “The Emergence and Evolution of Earth System Sciences,” in *Nature Review and Earth Environment* 1 (2020): 54–63.

¹¹ Timothy Lenton, *Earth System Sciences: A Very Short Introduction* (Oxford University Press, 2016), 16.

as the system evolves over time.”¹² A system, therefore, has four key characteristics that underscore the methodological and theoretical innovation of the ESS approach:

1. The system is made up of distinct yet interconnected parts.
2. The system functions as a whole, meaning the parts are not external to one another but rather organically work together to sustain the system.
3. The system evolves over time, undergoing transformation processes driven by the interaction of its components.
4. The system’s primary function is its own maintenance, meaning it is self-regulating.

In summary, the core theoretical premise of this field of research is that the Earth functions – or, as is often stated in these studies, “behaves” – like a system in which humanity is an integral and active component. The term “Earth System” refers to “the suite of interlinked physical, chemical, biological, and human processes that cycle (transport and transform) materials and energy in complex, dynamic ways within the system.”¹³ From an epistemological perspective, the “multi-component interactions between physical, chemical, and biological processes” highlight the transdisciplinary nature of the systemic approach. This approach is built upon the interaction of different but interrelated processes and components within the system, which themselves represent subsystems.

Features of the Earth System

It has been mentioned that the Earth System is composed of parts that function as subsystems within the system itself.¹⁴ Specifically, four subsystems – also referred to as “spheres” – are typically distinguished:

1. The lithosphere, which includes the chemically differentiated solid lands of the crust, the semi-liquid mantle, and the liquid layers at the Earth’s core.
2. The hydrosphere, which encompasses all the waters on the planet in their solid, liquid, or gaseous states.
3. The biosphere, which consists of all living organisms, further divided into “biomes,” or “ecological communities based on the physical surroundings of an area.”
4. The atmosphere, the gaseous envelope surrounding the Earth, extending from the planet’s surface up to 10,000 meters in height.

The theoretical core of the systemic approach is that these components, along with the subsystems within them, interact with one another, meaning they are engaged in a continuous process of exchanging matter and energy. To interact, therefore, means to exchange matter and energy. These exchange processes, or cycles – considered the “main components” of the Earth System, with the most fundamental being the carbon, sulphur, and nitrogen cycles – ensure the system’s self-regulation and maintenance, as the transformation of energy into matter and vice versa serves as the driving force behind Earth’s balance. As Lenton notes:

All the elements needed by life must be efficiently recycled within the Earth system. This in turn requires energy, to transform materials chemically and to move them physically around the planet. The resulting cycles of matter between the biosphere, atmosphere, ocean, land, and crust are called global biogeochemical cycles.

The subsystems of the Earth System interact with each other in various ways. These interactions work according to the following principles:

1. Non-linearity, meaning they are “characterized by drivers and responses that are not proportional.”

¹² Kent C. Condie, *Earth as an Evolving Planetary System* (Elsevier Academic Press, 2005), 26.

¹³ Will Steffen et al., “The Emergence and Evolution of Earth System Sciences,” 57.

¹⁴ See Lee R. Kump, James F. Kasting, and Robert G. Crane, *The Earth System* (Prentice Hall, 2010).

2. Complexity, that is, they are multi-scalar and multi-temporal, whereby a specific cause can “produce a ripple effect that exceeds the magnitude of the original impact in both space and time.”
3. Indeterminacy, meaning that due to the complexity of the interactions, there is a “stochastic or contingent element within them that eludes precise modeling.”¹⁵

Representing the System

Graphical representations can be of great help in framing the specificities of this approach. One of the seminal figures often used in this context is the Bretherton Diagram, a classical and simplified depiction of the Earth System and its interactions. As is readily discernible, the focus of the original diagram is on the interactions between the geosphere and the biosphere, illustrating the causal connections between the system’s individual components. These components are depicted as boxes, causally linked one another by arrows.

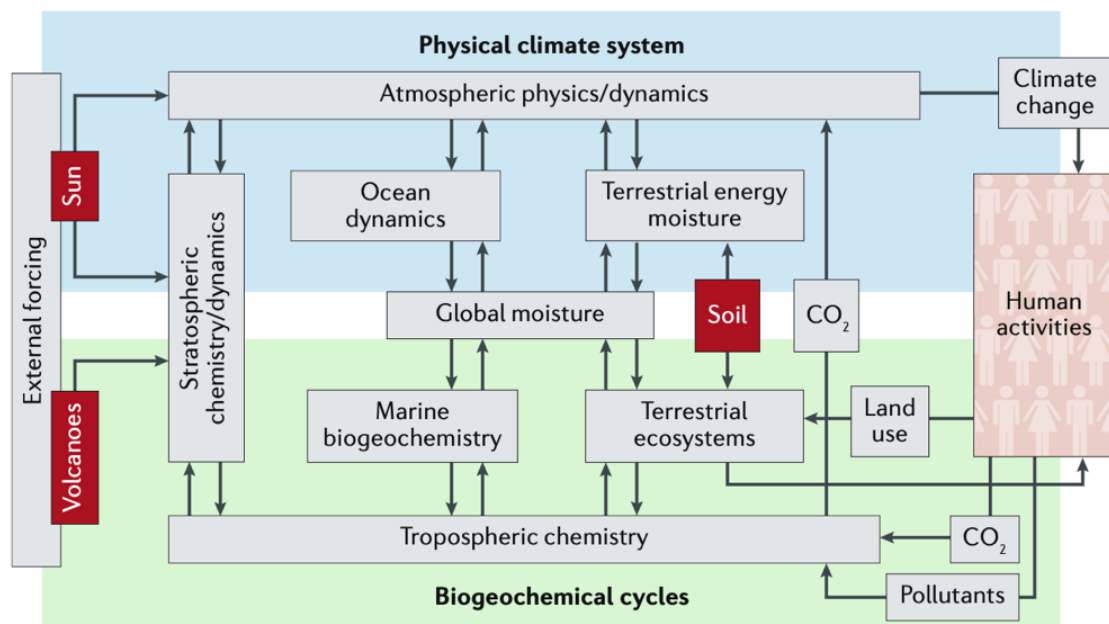


Figure 1. The Bretherton diagram. Adapted from Will Steffen et al., “The Emergence and Evolution of Earth System Sciences,” 56.

In Earth System sciences, humans are recognized as integral components of the Earth system, continuously interacting with and transforming other elements within it while being transformed themselves. However, in the traditional Bretherton diagram, humans are depicted as external agents acting upon the geosphere–biosphere system. This depiction has long been critiqued for portraying humans as separate from the system, when in reality, this separateness applies not only to humans but to all system components. Each element – humans included – remains extrinsic to the others. This critique has prompted repeated revisions of the diagram, leading to calls for a more integrated representation of the system’s components.

In response to these critiques, a redefined version of the Bretherton Diagram has emerged, incorporating key concepts from ESS, such as feedback loops, circular causality, and dynamic interactions. This updated model integrates the social dimensions more intricately than before. Although the anthroposphere is still distinguished from the geosphere, it is now understood as being connected through both material and symbolic elements,

¹⁵ R. A. Pielke Sr., H. J. Schellnhuber, and D. Sahagian, “Non-linearities in the Earth System,” *Global Change NewsLetter* 55 (2003), 11–15.

creating a more complex depiction. For instance, political economy, production, and consumption are now seen as integral parts of the Earth system, directly influencing atmospheric components like the troposphere and stratosphere. Similarly, symbolic elements such as knowledge, science, and technology are included, shaping energy systems that, in turn, impact the geosphere.

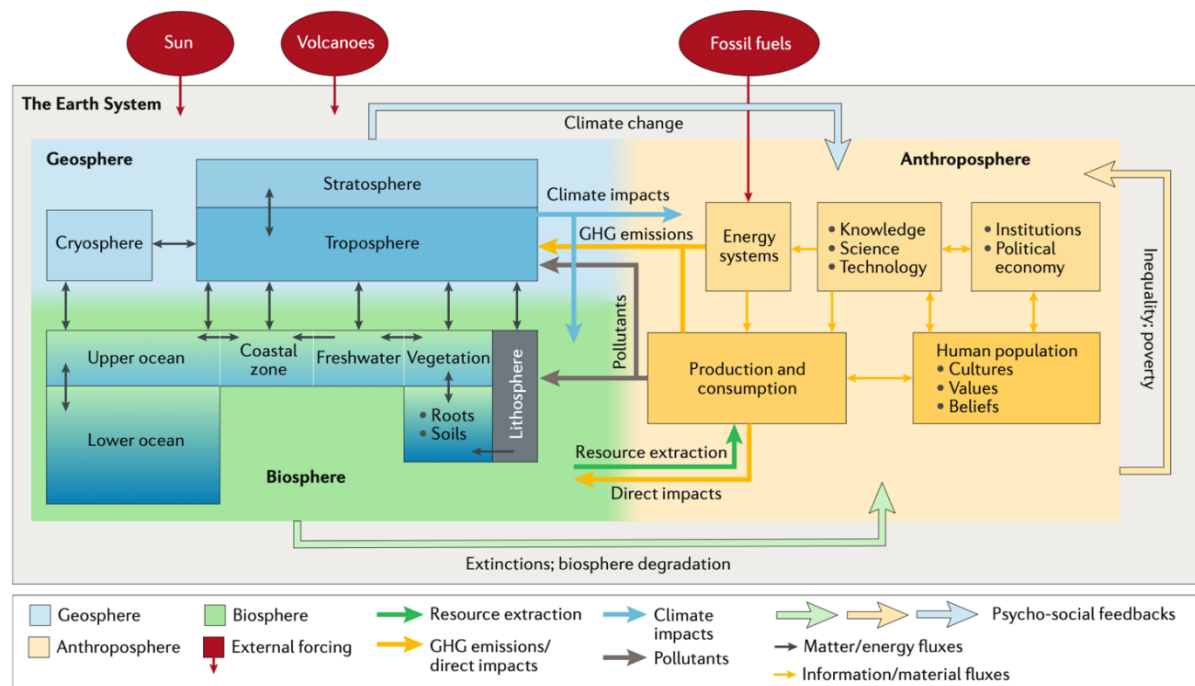


Figure 2. Refined Bretherton diagram. Adapted from Will Steffen et al., “The Emergence and Evolution of Earth System Sciences,” 61.

However, a crucial question persists: Does this new representation truly address the critique that system components are perceived as extrinsic to one another? While the updated diagram introduces greater complexity and nuance, it still adheres to the same underlying conceptual framework. Despite their interrelations, the system’s elements remain fundamentally external to each other. In this view, the parts exist independently of the relationships that connect them, with the system emerging as the sum of these autonomous parts. In fact, the issue lies not in the visual representation itself but in the structural logic it embodies. This reflects the broader conceptualization of systems in ESS, where systems are seen as collections of interconnected yet independent elements. Because these parts maintain their autonomy, they are considered to pre-exist the relationships that link them together.

This perspective leads to two key consequences, both previously highlighted by sociologist Niklas Luhmann.¹⁶ On an epistemological level, it reveals a paradox: systems are simultaneously more than the sum of their parts and, *at the same time*, the sum of their parts.¹⁷ On a practical level, this conception of systems – as composed of distinct parts and a whole – shifts the focus towards ideas of “control” and “planning.” In this view, the system becomes something that can be managed, with its behaviour and trajectories predicted through

¹⁶ Niklas Luhmann, *Social Systems*, trans. J. Bednarz Jr. (Stanford University Press, 1995), 5–12.

¹⁷ Already Edgar Morin was making this point as a positive feature of systemic thinking. See Edgar Morin, *La Nature de la Nature. La Méthode*, tome. 1 (Seuil, 1977).

complex simulations and modelling.¹⁸ And, as Lövbrand claims, “Objects can only be governed when they are represented and conceptualised in a way that can enter the sphere of conscious political calculation.”¹⁹ The ultimate aim is often to modify, alter, or redirect these trajectories – in a word, in line with its cybernetics roots, to “steer” them.²⁰ This framework is further reinforced by practical discussions within ESS, particularly in the context of climate management, about which Earth system scientists seem to be hinting. However, what happens if we move away from this notion of a system as a collection of parts and a whole? What if we instead adopt a relational perspective, where parts are defined by their interactions and interconnections rather than their separateness? This shift in perspective could open new ways of thinking about Earth systems – ones less focused on control and more on the processual, emergent relationships that define the system as a whole.

Ontology of Water

The Earth system consists of autonomous yet interconnected components, each of which can be viewed as a subsystem. These subsystems exhibit the characteristics of dynamic systems themselves, operating as wholes governed by some of the key features of the systemic approach: circular causality, feedback loops, and tipping points. This structural similarity implies that each subsystem can be analysed as a distinct system in its own right. The interactions between extrinsic parts, crucial to understanding the Earth system as a whole, also apply within these subsystems. One of the most significant examples of this is the hydrosphere, particularly the *water cycle*.

The hydrosphere includes all the water on the planet, present in solid, liquid, and gaseous states. It is driven by a continuous exchange of energy and matter, a process more specifically referred to – as we have already seen – as “circulation.” The hydrological cycle illustrates this constant transformation, where water moves between its three states while circulating across various parts of the system. The term “sphere” itself captures the cyclical movement of elements. Common representations of the hydrological cycle offer a simplified view of this process.²¹

¹⁸ On modelling and climate science, see Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Climate Change* (MIT Press, 2010); see also Stefan Aykut and Amy Dahan, *Gouverner le climat. 20 ans de négociations internationales* (Sciences Po Press, 2015).

¹⁹ Eva Lövebrand, Johannes Strippel, Bo Wiman, “Earth System Governmentality. Reflections on Science in the Anthropocene,” *Global Environmental Change* 19 (2009): 11.

²⁰ Will Steffen et al., “Trajectories of the Earth System in the Anthropocene,” *PNAS* 115, no. 33 (2018): 8252–59; Xi Chu, Timothy A. Kohler, Timothy M. Lenton, Jens-Christian Svenning, and Marten Scheffer, “Future of the Human Climate Niche,” *PNAS* 117, no. 21 (2020): 11350–55.

²¹ Even though it is clearly a simplification, this representation is widespread among scientific textbooks and ESS handbooks. See, for example, the official web site of NASA, where the relation between water cycle and ESS is illustrated (<https://gpm.nasa.gov/education/articles/nasa-earth-science-water-cycle>). This examples could be multiplied.

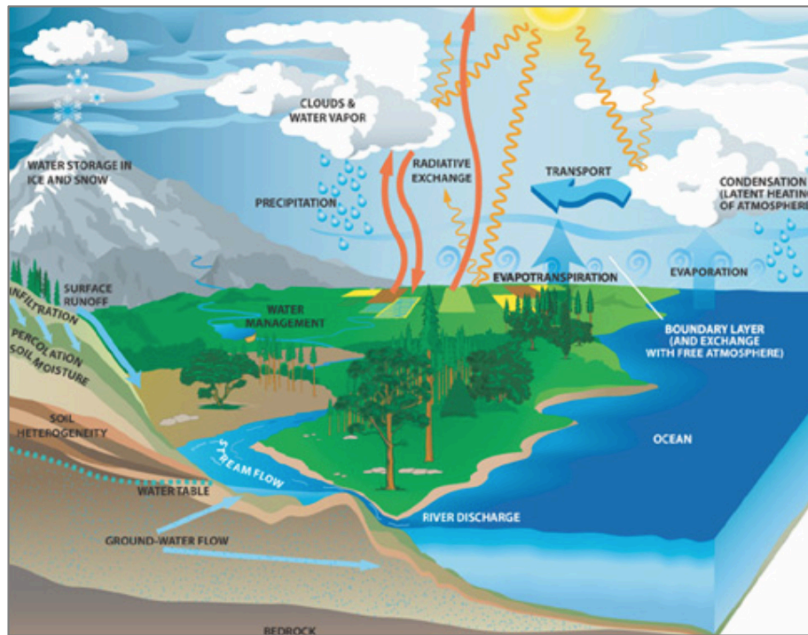


Figure 3. Nasa Earth science: Water cycle. Adapted from <https://gpm.nasa.gov/education/articles/nasa-earth-science-water-cycle>.

The traditional representations of the water cycle typically highlight its key stages but tend to overlook the complex history and evolving understanding of this process. As historians Jamie Linton and Jessica Budds have explored,²² there is a deep, layered history behind how we visualize and conceptualize the water cycle. While philosophers and scientists have long recognized the interconnectedness of various elements within the cycle, including the impact of human activities on water circulation,²³ the term “hydrologic cycle” itself was only introduced in the 1930s by American hydrologist Robert Horton. Horton’s work was foundational in establishing hydrology as a scientific discipline in the United States.

Moreover, Linton and Budds argue that the initial aim of defining the hydrologic cycle was not just to describe the natural processes involved, but also to carve out a new area of scientific inquiry, thereby forming a professional community of hydrologists. From the outset, the concept was shaped by technical and managerial needs, aiming to present water in a way that was understandable and controllable. However, as Linton observes, Horton’s intention was precisely to exclude the role of humans and the substantial influence of human activity on the water cycle. In doing so, it “naturalizes” the cycle, presenting it as a process independent of human influence, which obscures the social dimensions of the Anthropocene, namely, the epoch in which human activities have had a global impact on Earth’s systems, including the hydrological system. If, as Earth System sciences suggest, the Anthropocene represents a fundamental alteration of the natural parameters that defined the Holocene due to human actions, then these human factors must be integrated into our understanding of the water cycle.

From a philosophical perspective, the intricate relationship between politics, epistemology, and ontology²⁴ in the conceptualization of water is particularly significant. Political objectives play a crucial role in shaping how

²² Jamie Linton and Jessica Budds, “The Hydrosocial Cycle: Defining and Mobilizing a Relational-Dialectical Approach to Water,” *Geoforum* 57 (2014): 170–80.

²³ Jean-Baptiste Fressoz and Fabien Locher, *Chaos in Heavens: The Forgotten History of Climate Change* (Verso, 2024).

²⁴ For the triangulation between ontology, politics, and epistemology as a methodological framework, see Pietro Daniel Omodeo, *Political Epistemology. The Ideological Problem in Science Studies* (Springer, 2019).

water is visually and conceptually represented. We could explain this as follows: the way in which the water of a determinate being is produced and reproduced (ontology)²⁵ is deeply influenced by a system of knowledge (epistemology) that serves two main purposes: (1) to dissociate water from human activity and (2) to establish hydrology as a distinct scientific field, thereby rendering water as something that can be managed and controlled within political frameworks. This portrayal of water, as an entity existing independently of the processes that define it and external to human influence, reveals the profound interconnection between its epistemological and political dimensions.

Should philosophical analysis, therefore, pretend to correct science or scientific concepts in light of this critique? Doing so would imply that the observer – our analysis, in this case – possesses a superior or truer understanding of reality, which the current concept fails to fully capture.²⁶ The task, rather, is to formulate a different conceptual framework that offers a comparably robust link between politics, epistemology, and ontology. This would enable us to address new type of problem,²⁷ such as the relationship between the geosphere and the anthroposphere, a central issue posed by the Anthropocene.

Rather than relying on a system based on the interaction between parts and wholes, such as the hydrologic cycle or the broader Earth System, this alternative framework would emphasize the primacy of *relations* over things or substances. This shift in focus means moving away from treating water as an isolated entity and instead viewing it in terms of its relational existence – how it interacts with human and non-human systems, and how these interactions shape its being. By prioritizing relationality, we will indicate a way to challenge the notion of water as a static, politically neutral substance and open up a space for understanding it as deeply intertwined with human activity, culture, and politics. In this sense, water is no longer a passive resource to be managed but an active participant in a network of relations, shaped by and shaping the world around it.

The Hydro-Sociologic Cycle

The fundamental ontological assumption underlying both the hydrological cycle and the concept of the Earth System is that the system's parts exist prior to their relationships. This assumption posits that the components of the system – such as water, land, and atmosphere – exist independently before being interconnected through external relations. In this view, the parts precede the interactions that link them, implying that the connections between them are secondary or extrinsic to their existence.

One potential consequence of this approach is that it risks treating the components as isolated entities, with their relations being less essential or merely incidental. This can lead to a fragmented understanding of complex systems, where the dynamic interplay between components is downplayed or oversimplified. In contrast, drawing on numerous studies that explore the relationship between water and social power,²⁸ as well as a long philosophical tradition, Jamie Linton has proposed an alternative framework, grounded in the dialectic of internal relations as its fundamental ontological assumption. Rather than treating the parts of a system as pre-existing and independent, this framework emphasizes the inherent interconnectedness of the components, suggesting that elements like water are shaped by, and in turn shape, their relationships with other elements. This perspective seeks to capture the complexity and fluidity of interactions within systems, offering a more integrated understanding of phenomena such as the Anthropocene.

²⁵ I rely on the definition of ontology provided by Michael Hardt and Antonio Negri, *Empire* (Harvard University Press, 2001).

²⁶ The problem concerning the relationship between philosophy and science is crucial, especially regarding the Anthropocene, but it cannot be discussed here.

²⁷ See Isabelle Stengers, "Putting Problematization to the Test of Our Present," *Theory, Culture & Society* 38, no. 2 (2021): 71–92.

²⁸ To mention just two prominent examples, see Erik Swyngedouw, *Social Power and the Urbanization of Water: Flows of Power* (Oxford University Press, 2004); Noel Castree, *Nature* (Routledge, 2005).

The doctrine of internal relations emphasizes how things, in other words, do not relate to each other as ready-made, preformed entities (like billiard balls), nor do they emerge from these relations as independent entities. Thus, the very existence of things in a dialectical relationship presupposes the relationship and the nature of this relationship produces internal change in the things themselves. One aim of relational-dialectical thinking is therefore to consider how things – like water, nature, etc. – that are usually considered in the social (and natural) sciences to be ahistorical – do indeed have a history and may therefore be historicized.²⁹

From this perspective, the properties that constitute things emerge as a function of their relations with other things. This means that relations do not happen *between* things but rather that things are constituted *through* and *by* relations – on which they remain dependent. It's a processual view of the water circulation, that stresses its relational identity.

Linton and Budds's alternative to the hydrological cycle is what they call the "hydro-social cycle," "a socio-natural process by which water and society make and remake each other over space and time." According to this framework, nature and society shape each other *internally*: different kind of social relations produces different kind of waters, and vice-versa, in a recursive way (as stressed by the very idea of *circulation*). The process of emergence of things through relations, therefore, is both dynamic and historical: the assemblage that gives rise to a particular kind of water and a particular socio-political configuration is always in transformation. Linton and Budds offer a visual representation of the hydro-social cycle:

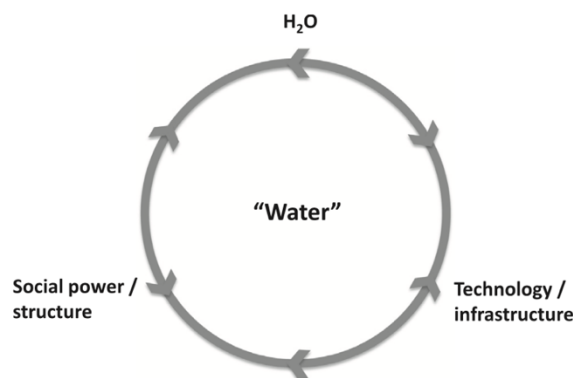


Figure 4. Descriptive title. Adapted from Jamie Linton and Jessica Budds, "The Hydrosocial Cycle: Defining and Mobilizing a Relational-Dialectical Approach to Water," 176.

The materiality of water is imbricated in particular ways with the "socio-technical formations" in which it takes shape. This mean, on the other hand, that water itself is an active, material element within this process that plays a part in shaping political structure, institutions, and technologies.

In essence, the hydro-social cycle reframes three key questions. First, instead of assuming a fixed definition of water, it asks what water is and how it is composed within different assemblages and social contexts. Second, rather than presupposing hydrology as the dominant field of inquiry, it explores how water is made knowable – how it is constructed through discursive practices and alternative ways of understanding. Finally, it challenges the separation of social and natural elements by examining how water internalizes social relations, power dynamics, and technologies.

²⁹ Jamie Linton, *What is Water? The History of a Modern Abstraction* (University of Chicago Press, 2010), 53.

Conclusion: Back to the Earth Itself

Through this brief exploration, we delved into hydrology to reframe the concept of system intended as a complex totality. Linton showed that the notion of hydro-social cycle, grounded in an ontology of relations, allows to reframe the relation between nature and society, threatening these two polarities not as external entities but as mutually shaping assemblages. This perspective rethinks the relationship between nature and society, moving away from the view of the water cycle as something “manageable” or, in Luhmann’s terms, predictable and controllable. Instead, by constructing (epistemology) the hydro-social cycle not as a static entity but as an ongoing process (ontology), we emphasize its inherent complexity, which in turn complicates the role of political planning and intervention (politics). While the exact redefinition of this epistemological–ontological–political triangulation remains abstract, I believe it presents a central issue to address in the context of the Anthropocene.

The problem now would be to build up the very notion of Earth starting from the “ontological plane” just discussed. As we have seen, ESS frames the Earth as a complex totality composed of autonomous parts that, only afterwards, interact and shape each other. This perspective, as Giulia Rispoli³⁰ has stressed, maintains an extrinsic vision of the relationship between the parts. The Anthropocene, as a geological and historical condition, seems to question precisely this separation, demanding we focus on interrelations. In particular, important strains of eco-political thought have claimed that is not the human as an abstract entity that caused the regime shift from the Holocene but rather capitalism as a determined and historical mode of production. How should this problem be integrated within this framework? Richard Levins has convincingly argued that, in the Anthropocene, capitalism should not be considered a *factor* within the Earth but rather, and more radically, as the *fundamental determinant* of the relations that produce and reproduce being.³¹ From a Simondonian perspective, the challenge is, once again, to grasp the relationships inherent in the process of individuation rather than focusing solely on the already individuated product of that process.

Even if we cannot answer such complex questions, we can point to some problematic issues that they highlight. From a philosophical perspective, the main problem we face in building a new concept of the Earth based on the primacy of relations over things is the impossibility of *differentiating* between things. If everything shapes everything else, where does the process start and where does it end?³² How can analysis speak meaningfully about reality, particularly the Earth, if even discourse itself is continuously shaped by the infinite material, symbolic, technological forces at play? Everything, as Adorno claimed against Bergson, is washed “away in an undifferentiated tide of life.”³³ Moreover, while geoengineering embodies the belief that the Earth system is controllable, this processual view of reality seems to move in the opposite direction – a retreat from action akin to Heidegger’s notion of *Gelassenheit*, a letting-be or passive resignation.

As already said, there is no simple answer to these questions. Rather, they seem to point to some of the crucial issues that should be addressed in the epoch of the Anthropocene.

³⁰ Giulia Rispoli, “Genealogies of Earth System Thinking,” *Nature* 1, no. 1 (2020): 4–5.

³¹ Richard Levins, “Dialectics and System Theory,” in *Dialectics for the New Century*, ed. B. Ollman and T. Smith (Palgrave Macmillan, 2008). Carles Seriano has developed a critique of the ESS’s epistemology starting from this very point. See Carles Seriano, “Epistemological Limitations of Earth System Science to Confront the Anthropocene Crisis,” *The Anthropocene Review* 9, no. 1 (2022): 111–125.

³² Linton is also aware of this issue but treats it as a positive aspect within his framework, asserting that things are continuously shaped and reshaped through their interactions with other things.

³³ Theodor W. Adorno, *Negative Dialectics*, trans. E. B. Ashton (Routledge, 1990), 8.

Anthropocene Metabolisms

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Introduction

In their landmark study, *The Shock of the Anthropocene: The Earth, History, and Us*, Christophe Bonneuil and Jean-Baptiste Fressoz push back against “the narrative of ecological awakening,”² according to which 20th-century Western society witnessed a gradual blossoming of ecological awareness into a powerful ecological consciousness.³ Instead, they identify six “grammars of environmental reflexivity”⁴ that have preceded the contemporary iteration of environmental thought: (1) *circumfusa* and the environment, (2) climate, (3) economy of nature, (4) society–nature metabolism, (5) thermodynamics, and (6) resource exhaustion. On the basis of these grammars, contrary to the ignorance-to-enlightenment understanding of environmental thought, they pose a different question: Why are we on the verge of a global climate disaster *despite* having long been aware of the likely disastrous consequences of unrestrained industrial production?

This sceptical question, raised in the old-fashioned tradition of so-called paranoid critical thought, outstrips the research directions that assume environmental destruction to be a byproduct of limited knowledge, whether due to historical constraints or conspiratorial manipulation. On the one hand, it demands a more rigorous reflection on the connection between epistemology, politics, and economics. Can the weight of the profit motive in decision-making be denied by the weight of evidence, for instance? Do money, power, and research even confront one another on the same terrain? On the other hand, the sceptical question raises the possibility that knowledge may not have the force necessary to engender the desired political outcomes. In that case, neither the solution proposed by Paul Crutzen – “wise application of the knowledge thus required in the noösphere, now better known as knowledge or information society”⁵ – nor the one advocated by Jürgen Renn – to recognise “the predicament of humanity in the Anthropocene as a challenge of knowledge”⁶ – may actually be the answer to the possibility of human extinction posed by the Anthropocene.

Regardless of the value of sceptical, paranoid questions compared to the illuminated path towards a post-Anthropocene society guided by environmentally conscious scientists, the six environmental grammars proposed by Bonneuil and Fressoz are an excellent starting point for further historical and conceptual investigation. To begin with, how distinct are these six grammars? The grammars of metabolism and thermodynamics, for example, exhibit significant conceptual overlap insofar as the discourses associated with both often deal with energy conversion, material exchanges, and resource flows. Furthermore, several of the grammars begin at roughly the same time, specifically in the 19th century. Given their potentially porous boundaries, is it possible that Bonneuil and Fressoz may be misidentifying subgenres of a more comprehensive discourse as distinct genres? Finally, how certain are

¹ Funded by the European Union (GA number: 101105880). Views and opinions expressed are however those of the author only and do not necessarily reflect those of the European Union or Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

² Christoph Bonneuil and Jean-Baptiste Fressoz, *The Shock of the Anthropocene: The Earth, History and Us* (Verso Books, 2016), 146.

³ See, e.g., Paul Warde, Libby Robin, and Sverker Sörlin, *The Environment: A History of the Idea* (JHU Press, 2018).

⁴ Warde, Robin, and Sörlin, *The Environment*, Chapter 8.

⁵ Paul J. Crutzen, “The ‘Anthropocene,’” in *Earth System Science in the Anthropocene*, ed. E. Ehlers and T. Krafft (Springer 2006). https://doi.org/10.1007/3-540-26590-2_3

⁶ Jürgen Renn, *The Evolution of Knowledge* (Princeton University Press, 2020), 384.

we that, for instance, the climate as understood two hundred years ago remains the same climate to which we refer today? Do ideas and concepts maintain relatively stable identities over time, as Arthur O. Lovejoy once argued, or can they undergo paradigm changes, threshold leaps, and quantum shifts? In fact, is it possible that distinct environmental grammars merge and fracture into new discourses over time?

With the above questions in mind, this paper focuses specifically on the concept of metabolism. For Bonneuil and Fressoz, the grammar of metabolism refers to “the exchange of matter and energy between human society and nature” and is strongly related to “a chemical and bookkeeping view of agriculture” that originated in the 19th century and lasted until the middle of the 20th century.⁷ They mention how, in the last century, metabolism became entangled with analyses of global material flows, systems ecology, and the Gaia framework. This is a useful and informative sketch of the metabolism discourse, but it does not exhaust the historical-theoretical richness of this particular concept. Therefore, in the discussion below, I attempt to reconstruct additional genealogical threads within the metabolism discourse to reveal more of its internal diversity. Stronger internal differentiation and greater genealogical variation do not necessarily undermine the coherence of this concept or grammar. Even if its identity is multiple and altered over time, this proves the enduring significance of the metabolism concept, which keeps being refashioned in response to changing states of affairs.

Methodological Reflection

Cleaning and scraping “bones like the critic and historian of our time” – this is how Deleuze and Guattari describe the work of those who merely reproduce concepts without reinventing them.⁸ And yet, sometimes, it is necessary to do a fair bit of archaeological dusting and brushing before invention can begin. Monuments need to be uncovered before they can be rearranged, just as stages must be built for conceptual personages to perform their roles. What is more, dusting, scraping, ordering – these are not activities devoid of inventiveness and even creation. There is art to the manual labour of the critic and historian.

Nonetheless, Deleuze and Guattari are doubtlessly correct in their assessment that “nothing positive is done, nothing at all” when concepts are presented either too formally, without substantive content, or too rigidly, without room for interpretation.⁹ What, then, is the correct way to elaborate concepts? For the two philosophers, *conceptual personages* are an essential component of the complex work of concept creation. All personages bear proper names: “the Socrates of Plato, the Dionysus of Nietzsche, the Idiot of Nicholas of Cusa.”¹⁰ In addition, philosophers themselves can become personages; for instance, the Spinoza of Deleuze, but also the Deleuze of Badiou, a potato fascist who clamors after being. When a personage is created successfully, the different between author and personage becomes indistinct. What remains constant, however, is their mutual association with a concept. And so, both Deleuze and Spinoza are associated with immanence, whereas the Deleuze of Badiou is only a partially successful caricature without a conceptual home.

The possibility of becoming a personage should not be associated exclusively with philosophers. The matter can be looked at from another angle: philosophy is not about disciplinary borders but concept creation, and so anybody who has contributed to the creation of a concept belongs among the ranks of philosophers. Specifically for this paper and its aim of differentiating genealogies within the conceptual history of metabolism, I propose treating some of the names associated with this concept as personages. Therefore, Sanctorius, Schwann, and Marx will be personages of metabolism. By treating an author as a personage, one must clean and scrape the conceptual

⁷ Bonneuil and Fressoz, *The Shock of the Anthropocene*, 156–57.

⁸ Gilles Deleuze and Felix Guattari, *What Is Philosophy?*, trans. Hugh Tomlinson and Graham Burchill (Verso, 2009), 83. Originally published in 1994.

⁹ Deleuze and Guattari, *What Is Philosophy?*, 83.

¹⁰ Deleuze and Guattari, *What Is Philosophy?*, 62.

bones, but the purpose of such archaeological work is to find, in addition to what they said, what they invented, or how each personage contributed something new to the historical-theoretical plane of a concept. A genealogy then becomes a dynamic arrangement of such archaeological personages. This paper highlights some of the conceptual personages within the grammar and discourse of metabolism.

Genealogies of Metabolism

Metabolism is a constellation of words, themes, and concepts. When we speak of metabolism in the singular, it appears to have a relatively unified history. Sanctorius was a scholar of metabolism, Schwann studied metabolism, Marx discussed metabolism, and so on – we should be able to establish a clear trajectory within this constellation, or discourse, and its development over time, in which all these and other names are points traversed by an advancing historical line of metabolism. However, Marx wrote about *Stoffwechsel* and *Riss*, and von Liebig mostly referred to *metamorphosis*. Sanctorius never used the word or any of its cognates. Schwann coined the expression *metabolismus*, but it only caught on decades later and in a different country, the United Kingdom. Already at the level of terminology, the idea of a single, unified history of metabolism is suspect.

Is there, beyond terminological fragmentation, a deeper thematic unity to be rediscovered? For example, is not all metabolism theory about exchanges between two variables, the one generally being society and the other nature? But it is questionable how helpful this degree of generalisation is, when all specific content is abstracted away, and the considerable differences between disciplinary fields are ignored. Can we say, for instance, that when scholars discuss biochemical reactions in cells, exchanges between the energy pools of species, agricultural conversion of material into food in nonindustrial societies, colonial and industrial farming with developed chemistry in modernity, and advanced fossil fuel societies with global resource and energy flows – all these situations with their distinct social, political, and epistemic technologies; do they all amount to the same “theme,” metabolism?

Without the unity of word and theme, we are left with conceptual identity. Behind the many different words and themes, something recognisable remains. Perhaps, as Deleuze and Guattari said, what remains is the plane of immanence associated with a concept in which the concept undergoes changes, reforms, and revolutions in the hands of those who shape it. Below, I attempt some tentative surveying of the conceptual-historical plane of metabolism and its personages.

Sanctorius Sanctorius

Some scholars have claimed that the history of metabolism starts with Sanctorius Sanctorius, the 17th-century Venetian physician. According to Carpenter, although Sanctorius was a notable figure in the development of metabolism studies, “modern metabolism studies began with Lavoisier.”¹¹ This position is contested by Eknoyan, who describes Sanctorius as the “founding father of metabolic studies,” whose experiments “laid the basis of all future metabolic studies.”¹² Bing claims that Sanctorius was “the first of the *modern* students of metabolism,”¹³ and so does Nail, who argues that “the idea of metabolism . . . has its *modern* origins in the work of the Venetian physician Sanctorius.”¹⁴ The two editions of *Surgical Metabolism* reiterate the notion that the beginnings of a modern understanding of metabolism lie with Sanctorius, although in both texts the only source for this claim is

¹¹ Thorne M. Carpenter, “The Historical Development of Metabolism Studies,” *Journal of the American Dietetic Association* 25, no. 10 (1999): 837–41, 837.

¹² Garabed Eknoyan, “Sanctorio Sanctorius (1561–1636)–Founding Father of Metabolic Balance Studies,” *American Journal of Nephrology* 19, no. 2 (1999): 231–32.

¹³ Franklin C. Bing, “The History of the Word ‘Metabolism’,” *Journal of the History of Medicine and Allied Sciences* 26, no. 2 (1971): 158–80, 158. My emphasis.

¹⁴ Thomas Nail, *Marx in Motion: A New Materialist Marxism* (Oxford University Press, 2020), 101. My emphasis.

Eknoyan's aforementioned article (meanwhile Nail cites Bing's work).¹⁵ This treatment of Sanctoirius confirms the tendency identified by Hollerbach: "Historical accounts of Sanctoirius and his work tend to foreground the genius who invented, almost out of the blue, a new medical science that profoundly influenced the modern age."¹⁶ However, even Hollerbach – who offers a much more sober and extensive analysis of Sanctoirius, although in the history of science rather than in the concept history of metabolism – agrees that Sanctoirius was something of a modern precursor who "introduced into the medical field a form of quantitative research that represents *an early iteration of today's self-tracking, or self-quantifying, technology.*"¹⁷ There seems to be wide agreement, therefore, at least in one part of the highly dispersed metabolism discourse, that in Sanctoirius, we find a figure who introduced experimentation and quantification into medicine, invented the idea of metabolism and the field of metabolism studies, and foreshadowed the contemporary medical panopticon.

These statements exemplify some of the issues and difficulties with metabolism scholarship. For instance, how were Sanctoirius's research and ideas *modern*? It is true that Sanctoirius famously used an innovative device, a weighing chair suspended from a steelyard balance, to measure what we would now call metabolic changes in the body. However, neither does the concept of metabolism appear in his works, nor are there any indications that Sanctoirius understood what he was doing in a way that would be comparable to ours – that is, through knowledge of biochemistry. Instead, his understanding of medicine and the body remained within Galenic parameters, and his cherished pivotal idea of insensible perspiration was not his own invention.¹⁸

Then, there is the terminological confusion. Are "metabolism," "metabolic studies," and "the idea of metabolism" synonyms with the same referent? Even considered superficially, it would seem that the thing, the idea of the thing, and the studies of the thing refer to distinct phenomena. This confusion between reference levels is part of a broader contemporary fuzziness over the meaning of the metabolism concept, which is used across a variety of fields, from physiology and biochemistry to environmental studies and ecology to social theory and geography to eco-Marxism and the Anthropocene discourse. Do all these disciplines and fields understand the same thing by metabolism, and has this understanding remained unchanged since Sanctoirius's writings over four hundred years ago? And if so, what is this common thread between, say, John Bellamy Foster's arguments about the metabolic rift caused by capitalism and Sanctoirius's aphorism that "They who Piss more than they Drink, perspire little or nothing"?¹⁹ Some scholars have claimed that the validity of Sanctoirius's experiments was confirmed in the 20th century,²⁰ but this is true only if his vocabulary is converted into modern, biochemical language while doing away with its Galenic context. In addition, although Sanctoirius did show that the body was undergoing constant change and was often in a state of disbalance, this was not a particularly new or modern insight – it is not as if before the 17th century bodies were considered unsusceptible to change. But even if we were to grant that Sanctoirius introduced a new understanding of change within bodies, would this be enough to make him a *modern* student of metabolism?

¹⁵ Christy M. Lawson, Chandler A. Long, Reagan Bollig, and Brian J. Daley, "Introduction to Metabolism" in *Surgical Metabolism: The Metabolic Care of the Surgical Patient*, ed. Kimberly A. Davis, and Stanley H. Rosenbaum (Springer, 2014), 1–21; C. Lindsay McKnight, Jared H. Griffard, Sneha G. Bhat, Reagan W. Bollig, Christy M. Lawson, Chandler A. Long, and Brian J. Daley. "Introduction to Metabolism," in *Surgical metabolism: The Metabolic Care of the Surgical Patient* (2nd ed.), ed. Kimberly A. Davis and Stanley G. Rosenbaum (Springer, 2020), 3–16.

¹⁶ Teresa Hollerbach, *Sanctoirius Sanctoirius and the Origins of Health Measurement* (Springer Nature, 2023), 2.

¹⁷ Hollerbach, *Sanctoirius*, 1. My emphasis.

¹⁸ Hollerbach, *Sanctoirius*, Chapter 3.

¹⁹ Sanctoirius, *Medicina Statica: Being the Aphorisms of Sanctoirius* (2nd ed.), trans. John Quincy (1720), 100. Originally published in 1614.

²⁰ Eknoyan, "Santorio Sanctoirius"; Bing, "The History of the Word 'Metabolism'."

However, my point is not to contest the historical significance of Sanctörius to the development of modern metabolism discourses. Rather, this significance must be sought elsewhere than in the particularity of his ideas, tools, and experiments, none of which are very modern or relevant to contemporary knowledge. The question is this: What is it about Sanctörius that makes him appear a worthy forebear? Why does this particular figure, objectively so distant from us, represent something that is subjectively perceived as modern and, thus, still of “our” time? In other words, what does the selection of Sanctörius as the precursor of contemporary metabolism discourse say *not about Sanctörius himself but about the field that nominates him?*

One reason could be scholarly inertia. When writing general introductions – for instance, as in the case of *Surgical Metabolism* – scholars often cite established sources that are easy to find in database searches, hence the prevalence of the aforementioned articles by Bing and Eknöyan. Sometimes, this is done for little more than ticking the checkbox of having done due historical diligence; for example, this is surely the case with Nail, whose theory of metabolism has absolutely no connections, explicit or implicit, with Sanctörius.

Another reason may be the double fetishism of the Renaissance and the scientific revolution. If a contemporary field can locate its origins within that most hallowed intellectual period and event of Western history, then so much the better. If a suitable figure, such as an influential and trailblazing professor with an experimentalist disposition, can be identified as a precursor, then the prestige of the idea and the discipline which this figure is said to represent is further enhanced.

At the same time, speaking a little less cynically perhaps, the nomination of Sanctörius as forebear may be driven by the self-recognition of a certain field and its practitioners in the inherited historical image of the Venetian physician. Bing illustrates this point with typical candour: “Most of us remember him as the small man with the trim beard who sits in the chair shown in the drawing that serves as a frontispiece to his book.”²¹ Few scholars, if any at all, have taken the pains to properly contextualize and understand Sanctörius’s work in the way Hollerbach has done. Instead, the source about, and subsequently the understanding of, Sanctörius is quite basic: the suggestive image of “the small man with the trim beard” sitting upon his weighing chair. Thus, to understand the contemporary meaning of Sanctörius, knowledge of the intricacy of his actual epistemic practices is of less significance than the content of this popularizing image.

The image depicts a man sitting on a chair suspended from a steelyard scale attached to the ceiling and fastened to a small platform on the ground for additional balance. Some sort of measuring indicators are attached to the bottom of the chair, and there is a table in front of the chair set with food and drink. The man on the chair is caught in an awkward position as if balancing himself while reaching to, or away from, the table. The chair itself is notable: it is more like a small bench with four wooden pillars and a roof – it holds the man sitting on it like a bird in a cage. The table, set on a small platform to bring it up to the height of the man, seems to have wheels. A window overlooks the scene.

On the one hand, the modern meaning conveyed by this image is quite simple: a man is weighing himself to understand the workings of his body and the status of his health. Insofar as metabolism is connected with individual nutrition, weighing remains a basic practice: “In our so-called balance experiments today, in order to estimate the body’s requirement for protein for example, we handle the intakes and outputs of the body essentially as Sanctörius did, adding chemical analyses of the materials which he could only characterize in terms of weight and volume.”²² But in order to get from Sanctörius’s weighing chair to the not-inconsequential addition of chemical analyses, a great many other instruments and tools had to be developed. Carpenter describes a variety of face masks, breathing devices, and gasometers for measuring respiration, all the way to the Benedict-Roth apparatus in

²¹ Bing, “The History of the Word ‘Metabolism’,” 158–9.

²² Bing, “The History of the Word ‘Metabolism’,” 159.

the 20th century.²³ This is just one strand of devices, along with microscopes for investigating structural composition, data-processing machines for statistical analyses in measuring industrial metabolism, and satellites and observation stations for environmental surveying in earth-system metabolism, among many other technologies employed in the multitude of fields linked to metabolism.

Therefore, Hollerbach is correct in drawing what may, at first, seem like an exaggerated historical connection between Sanctorius's weighing chair and smartwatches for live-tracking body status. What underpins this connection is the entanglement between a living thing as an object; health as a norm; a variety of related epistemic discourses such as physiology, nutrition, and biochemistry; and instruments used as framing devices that both participate in this entanglement and articulate it. In this sense, Sanctorius can, indeed, be called a *modern* precursor of metabolism: not merely because he introduces technology as a key component in the study of bodies and their health, but also due to the recognizable presence of this complex entanglement between discipline (the surveillance of the body), biopolitics (the use of health as a political norm), and the technosphere (the articulation of life through technological framing).

Theodor Schwann

It is well known that the concept of *metabolism* was first introduced by Theodor Schwann in 1839, and that it became popular in English scholarship several decades later. However, Schwann's fame is not associated with this particular conceptual invention; instead, he is known as "one of the founders of cell doctrine,"²⁴ or cell theory, which remains foundational to contemporary biology. This makes it even more interesting that in his major work, *Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants*, Schwann introduced metabolism and cell theory as interwoven concepts, with the former explaining the latter.²⁵

Schwann starts by considering an established physiological fact: plants are composed of cells and are nothing more than aggregates of these cells, whereas animals, which exhibit significantly more physiological complexity, are individual wholes – that is, systematic totalities whose principle of organisation exceeds their constituent parts. With a critical disposition towards this state of knowledge, he examines two animal components exhibiting significant physiological differences, namely, the *chorda dorsalis* and the cartilage. He discovers that the two components consist of cells and that these cells demonstrate "complete accordance" in terms of their formation, development, and growth with those found in plants. "We have now thrown down a grand barrier of separation between the animal and the vegetable kingdoms," argues Schwann.²⁶ In addition, most animal tissue can be broken down into the same elementary units, cells. Furnishing these two proofs – the *complete accordance* between plant and animal cells as well as the *universality* of cells in animals – Schwann can claim that "there exists one general principle for the formation of all organic productions, and that this principle is the formation of cells."²⁷ The foundation for what he calls cell-theory is thus laid down.

But this is only half of the enquiry. Schwann states that cell-theory also includes "the conclusions which may be drawn from this proposition,"²⁸ or from the discovery of the common principle unifying plant and animal kingdoms along with all organic life. The implications and further questions raised by cell-theory are not minor. The

²³ Carpenter, "The Historical Development of Metabolism Studies."

²⁴ Tony Abraham Thomas, "Theodor Schwann: A Founding Father of Biology and Medicine," *Current Medical Issues* 15, no. 4 (2017): 299–301.

²⁵ Theodor Schwann, *Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants*, trans. Henry Smith (Sydenham Society, 1847). Originally published in 1839.

²⁶ Schwann, *Microscopical Researches*, 34.

²⁷ Schwann, *Microscopical Researches*, 166.

²⁸ Schwann, *Microscopical Researches*, 166.

distinction between plant and animal understood as the difference between an aggregate and a totality was, in addition to a biological fact, a fact of significant philosophical import. For instance, German Idealists such as Kant and Hegel both used this distinction in their considerations of the structure of knowledge – knowledge organisation must follow the principles of nature, which dictate that an aggregate (i.e., a plant) is inferior in complexity and function to an organised totality (i.e., an animal). But if both plants and animals follow the same principles of composition and growth, where does the difference between the two lie? If all life is unified through cells, whence comes organic variation, clearly visible between plants and animals and within each kingdom as well? Finally, if the cell is responsible for the organisation of all organic beings, what exactly are the powers of cells, and where do they originate from?

Schwann was well aware of these questions. After proposing cells and their development as the common principle of all organic life and organised bodies, he proceeded to consider the theoretical implications of this discovery by cutting through a series of dualities. First, there are two frameworks for accounting for “the fundamental powers of organised bodies:” teleology and physicalism.²⁹ Schwann rejects the former in favour of the latter by claiming that the organisation of a body depends not on an immaterial principle, such as the soul, but on the physical power of cells, each of which carries the ability to structure itself, to grow, and to reproduce “in accordance with strict laws of blind necessity.”³⁰ Then, having rejected teleology, he continues to another duality, this time regarding physical organisation: holism versus individualism. The totality of the organism, argues Schwann, is a condition for the functioning of cells, but it is not the cause. Cells are capable of independent growth – therefore, their reproductive power rests with them alone. We find teleology and holism torn down to make way for physicalism and individualism; all this by the power of cells.

Finally, we arrive at the fundamental question: What exactly are the powers of cells? According to Schwann, first there is the plastic power, which allows a cell to attract molecules from its environment and arrange them into structures, thus developing the nucleus and the walls along with further structures. As important as the plastic power is, however, it is not what distinguishes organic life because crystals, for example, are also endowed with the plastic power to construct themselves. The plastic power is not where the difference of organic life from inorganic nature lies. Instead, this distinction is premised on the *metabolic power*, “the faculty of producing chemical changes in its [a cell’s] constituent particles.”³¹ Cells do not merely attract molecules from their surroundings; they break down and rearrange components to produce new materials. Contrary to inorganic nature, which can build structures only when all materials are correctly provided in the proper form, organic life intervenes in its surroundings more acutely – perhaps more creatively? – to extract conditions for its own growth.

We should not overstate how speculative Schwann intended to be at that time. The metabolic power of cells was the power of chemistry following blind laws of necessity. He identified two conditions for this power to function in an organic body: the right *temperature* and the presence of carbonic acid gained through *respiration*. The purpose of his argument was to overcome “that magical character, to which attaches the idea of Life,”³² in favour of a more scientific – that is, physicalist and individualist (versus teleological and holistic) – understanding of organic and nonorganic nature.

With Schwann, certain conceptual patterns are laid down that are still operative. The distinction between plant and animal is diminished, but the difference between organic and inorganic life becomes thicker. At the same time, at least in Schwann’s time, the line separating the organic and the inorganic remains porous: crystals exhibit similar features to organic bodies, and is crystallization not part of the cell’s metabolic power? This line will be

²⁹ Schwann, *Microscopical Researches*, 187.

³⁰ Schwann, *Microscopical Researches*, 190.

³¹ Schwann, *Microscopical Researches*, 197.

³² Schwann, *Microscopical Researches*, 202.

reinforced with further developments in cell theory, but it remains active even during the Anthropocene. More importantly, focusing on the chemical abilities of the smallest particles within bodies is still part of the modern metabolism discourse.

A more in-depth analysis of the passage from Schwann to his contemporary legatees would require at least one interlocutor along the way, namely, Alfred J. Lotka and his 1925 work titled *Elements of Physical Biology*. Here, we could find some of the beginnings for the entanglement between the metabolic, biochemical power of cells and the quantitatively oriented study of populations. For now, however, we will have to jump to the recent past, where this particular entanglement is already in place.

The full maturation, or perhaps the full deployment, of Schwann's discovery of the metabolic power of cells can be found in Brown and colleagues' ambitious and influential attempt to develop "a metabolic theory of ecology" based on a "mechanistic, quantitative, synthetic framework" that would "eventually provide a conceptual basis for ecology similar to that which genetic theory provides for evolution."³³ Echoing Schwann in their view that metabolism is "one of the great unifying processes in biology," the authors claim that metabolic action connects "all levels of organisation, from molecules to ecosystems."³⁴ We find here a significant but perfectly logical expansion of the German physiologist's original proposal: if organic bodies are expressions of the metabolic power of cells, it makes sense that further layers of complexity involving aggregated bodies would continue to exhibit an imprint of this original power. The difficulty, of course, is to demonstrate how exactly this metabolic power is transmitted and retained in increasingly large groupings of organic bodies in multi-actor environments.

According to Brown and colleagues, cells are no longer the kernel of metabolism. The minimal metabolic unit has shifted from cells to their component parts, organelles, whose "structure and function are nearly identical across taxa and environment."³⁵ Compared to Schwann, the size of the elementary metabolic particle has decreased further, but the complete accordance and universality of this particle across organic life – or, at least, across eukaryotic life – remains in place. Like cells, organelles perform the basic metabolic work of processing chemical compounds. However, this work occurs within the constraints imposed by the whole organism, specifically by following three features of the organism: body size, temperature, and stoichiometry, which refers to "the quantities, proportions, or ratios of elements in different entities."³⁶ Variations in these three features can affect metabolism in multiple ways, such as slowing it down or speeding it up. In addition, organisms do not exist in isolation but rather within environments, and relationships with said environments depend on three active functions of the organism: acquiring the necessary elements from the environment, maintaining the organism in a state of fitness, and excreting waste products. Variations in all three functions due to environmental changes can, once again, affect the metabolic work performed in organelles. Therefore, Schwann's metabolic power, which was located quite firmly, even physically within the cell, is distributed over a range of conditions, levels, and proportions. The work performed by organelles is clearly significant, but metabolism as such appears much less of a physically localizable power and more a nomadic, wandering synthesis of the various circumstances, internal and external, undergone by an organism.

If the metabolic power is no longer situated within cells because, in fact, it has become dispersed over multiple conditions of the body, functions of the organism, and variations of the environment, what is metabolism for Brown et al., and how can this metabolism manifest itself across all these different levels? Indeed, metabolism in this framework can no longer be properly called "a power" possessed by or contained within a certain unit.

³³ James H. Brown, James F. Gillooly, Andrew P. Allen, Van M. Savage, and Geoffrey B. West. "Toward a Metabolic Theory of Ecology," *Ecology* 85, no. 7 (2004): 1771–89, 1786.

³⁴ Brown et al., "Metabolic Theory of Ecology," 1786.

³⁵ Brown et al., "Metabolic Theory of Ecology," 1777.

³⁶ Brown et al., "Metabolic Theory of Ecology," 1774.

Instead, metabolism is “the *rate* of energy uptake, transformation, and allocation.”³⁷ Organelles intake, convert, and dispose of materials – as do organisms and populations, along with entire ecosystems. Stoichiometry, which considers relations as proportions among materials, becomes the analytic basis of metabolic activity. The entire conceptual framework is reorganised with a vocabulary of “energy pools,” “turnover rates,” and “fluxes.” Life consists of a constant circulation of materials and their conversion into energy, from the smallest organelles to prey–predator relations in ecosystems. All these transmissions, exchanges, and productions, which may appear dispersed and loosely connected, are held together by the metabolic rate, which “determines the rates of almost all biological activities.”³⁸ The structure is sutured by constancies in the speed of exchange over time.

From this perspective, organisms are effectively treated as machines of material conversation and vessels of energy transmission. Material and energy are not “distinct ecological currencies”³⁹ but two sides of the same coin, given their mutual subjection to the same metabolic rate. Furthermore, because metabolism provides overall control and sets the aim of organic activity at the level of organelles and bodies, it also “determines the demands that organisms place on their environment for all resources.”⁴⁰ As a result, ecosystems, which “are simply the sums of the stores and fluxes of the constituent organisms,” are expressions of the metabolic rate at a greater scale.⁴¹ Territories are nothing but surface areas for fluxing energy, similar to the membranes of organelles, which are zones for material–energy conversion. Unsurprisingly, species interactions are only phenomenal events of the underlying metabolic rate; they convey in relatively static representations, such as competition over food sources, the genuine dynamism of metabolic processes involving constant fluctuations in energy quantities. Most importantly, we find that the metabolic rate is perfectly scalable from the smallest organic entity to large networks of organic bodies and even structures of networks. To Schwann’s principles of complete structural and functional accordance and universal composition of elementary organic particles, a new principle is added along the lines of stoichiometric scalability. Whatever is common to organic life must be so not only at the level of cells but across all levels.

Given this dispersion of metabolism over conditions, functions, and variations as well as keeping in mind its identity across a variety of levels involving organelles, whole-organisms, and species, one would be justified in wondering whether metabolism is something actual and real or abstract and nominal, perhaps even metaphorical – a mere name for what is, in reality, a multitude of independent phenomena and events. For Brown, however, metabolism is one and real: “The overall rate of these processes, the metabolic rate, *sets the pace of life*.”⁴² The various processes and their rates do not add up to an aggregate name; rather, they are determined by a common rate, the metabolic rate, which has its own existence and thus names something that is independently real. This real, independent rate underpins phenomenal organic activity by determining its speed of experience, or the pace of life.

Nonetheless, the question remains: What does it mean for a *rate* to be real? A rate is much less physically present than a power, and it exists only as a quantified expression. It is clearly “a process,” but the reality of process is more difficult to express in representational terms than that of physical particles and their powers. Thus, the overemphasis on quantification and mathematical abstraction in Brown et al. should not lead us to dismiss them as merely performing an idealization, or abstraction in the pejorative sense, of the materiality of metabolism. Instead, the constant provision of functions and references to quantification may be considered part of an attempt to comprehend metabolism as *process* – it is not a fixed power within a cell or even an organelle that holds organic

³⁷ Brown et al., “Metabolic Theory of Ecology,” 1772, my emphasis.

³⁸ Brown et al., “Metabolic Theory of Ecology,” 1772.

³⁹ Brown et al., “Metabolic Theory of Ecology,” 1774.

⁴⁰ Brown et al., “Metabolic Theory of Ecology,” 1772.

⁴¹ Brown et al., “Metabolic Theory of Ecology,” 1782.

⁴² Brown et al., “Metabolic Theory of Ecology,” 1772, my emphasis.

life together but a nomadic, fluctuating *synthesis* whose localisation is no longer physicalist in the sense of Schwann.

To similar ends of describing process, humanities scholars bend over backwards with hyphens to indicate processual activity, inventing phrases like society-in-nature and hanging-together-in-precarity, whereas Brown and colleagues speak of ratios, fluxes, and turnover – along with one ruling rate. The latter discourse is quantitative and even “mercantile” in the sense of treating everything as an exchange. The former is often metaphorical at best when it is not an outright bouquet of empty neologisms. It is difficult to say which is superior, but we have clearly not surpassed the difficulty of speaking about process.

Karl Marx

Another genealogical thread within the metabolism constellation concerns Karl Marx. In her landmark study, Fischer-Kowalski claims that “within the nineteenth-century foundations of social theory, it was Marx and Engels who applied the term metabolism to society.”⁴³ Saito speaks about “Marx’s original insight into metabolism,”⁴⁴ Moin mentions “Marx’s remarkable recontextualization and utilization of the term,”⁴⁵ and Nail, with typical exaggeration, refers to metabolism as “an extremely integral concept introduced by Marx.”⁴⁶

Marx did not introduce the concept of metabolism, nor did he use the word itself. In the 19th-century German context, the term “*metabolismus*” derived by Schwann from an ancient Greek base was not popular; instead, the term “*Stoffwechsel*” was preferred,⁴⁷ also by Marx.⁴⁸ In addition, Marx’s social understanding of metabolism was influenced by the works of scholars such as Roland Daniels and Justus von Liebig, among others, who were already working in this direction.⁴⁹ Nonetheless, it is true that Marx placed metabolism on a new stage, giving this concept new life.

Some scholars have argued that for Marx, metabolism is a metaphor rather than a concept. For instance, when discussing metabolism in Marx and contemporary environmental discourse, Moore claims that “metabolism is a seductive metaphor.”⁵⁰ At least Moore does not subscribe to a pejorative understanding of metaphors; instead, he also calls the law of value “one of Marx’s favored metaphors”⁵¹ and refers to “Haraway’s cyborgs” and “Actor-Network Theory’s hybrids” as some of “the most famous metaphors”⁵² in the present environmental discourse. In general, Moore moves easily between discussions of “conceptual vocabulary,” “conceptual language,” and “metaphors.” A strong distinction between concept and metaphor, therefore, does not seem to be operative in his text. The case is different with Moin, who speaks of “Marx’s allegorical *Stoffwechsel*”⁵³ and insists that “Marx

⁴³ Marina Fischer-Kowalski, “Society’s Metabolism: The Intellectual History of Materials Flow Analysis, Part I, 1860–1970,” *Journal of Industrial Ecology* 2, no. 1 (1998): 61–78, 64.

⁴⁴ Kohei Saito, *Marx in the Anthropocene: Towards the Idea of Degrowth Communism* (Cambridge University Press 2022), 7.

⁴⁵ Bilal Moin, “Mapping ‘Metabolism’ in Marx’s Capital,” *Critique* 52, no. 1 (2024): 129–38, 130.

⁴⁶ Nail, *Marx in Motion*, 99.

⁴⁷ D. Fraser Harris, “The Date of the Introduction of the Term ‘Metabolic,’” *Nature* 98, no. 2464 (1917): 389–90.

⁴⁸ On the significance of Marx’s “kinetic” vocabulary, including *Stoffwechsel*, see Nail, *Marx in Motion*, 17.

⁴⁹ Moin, “Mapping ‘Metabolism’; for a more critical account of Marx’s sources, see Kohei Saito, “Marx in the Anthropocene: Value, Metabolic Rift, and the Non-Cartesian Dualism,” *Zeitschrift für kritische Sozialtheorie und Philosophie* 4, no. 1–2 (2017): 276–95.

⁵⁰ Jason W. Moore, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital* (Verso, 2015), 75.

⁵¹ Moore, *Capitalism*, 52.

⁵² Moore, *Capitalism*, 23.

⁵³ Moin, “Mapping ‘Metabolism,’” 136.

employs the term *Stoffwechsel* to establish a *metaphorical representation*⁵⁴ of real capitalist processes, such as production, labour, and alienation. In addition, he claims that Marx used metabolism as an allegory “to characterize central concepts”⁵⁵ in *Capital, Volume 1* and to “symbolize”⁵⁶ fundamental capitalist relations, both social and natural. However, despite clearly working with a distinction between concept and metaphor, Moin does not explain it, nor does he offer any argument or evidence as to why metabolism is a metaphor, symbol, or allegory rather than, say, the name of a real phenomenon. Instead, he finishes the article by abruptly turning to Nietzsche’s idea that truth is a mobile army of metaphors. But was this Marx’s idea of “truth”?

It seems unlikely. Scholars in the ecological Marxist tradition have made compelling claims that for Marx, metabolism (and its rift, as we will see) was a key concept describing real processes and states of affairs. For instance, Foster argues that “the concept of metabolism gave Marx a more solid – and scientific – way in which to depict the complex, dynamic interchange between human beings and nature.”⁵⁷ Saito also says that Marx’s “metabolic process is, first of all, a natural-ecological process . . . common to any historical stage.”⁵⁸ Both authors offer extensive discussions of Marx’s texts and previous scholarship to substantiate their claims. Therefore, although Marx made extensive use of poetic devices and figures, such as vampires and other fantastical beasts, there is no indication that metabolism was such a poetic device. Finally, if metabolism were a metaphor, then Marx’s theory of the metabolic rift would make little to no sense, and it would contradict one of the basic methodological principles of historical materialism: to start and finish with the real. Thus, although Moin’s article offers some interesting genealogical information on Marx’s use of the metabolism concept, his treatment of metabolism as a metaphor, symbol, or allegory is a gross error.

What did Marx mean by the concept of metabolism? It is well known that the concept is scattered across his works, with no separate text or essay dedicated to its complete exposition. Consequently, scholars have offered various reconstructions of metabolism in Marx. For instance, Nail argues that “Marx’s theory of metabolism is threefold: on the largest scale, there is a ‘metabolism of nature,’ within which a ‘human metabolism with nature’ emerges and within which a further ‘social metabolism’ emerges.”⁵⁹ Similar expositions have been offered by others.⁶⁰ The threefold structure of metabolism is a good indication of the complexity of this concept in Marx’s thought, but the problem, particularly with Nail, is that ecological-speculative interpretations of Marx tend to largely dismiss a significant component of Marx’s understanding of metabolism: labour.

In her aforementioned article, Fischer-Kowalski stated that Marx uses metabolism “in conjunction with the basic, almost ontological, description of the labor process.”⁶¹ Although one could debate whether Marx’s description of labour is ontological, Fischer-Kowalski is correct in emphasizing the close connection between metabolism and labour in Marx. Any attempt to read Marx that diminishes the significance of labor in production and reproduction in favour of, say, a “new materialist Marxism” (Nail) or “degrowth communism” (Saito) is a philosophical mutilation. One can perhaps understand this rejection of labour as a reaction to the dogmatic

⁵⁴ Moin, “Mapping ‘Metabolism,’” 134, my emphasis.

⁵⁵ Moin, “Mapping ‘Metabolism,’” 129.

⁵⁶ Moin, “Mapping ‘Metabolism,’” 134, 135, 136.

⁵⁷ John Bellamy Foster, “Marx’s Theory of Metabolic Rift: Classical Foundations for Environmental Sociology,” *American Journal of Sociology* 105, no. 2 (1999): 366–405, 381.

⁵⁸ Foster, “Marx’s Theory of Metabolic Rift,” 19.

⁵⁹ Nail, *Marx in Motion*, 103.

⁶⁰ See, e.g., John Bellamy Foster, “Marx and the Rift in the Universal Metabolism of Nature,” *Monthly Review* 65, no. 7 (2013): 1–19.

⁶¹ Fischer-Kowalski, “Society’s Metabolism,” 64.

interpretations of the labour theory of value. Even so, does the rejection of dogma justify philosophical mutilation, and does it not produce a new partial reading with its own dogmatic angle?

An interesting historical attempt to understand the metabolism of society and nature on the basis of labour was carried out by Karl Wittfogel in the early stages of his career. Wittfogel was highly critical of what he called “the political neglect of the existing links connecting nature and the political sphere.”⁶² Without such links, when nature and politics are considered to interact directly, “the normal metabolism must of course be replaced by a miracle.”⁶³ The result is a naturalization of certain political categories and the reduction of political arrangements to natural conditions; two sides of the same process, which we could call *primitive biopolitics*. Against such primitive biopolitics – which, according to Wittfogel, can be encountered in imperial history, liberal geopolitics, and crude materialism – he proposed labour as the category in which the natural and the social can become interlinked. Following Marx, Wittfogel divided labour into three parts: objects, means, and the work itself. Accordingly, in addition to having a social dimension, each of these three parts is conditioned by natural characteristics. More specifically, through labour, nature takes on social qualities; Wittfogel spent little time on this because he considered this part of metabolism to be over-researched. Just as importantly, however, not only is nature socialized through work but *labour is also naturally conditioned* at all times, and through labour, society. Therefore, the metabolism of society and nature, instead of happening directly between the two, takes place through the mediation of labour, whereby labour and its components are codetermined by society and nature alike. To illustrate his claims, Wittfogel drew on Marx’s idea of natural wealth, the natural needs and capacities of people, and the management and challenges of soil and water usage. A more recent example would be Malm’s work on the complex interaction between water and coal resources for energy generation on the one hand with capitalist labour organisations on the other.⁶⁴

At the same time, contemporary ecological Marxists have shown that our understanding of Marx’s metabolism would be incomplete if it did not include the sub-concept of “einen unheilbaren Riß” in the *Stoffwechsel* of society and nature. Over the last two and a half decades, interesting debates have emerged on the best way to render *Riss* into English; the issue is not just the correctness of the translation but also its conceptual implications. It is widely agreed that the contemporary rediscovery of this sub-concept begins with Foster’s work, which argued that for Marx, the *metabolic rift* refers to “how large-scale industry and large-scale agriculture combined to impoverish the soil and the worker”⁶⁵ as well as to undermine the “basic conditions of sustainability.”⁶⁶ According to Foster, Marx saw capitalist society as inevitably producing a distorted relationship between nature and society that results in significant damage to and potentially utter destruction of the environmental foundations of human existence. Foster himself extended this concept in his later works⁶⁷ by arguing that the Anthropocene describes precisely this cataclysmic rift in nature–society metabolism.

Another important intellectual figure in this debate is Moore, who initially embraced Foster’s idea of the metabolic rift before switching to his own conception of the *metabolic shift*. The disagreement is already present in Moore’s earliest engagement with Foster: “I think there is a metabolic rift in general and a succession of metabolic

⁶² Karl A. Wittfogel and G. L. Ulmen, “Geopolitics, Geographical Materialism and Marxism,” *Antipode* 17, no. 1 (1985): 21–71, 23. Originally published in 1929.

⁶³ Wittfogel, “Geopolitics,” 25.

⁶⁴ Andreas Malm, “The Origins of Fossil Capital: From Water to Steam in the British Cotton Industry,” *Historical Materialism* 21, no. 1 (2013), 15–68.

⁶⁵ Foster, “Marx’s Theory of Metabolic Rift,” 379.

⁶⁶ Foster, “Marx’s Theory of Metabolic Rift,” 383.

⁶⁷ See, e.g. John Bellamy Foster, Brett Clark, and Richard York, *The Ecological Rift: Capitalism’s War on the Earth* (NYU Press, 2011).

rifts specific to each successive phase of world capitalist development.”⁶⁸ There is something too absolute and apocalyptic in Foster’s treatment of the metabolic *Riss*. For Moore, there is not a singular rift by means of which capitalism tears society away from nature. Instead, capitalism reconstituted, and has kept reconstituting, the relationship between society and nature. Moore thus advocates focusing on “*shifts* (provisional and specific unifications), not *rifts* (cumulative separation).”⁶⁹ The point is the destructive *connection* between nature and society under capitalism rather than their mutual separation.

More recently, Nail has argued that “metabolic transformations are somewhere between shifts and rifts.”⁷⁰ The concept of rift is too absolute and implies an ontological break with nature, which is impossible, whereas shift is too tame a way of describing the damage caused by capitalism. Nail thus proposes the concept of *metabolic drift*, whereby capitalism is said to produce an accelerated metabolic disbalance that is tending towards human extinction without, however, threatening nature as such, which is always only relatively stable and thus always capable of reconstitution. Similarly, Saito has proposed something of a *metabolic rift-and-shift* interpretation whereby capitalism produces three kinds of metabolic rifts (material, spatial, and temporal) along with three ways (technological, spatial-geographical, and temporal-historical) of shifting the damage caused by said rifts.⁷¹ It is interesting that Nail, who adopts a more speculative philosophical vocabulary, generally departs from the position defended by Moore, whereas Saito aligns himself with Foster. We can see how the incoming generation of thinkers inspired by Marx’s understanding of metabolism both maintain certain divisions inherited from their predecessors while also looking for ways of moving beyond them.

For Marx, there is no *Stoffwechsel* without *Riss*, just as there is no social metabolism between nature and society without the mediation of labour, the only category capable of assuming and intermixing both natural and social qualities. We could say that the metabolic power, instead of being located within cells, rests with labour power, which performs the work of gathering, converting, and discharging material and energy. What is missing in all these accounts, however, is a Sanctorian element – that is, a focus on the apparatuses that frame and enable metabolic labour.

Conclusion: Surplus Genealogies

Many more genealogical threads and personages remain to be explored within the plane of metabolism. For instance, in addition to the social metabolism that begins with Marx and leads to contemporary eco-social debates, there is the trajectory of energy and resource metabolism, which traverses personages such as Erich W. Zimmerman and Stephen Vickers Boyden, along with the institutional discourse of UNESCO’s Man and the Biosphere Programme. It may have some affinity with the industrial metabolism discourse surveyed by Fischer-Kowalski.

Then, there is the metabolic systems-thinking thread, which winds through James Lovelock and such works as *Metabolism of the Anthroposphere: Analysis, Evaluation, Design*.⁷² This thread would also need to consider the International Geosphere-Biosphere Program as well as Earth-system science and its concept of “transport.”

Not least, there is the personage of Vladimir Vernadsky and his biosphere/noosphere duality, which may belong to the strange thread of epistemic and technological metabolism, which passes through American and

⁶⁸ Jason W. Moore, “Environmental Crises and the Metabolic Rift in World-Historical Perspective,” *Organization & Environment* 13, no. 2 (2000): 123–57, 128.

⁶⁹ Moore, *Capitalism*, 84.

⁷⁰ Nail, *Marx in Motion*, 108.

⁷¹ Saito, *Marx in the Anthropocene*, Chapter 1.

⁷² Peter Baccini and Paul H. Brunner, *Metabolism of the Anthroposphere: Analysis, Evaluation, Design* (MIT Press, 2023).

Japanese sociology associated with the knowledge society and information society concepts, respectively, until it decants in Peter Haff's reinvention of the technosphere.

And we should not, finally, forget the ever-important distinction between the organic and the inorganic, which connects the plane of metabolism to the foggy, swampy territory of biopolitics. The Anthropocene paradigm, with its focus on geology, might belong to this genealogical family as well, although its presence in the systems and technological metabolisms is also notable. Is the Anthropocene a new beginning within the plane of metabolism or, perhaps, an intertwining and culmination of certain previously unconnected metabolism threads? All of these and more questions remain to be considered in the future.

SECTION THREE: WATER CULTURE



Juridical Waterscapes in the 19th Century

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Introduction

In ancient times, the first major civilizations emerged around abundant water sources. Water has always been a fundamental element of any human society. It is an essential resource for meeting basic human needs as well as a vital means of production. These dual characteristics led to the development of comprehensive legal systems to regulate its use. Unsurprisingly, water has long been a stimulating subject for jurists. Its inherent multifunctionality has attracted the attention of the legal imaginary, particularly when it comes to establishing a balance between the exclusive use of water and collective rights.

Today, water is increasingly discussed on a global scale as a common good that must be defended against market-driven appropriation. The ban on private management of and profit-making from water services has led to new participatory management models. The idea of common goods as an alternative to the public-private divide has found a suitable context in water services, which are often marked by public inefficiency and private speculation. The commons project aims to establish a form of non-proprietary ownership – that is, a way of using goods that does not fall within the confines of full and absolute property that excludes third parties. Instead, the project proposes that the holder of a good and the user of that good can be disentangled.¹

This visionary project, advanced in Italy by the Rodotà Commission,² encompasses environmental protection and the guarantee of a minimum water supply while also enhancing user rights and promoting participatory mechanisms.

As underlined by Federico Caporale,³ in the current context of water services, the multifunctional nature of water has become a key issue. Two distinct perspectives have emerged: the first prioritizes water's sanitary and social role, addressing essential needs, such as food and hygiene (domestic consumption), while the other views water as an economic resource for non-essential uses, such as recreation, agriculture, industry, or commerce. Historically, the first kind of use was seen as a civic duty to prevent the spread of disease, but it has since evolved into a fundamental individual right. Meanwhile, the second kind of use, once a tool for shaping national economic policy, has diminished in significance.

In public debate, this distinction is often overlooked, with the social importance of water overshadowing other considerations. This neglects the fact that the legal history of water has always balanced economic activities with human consumption. In addition, public discussions have blurred other crucial distinctions, such as those between the different operational segments of water services (distribution, purification, and sewage) and the various regulatory priorities.

¹ For a discussion addressing the contemporary issues surrounding common goods, see Xenia Chiaramonte and Paolo Napoli, "Istituire il comune: per un'appartenenza non proprietaria. Conversazione con Paolo Napoli," in *Istituire: Politica, filosofia, diritto*, ed. Federica Buongiorno and Xenia Chiaramonte (Meltemi, 2024).

² "Commissione Rodotà - per la modifica delle norme del codice civile in materia di beni pubblici (14 giugno 2007) – Relazione," Ministero della Giustizia, accessed October 7, 2024, https://www.giustizia.it/giustizia/it/mg_1_12_1.wp?facetNode_1=3_1&facetNode_2=0_10&previousPage=mg_1_12&contentId=SPS47617#.

³ Federico Caporale, *I servizi idrici. Dimensione economica e rilevanza sociale* (Franco Angeli, 2017), 427.

The focus has mostly been on pricing rather than the quality of service, the sustainable management of water resources, or the deteriorating infrastructure. When it comes to regulation, the focus on operational efficiency and social needs has often come at the expense of environmental protection, resulting in short-term strategies that fail to consider long-term sustainability.

For the purposes of this paper, I intend to isolate a specific thread within this vast historical narrative, shedding light on certain aspects that remain relevant today. These aspects began to take shape nearly two centuries ago with the “case” of water, when jurists were compelled to address the issue, forming a set of doctrinal principles that continue to be vital for understanding the modern legal framework governing this indispensable good: water.

This reconstruction is primarily based on the invaluable research of Federico Caporale. This analysis is contextualized within continental Europe, with a particular focus on the Italian case. This approach allows us to examine more closely the challenges that water has posed to law, particularly for jurists of the 19th century. Moreover, it highlights that the complexity of this issue still merits thorough exploration rather than being taken for granted or oversimplified by easy slogans that may obscure the intricate nature of the subject.

Although I have long been interested in the issue of common goods and their protection, and although I have closely followed the work of the Rodotà Commission, I am not an expert in the field of water and water services. Therefore, I rely on specialists in the sector, even within the broader and politically engaged context of safeguarding common goods and advancing environmental protection.

Water Legislation in 19th-Century Italy

The debate on the distinction between public and private waters became particularly important in Europe in the 19th century, when the principles that still dominate the contemporary conceptual system were being defined. Since the first decades of the 19th century, there has been a progressive limitation of individual rights over waters and a definition of new public and collective interests related to its use. Public regulation of water is not a new concept, but it took on distinct characteristics during the 19th century. Up to that point, the distribution of water among conflicting uses was primarily, though not exclusively, entrusted to private institutions, which aimed to maximize its exploitation.

This important trajectory is especially well illustrated by Federico Caporale’s paper “Acque pubbliche ed acque private tra Otto e Novecento” (Public and Private Waters between the Nineteenth and Twentieth Centuries).⁴ His reconstruction, which I briefly outline here, has the advantage of being innovative and original, relying on key texts from the debate on water law between the 19th and 20th centuries rather than on secondary literature. The present contribution, on the other hand, should be considered solely as a review of that literature to genealogically shed light on the present, in which water increasingly takes on a new form – that of a common good. Before reaching this contemporary perspective, let us examine the path that has brought us here.

The modern system, which took shape throughout the 19th century in parallel with the gradual development of administrative law, fully emerged toward the end of the 19th century. Its emergence was prompted by two major factors that demanded significant government intervention in water management, control, and regulation. First, the use of water resources, often referred to as “white coal,” for hydroelectric power production brought about significant changes in water law and concession. Second, the growing issue of domestic water use and the simultaneous process of urbanisation highlighted the role of water in safeguarding public health.

⁴ Federico Caporale, “Acque pubbliche ed acque private tra Otto e Novecento,” in *La città liquida. La città assetata. Storia di un rapporto di lunga durata*, ed. Massimo Galtarossa and Laura Genovese (Palombi, 2014), 253–72.

The new legal project of the 19th century was based on the idea that entrusting the ownership of water to the state would enable rational management, oriented toward a balanced weighing of the interests of farmers, industries, and private citizens. The result of this process, which I am about to describe in detail, was that individual water rights were restricted through the refinement of a broad regime of servitudes and the extension of the category of public waters. In this context, two sources are of particular importance.

The first source is the Italian Civil Code of 1865, which established that only rivers and streams were state waters (*acque demaniali*). Minor courses were subject to a regime of free use by *rivieraschi* (riverine dwellers), provided the following two conditions were met: the waters withdrawn had to be used for agricultural or industrial purposes, while leftover water had to be returned to the ordinary course.

The second source is the Public Works Law (*Legge sui Lavori Pubblici*, 1865), which considered minor course *rivoli* (rivulets), ditches, and culverts to be public waters, usable by private individuals only by virtue of a concession, or when a private individual claimed a legitimate title.

Thus, the free-use regime of the Civil Code was opposed to the concessionary regime of special legislation, namely, the Public Works Law. Concession was based on private parties respecting the public interest, while the Civil Code allowed private parties to use the water immediately. It is on the basis of this contradictory system that the debate of the jurists of that time (legal professionals, lawyers, magistrates, public administration, university professors, etc.) arose. However, it should be said that these two sources share a crucial point: they are both based on a nominal, quantitative principle. Let us examine what this means.

The definition of “fiumi, torrenti, rivi, fossati o colature” (rivers, streams, rivulets, ditches, or culverts) *per se* was no longer a valid criterion. The first reason pertains to the definition of nature itself, as given to us by Aristotle: nature is movement; it contains within itself the principle of its own change. Thus, how is it possible to establish once and forever what a natural good is, such as a river, stream, and so on?

Giandomenico Romagnosi’s essential contribution should be mentioned here. In two seminal works, *La condotta delle acque* and *Della ragione civile delle acque nella rurale economia*,⁵ the author distinguished the goods subject to public ownership by basing his reasoning on the notion of public interest. The state owned two classes of goods: those that were public, intended for public use, and those that were the subject of pure fiscal or state ownership but not public use, which the state enjoyed as if it were a private owner. Thus, public ownership was not in itself a guarantee of public use.

“State” ownership, here translated as *demaniale*, essentially means patrimonial. Waters belonged to the first class of goods only if they were capable of satisfying public use, and that use had to be actual and present (and not merely potential) and had to be understood as an “objective element of fact, subject to possible change over time.” One can see with Romagnosi that this logic has changed. It is public use that becomes the defining criterion for identifying public waters rather than their physical characteristics.

The second crucial thinker here is Romagnosi’s pupil, Giacomo Giovanetti.⁶ The prominence given to public interest by Giovanetti was significant: he went so far as to advocate the overcoming of any distinction between public and private waters, leaving as the only residual space for individual rights the regulation of concessions based on the public interest.

⁵ Gian Domenico Romagnosi, “Della condotta delle acque” (1824) in *Della condotta delle acque e della ragione civile delle acque. Trattati di Gian Domenico Romagnosi* (Milano 1843); Gian Domenico Romagnosi, “Della ragione civile delle acque nella rurale economia (1829–1830),” in *Della condotta delle acque e della ragione civile delle acque. Trattati di Gian Domenico Romagnosi* (Milano 1843).

⁶ Giacomo Giovanetti, *Del regime giuridico delle acque* (Novara 1989). Originally published in 1843.

The profitability of water and the needs of agriculture and industry became, in the theoretical and practical contributions of these jurists, clearly preponderant reasons over individual needs. Public use thus acquired absolute centrality in the limitation of individual rights.

However, the legislature of unified Italy did not immediately embrace these kinds of new advances in doctrine. On the contrary, it tended to be more central to the so-called vanguards of legal doctrine at the time rather than being shared by public opinion or even simply by public administration and other legal professionals.

Three Legal Currents

We could say, therefore, that the situation was characterized by the existence of the following three main currents: (a) the “privatists,” who advocated the application of the Civil Code to minor waterways; (b) the “demanialists,” who argued in favor of the prevalence of the Public Works Law; and (c) the so-called “distinguishing system,” which opted for an intermediate position, whereby minor waterways could be either public or private due to their ability to serve public interests.

Privatists

Predictably, the “privatists” counted among state waters only rivers and streams and subjected minor waterways to the free-use regime of Article 543 of the Civil Code.

The discretionary criterion between public and private waters was strictly nominal: the state or private ownership of waters was determined by the nature of rivers and streams rather than by minor streams. However, in a trial setting, it was complicated to base judgments solely on engineering and scientific criteria, such as the amount of water carried by a river and its volume in the summer and winter periods. Thus, the judges, while reaffirming the application of the merely physical/nominal criterion, advanced a new aspect by referring to the so-called *existimatio circumcolentium*, a principle of the legal Roman tradition according to which, for the purposes of the recognition of what was a major or minor watercourse, one needed to evaluate the opinions of scholars of history and geography as well as of the inhabitants of the places where the river flowed.

A rigidly formal analysis, typical of the nominal criterion, was thus made partially elastic through recourse to historical, social, and cultural aspects, which tended to privilege the utility of the resource in the geographical context rather than the physical elements of the watercourse.

Another crucial – indeed, we can say ingenious – element of this principle for the advancement of the categories of water law was the identification of a fundamental difference between statehood (*demaniale/patrimoniale*) and the publicity of waters. State waters and private waters were characterizations that pertained to the subjective ownership of goods, while publicity had a functional character that could accompany both ownership regimes.

Therefore, once again and more clearly than before, we find that the state (*patrimoniale/demaniale*) is not the same as the public. On the contrary, publicity did not pertain to the proprietary aspect but to the nature of the goods: it was related to the social significance of waters, understood as natural forces capable of bringing, at the same time, great wealth and tremendous devastation. The role of the state, with regard to public waters, was one of surveillance, control, and protection: it was intended to prevent the damage caused by the negligence of private individuals to the waters they owned.

In this context, minor waterways remained fully private as far as the ownership regime was concerned, but were considered public because of their social relevance. A liberal approach can be found here, whereby the state supervises and controls in order to protect the community, but it does not directly intervene in water management.

Demanialists

The “demanialists” argued in favor of the prevalence of the Public Works Law. Here, waters are basically considered static. Almost all waters were considered public and implicitly recognized as having the capacity to serve public interests. In a nutshell, the “demanial” doctrine, moving from the identity between statehood and publicity, simply extended the listing offered by the relevant article of the Civil Code to all waters, deeming it a mere unintentional omission to fail to include minor waterways in the list proposed in the relevant article.

Distinguishing System

The intermediate doctrine makes an explicit statement of preference for the teleological/functional criterion. According to the jurists adhering to this current, the proprietary status of waters depended on their suitability to serve public interests: the physical nature of the watercourse became only a secondary element in determining its legal qualification. Because of the different geographical areas in which they were located and the consequently different economic, cultural, and social contexts, a large river could be judged unsuitable to serve public interests, while a small watercourse could be.

Therefore, suitability to serve public interests was substantiated by a plurality of elements: of customs and facts, as well as of the true state of the places where the waters are found, the circumstances of their location, size, volume, nature, and course, and the economic utility of their uses. This criterion is obviously elastic and dynamic: economic utility changes with technological and cultural development, customs are diachronic entities, and social opinion may evolve over time.

The judges argued that the recognition of the public nature or state ownership (*demaniale*) of a waterway was a factual question that had to be resolved on a case-by-case basis at the end of an assessment taking into account the peculiar geographic, historical, social, and economic aspects.

Conclusion

It is the new term *bacino idrografico*, literally translatable as hydrographic basin, which embodies the legal solution. The concept of *bacino idrografico* had a broader scope than words such as rivers and streams. The latter primarily referred to the nominal principle and, therefore, to the physical and geographical characteristics of the watercourse. The new concept, on the other hand, also took into account the social, economic, and cultural elements peculiar to the place where waters flowed and, consequently, the public and collective interests they were capable of satisfying.

The general sense that can be inferred, therefore, is that in the field of water, as early as the 19th century, the conceptual inversion of the classical legal path of defining the taxonomy of goods was determined: that is, it proceeded *from goods to regimes* by reversing the classical path, which goes *from regimes to goods*. It is the goods that command the discipline and not vice versa, proving their mutability and the principle of change inherent in nature. Nature has been defined in the field of water through the broad concept of *bacino idrografico* to encompass the various forms that it can take and to assist, on a case-by-case basis, the action of the courts.

Agriculture and Water Practices in Islamic Societies: Interdisciplinary Perspectives from the History of Science and Environmental History¹

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Introduction

This paper explores the intersection of environmental history and the history of science within Islamic societies. The reflections offered here are preliminary and based on selected examples and a general overview of existing scholarship rather than a comprehensive analysis. The primary goal is to demonstrate how historical studies in the field of science can deepen our understanding of how past Islamic societies engaged with their environments and addressed ecological concerns. By examining water management practices across seasonal cycles, this paper seeks to illuminate how knowledge of periodic climatic changes shaped responses to environmental challenges, particularly within the cosmological frameworks of historical Islamic thought. The integration of environmental history and the history of science offers a valuable lens through which to better comprehend how natural hazards, climatic fluctuations, and sustainability were conceptualised in pre-modern Islamic contexts. These concepts, however, must be understood not through a modern lens, but within the specific intellectual, social, and cultural paradigms of the time. This study aims to encourage further research into how the history of science can enrich our understanding of past environmental concerns. It also suggests a closer examination of how these concerns and related practices were embedded within broader worldviews, reflecting the complex relationships between human societies and their ecosystems.

Water Management and the Growing State

Recent studies suggest that, prior to Islam, Middle Eastern societies were primarily influenced by agricultural and irrigation technologies developed under the Sasanian Empire in Persia.² Muslims inherited these technologies, particularly the riverine systems, and relied heavily on them until the early ninth century. However, as sedentary lifestyles increased, cities expanded rapidly, and water structures began to deteriorate due to over-extraction, the need to revitalise water management became critical. Many inhabitants of the newly settled areas in greater Mesopotamia were former soldiers, with the state responsible for providing their food.³ During this period, there was a significant increase in land cultivation. Agriculture in Mesopotamia was heavily dependent on river-based irrigation systems, which utilised carefully engineered canals with appropriate gradients and a deep understanding

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² Michael G. Morony maintains that the roots of the economic system of the early Islamic centuries were in the Sasanian Empire, considering that the economic development in the Sasanian era during the 6th century coincided with the economic decline of the Mediterranean world. Two significant sectors that had an impact during this time were irrigated agriculture and mining. See Michael G. Morony, "Economic Boundaries? Late Antiquity and Early Islam," *Journal of the Economic and Social History of the Orient* 47 (2004): 166–94.

³ For an in-depth study in this regard, see Hugh Kennedy, "The Feeding of the Five Hundred Thousand: Cities and Agriculture in Early Islamic Mesopotamia," *Iraq* 73 (2011): 177–99. Since new cities in the Islamic world were mostly established in different locations than previous urban centres, it appears that Islamic society took new environmental factors into account. For a related study, see Peter J. Brown, "Supplying a Medieval Metropolis: Water Management and Agriculture in the Hinterland of Early Islamic Basra," *Water History* 14, no. 3 (2022): 379–98.



of seasonal floods. Ongoing land reclamation practices, including drainage, the creation of new canals, and the maintenance of existing ones to remove surface salts and cultivate fertile soil, were essential to sustaining agriculture. Although these agricultural activities generated significant profits for both the state and landowners, they were also expensive and required substantial labour. As a result, effective land reclamation and irrigation practices held great economic significance.⁴

Nevertheless, some studies suggest that, despite Muslim investment in irrigated agriculture, the focus was more on maintaining existing technologies and intensifying their use rather than developing new methods.⁵ With the rise of the centralised Islamic Caliphate, local economies became integrated into a larger market, and the demand for crops became part of the commercial process, shifting agriculture from traditional practices to more specialised, market-oriented production.⁶ Moreover, water storage became crucial for enabling summer cultivation in the absence of rainfall. A key example of this is the expansion of rice farming in southern Iran and Iraq, facilitated by continuous access to water resources.⁷

Water Technologies in Agriculture

It should be noted from the outset that technologies for water management and irrigated agriculture were not usually perceived as interdependent. Hydrology knowledge and water practices had broader applications beyond irrigation, including urban water-canal and water mills.⁸ With the expansion of the Islamic rule, the two technologies underwent considerable developments as integral components of the economic growth. However, there is little indication that they were reciprocally practiced and advanced together. The surviving texts in the two fields from the Islamic period are very scattered and limited compared to the sciences such as mathematics, medicine, or astronomy.⁹ It remains unclear to what extent the surviving textual evidence represents practical applications or merely serves as collections of theoretical knowledge. However, recent studies indicate that regions with more limited access to water resources tend to have a more extensive body of literature on water

⁴ See, e.g., Kennedy, "The Feeding of the Five Hundred Thousand"; Peter Verkinderen, "Land Reclamation and Irrigation Programs in Early Islamic Southern Mesopotamia: Self-Enrichment vs. State Control," in *Authority and Control in the Countryside: From Antiquity to Islam in the Mediterranean and Near East* (Sixth–Tenth Century), ed. A. Delattre, M. Legendre, and P. Sijpesteijn (Brill, 2019), 500–527. For the significance of mathematical skills in water-management practices in this period, see Razieh S. Mousavi, "Calculation and Power: Engagement of Astronomers in Water-Management Projects in the Early Islamic State," in *Early Modern Political Epistemology*, ed. P. D. Omodeo and S. Babu (Brill, forthcoming).

⁵ For instance, Morony highlights the continuity of established pre-Islamic systems into the Islamic world, such as irrigation technologies and land management practices while also acknowledging certain areas of innovations. See Michael G. Morony, "Continuity and Change in the Administrative Geography of late Sasanian and Early Islamic al-ʿIrāq," *Iran* 20 (1982): 1–49.

⁶ The theory of the "Green Revolution" in the early Islamic economy was initially introduced by Andrew M. Watson and is widely accepted today. See Andrew M. Watson, *Agricultural Innovation in the Early Islamic World: The Diffusion of Crops and Farming Techniques, 700–1100* (Cambridge University Press, 1983). However, it has also faced some criticism. See, e.g., Michael Decker, "Plants and Progress: Rethinking the Islamic Agricultural Revolution," *Journal of World History* 20, no. 2 (2009): 187–206. A more recent study suggests that this theory should be examined within an integrated environmental framework, considering the interactions among plants, animals, soils, and water, rather than focusing solely on new crops and irrigation. See Helena Kirchner et al. "Re-thinking the 'Green Revolution' in the Mediterranean world," *Antiquity* 97 (2023): 964–74.

⁷ See Marius Canard, "Rice in the Middle East in the First Centuries of Islam," in *Production and the Exploitation of Resources (Formation of the Classical Islamic World)*, ed. M. G. Morony (Ashgate, 2002), 153–67.

⁸ For an informative overview of the history of water technologies in the Islamic societies, see Charlotte Schriwer, "Water and Technology in the Islamic World," in *Routledge Handbook on the Sciences in Islamic Societies: Practices from the 2nd/8th to the 13th/19th Centuries*, ed. P. Barker, S. Brentjes, R. Brentjes (Routledge, 2023), 523–537. For an exploration of the understanding of hydraulic jump, the concept of the void, and the water cycle in the works of the 11th-century Muslim polymath al-Bīrūnī, see Massimiliano Borroni and Vladimiro Boselli, "Hydraulics and Hydrology in a Passage of the *Kitāb al-Āṭār al-bāqiya* by al-Bīrūnī," *Arabic Sciences and Philosophy* 31 (2021): 159–82.

⁹ For an overview of the surviving manuscripts on agriculture and botany from the Islamic period, see Fuat Sezgin, *Geschichte des arabischen Schrifttums* (vol. 4), "Alchemie, Chemie, Botanik, Agrikultur bis ca. 430 H." (Brill, 1971), 330–46.

technologies.¹⁰ This phenomenon may be attributed to a combination of distinct geographical circumstances and knowledge traditions prevalent in those regions. For example, the Nile River was more than just a vital water source in the lives of the Egyptians. The annual fluctuations of the Nile, which significantly influenced the economy and daily life, also served as markers for seasons and a means of defining annual periods. To monitor the water levels of the Nile during its annual floods – a critical task for determining land taxes – a structure known as the “Nilometer” was created, which was later reconstructed and used during the Islamic period.¹¹ The arrival of rising waters in different regions of the Nile was highly irregular, while the Egyptians’ civil calendar was structured in a simple manner. This discrepancy led scholars to propose various hypotheses regarding the origin of the calendar, including the theory that Egypt’s 12-month of 30 days plus five-intercalation day calendar resulted from an averaging method over long periods of time, allowing it to function despite seasonal shifts. However, this theory has been contested by those who argue that such a prolonged process of observation was technically impossible in ancient Egyptian society.¹² This example signals that expectation of nature and periodicity of seasonal changes was comprehended beyond calendrical regulations.

Studies indicate that in Islamic societies, irrigation technology was typically linked to advanced agriculture and was rarely used for the cultivation of ordinary crops.¹³ The Middle East and Mediterranean areas have a strong focus on water, with cities strategically situated near water sources. The primary economic lifelines for governments in these regions are agriculture and tax revenue, highlighting the significance of water management. While the sources on hydrology from the Islamic world predominantly demonstrate the scholars’ reliance on the Aristotelian tradition, some aspects of these sources, along with archaeological evidence, reveal a synthesis of local knowledge practiced in these regions with translated theoretical doctrines. An excellent example of this amalgamation can be found in the masterpiece of the Persian scholar, Abū Bakr Muḥammad Karājī (fl. 11th century), titled *The Extraction of Hidden Waters*, which frequently presents a fresh perspective on the common scientific wisdom concerning the flow of water on the Earth’s surface. He challenged the prevailing belief of his time regarding the spherical shape of the Earth to explain the significance of topographical features on water flow. Karājī’s descriptions of water quality and the characteristics of suitable ground for water extraction in his text reflect his experience as a water engineer in the mountainous parts of western Iran.¹⁴ However, we lack a sufficient number of texts in this field to enable comparisons of how different authors from various local backgrounds addressed the integration of practical elements into theoretical knowledge.

Technology Meets Regional Environments

Various enduring structures within Islamic societies have persisted over time, with some still in use today. One such example is the Norias, primarily found in Mediterranean regions. These are collections of water-raising mechanisms situated along rivers, typically consisting of towering water wheels equipped with enclosed compartments around

¹⁰ For instance, the surviving literature from North Africa and western Asia is notable for both its quantity and richness of content. Michael G. Morony, “Introduction,” in *Production and the Exploitation of Resources*, ed. Michael G. Morony (Ashgate, 2002), xv–xxvii, xxiii.

¹¹ For a discussion on the water-engineering techniques related to this reconstruction in the ninth century, see Mousavi, “Calculation and Power.”

¹² Juan Antonio Belmonte and José Lull, *Astronomy of Ancient Egypt: A Cultural Perspective* (Springer, 2023), 324–325. See also Anthony Spalinger, *Feasts and Fights: Essays on Time in Ancient Egypt* (Yale Egyptological Institute, 2018), 3–4.

¹³ In his study of the Valencia irrigation system, Thomas F. Glick argues that, in contrast, these structures were predominantly employed for the cultivation of ordinary crops. Thomas F. Glick, *Irrigation and Society in Medieval Valencia* (Harvard University Press, 1970), 2627.

¹⁴ For Karājī’s hydrological knowledge, see “Kaveh Niazi: Karājī’s Discourse on Hydrology,” *Oriens* 44, no. 1–2 (2016): 44–68.

their rims for water collection. The collected water serves agricultural fields and powers mills.¹⁵ Another significant water structure, commonly found in central Iran, is the *qanāt*. This term typically refers to subterranean aqueducts that transport groundwater along a sloping gradient. The use of *qanāt* dates back to pre-Islamic eras, predating even the Sassanian dynasty in Iran. However, later innovations in construction and usage, such as situating *qanāts* alongside rivers instead of excavating aquifers at higher elevations, enabled them to harness the riverbed's seepage.¹⁶ These innovations also reached Arabia prior to the advent of Islam.¹⁷ *Qanāts* were sometimes constructed above ground with open water channels. The term *falaj*, meaning "divided into segments" in Arabic, denotes an irrigation system commonly utilised in Yemen and present-day Oman. This system effectively distributes water resources among local residents, relying on gravitational flow from the water source to homes and farms. The infrastructure of *falaj* systems occasionally includes watchtowers, mosques, and other complex buildings. The development of this system is also credited to the Sasanians, evolving from their *qanāt* system to suit the needs of the region.¹⁸

The diverse structures found in different regions are linked to local needs based on environmental and climatic conditions. However, a thorough study is required to explore the potential transmission of techniques, as well as the similarities and differences in these structures, considering that they all operated within the broader knowledge framework of the Islamic world. For instance, it was dominantly believed, based solely on historical sources, that the extensive water structures in the Iberian Peninsula were a result of Muslim influence following the conquest in 711 CE. This notion has been seriously challenged upon examining archaeological evidence. Notably, some aqueducts found throughout the Iberian Peninsula that bear similarities to Persian *qanāts*, date back to pre-Islamic time in the Roman Empire.¹⁹ Moreover, research on water supply technologies indicates a close relationship with political stability. For instance, the fact that the peak of riverine irrigation in the western Islamic world came after the eastern part,²⁰ suggests that these societies should not be uniformly regarded in terms of access to and utilisation of water distribution systems. Moreover, these questions need also be addressed in the context of seasonal variations and the diverse traditions of water management and usage in these regions.

The same question arises when considering the agricultural irrigation technologies in the Islamic world. In a study on the history of engineering in the Islamic world, Donald R. Hill and Ahmad Y. al-Hassan identify four distinct types. First, basin irrigation: A riverine system, employed, for instance, in Egypt, where fields were flooded by river water. Second, perennial irrigation: This method involves watering crops regularly throughout the growing season by channelling water into a network of small channels over the field. Water is diverted from a main artery, such as a river, major canal, or *qanāt*, into these supply canals. Third, terrace irrigation: This technique was used in hilly regions, through creating a series of terraces down a hillside to capture and use water more effectively. Fourth,

¹⁵ On Norias, see Schriwer, "Water and Technology," 528–29. In the early Islamic centuries, mills were owned by the ruling system or wealthy religious institutions, but in later periods, private ownership also emerged. For a related study, see Cristina Tonghini, "Flour for the Caliph: Watermills in the 'Land behind Mosul'," in *The Historian of Islam at Work: Essays in Honor of Hugh N. Kennedy*, ed. O. Letizia and M. van Berkel M. (Brill, 2022).

¹⁶ Paul Ward English, "The Origin and Spread of Qanats in the Old World," *Proceedings of the American Philosophical Society* 112, no. 3 (June 21, 1968), 170–81.

¹⁷ Robert L. Raikes, "Comments on Water Conservation in Ancient Arabia," *Proceedings of the Seminar for Arabian Studies* 8 (1978): 30.

¹⁸ On the *falaj* system, see Schriwer, "Water and Technology," 531–33; Paolo M. Costa, "Notes on Traditional Hydraulics and Agriculture in Oman," *World Archaeology* 14, no. 3 (1983): 273–95. Reprint in Michael G. Morony (ed.), *Production and the Exploitation of Resources* (Ashgate, 2002), 303–25.

¹⁹ See, e.g., Thomas F. Glick, "Hydraulic Technology in al-Andalus," in *The Legacy of Muslim Spain*, ed. S. K. Jayyusi (Brill, 1992), 974–86.

²⁰ Michael G. Morony, "Introduction," xxiv–xxv.

Wadi irrigation: This method relies on sporadic rainstorms in arid areas. Stormwater is collected behind dams and used to irrigate nearby fields.²¹

Water Management and Agricultural Economy

Another factor to consider in environmental history is that both water management and agriculture were heavily reliant on access to labour force, and a shortage of labour could disrupt their operations. In this context, one area that remains relatively unexplored is the economy centred around nomadic pastoral communities. Given that historical literature was predominantly authored by sedentary individuals, the negative portrayal of nomads should be approached with caution. Evidence from paleoclimatic and archaeological studies suggests that the Middle Eastern environment could sustain both pastoralism and sedentary agriculture, potentially fostering mutual economic benefits. The notion that desert-nomads relied solely on pastoralism is often inaccurate, as they frequently engaged in a diverse range of economic activities including hunting, trade, and part-time agriculture.²²

It is around this time that Ibn Waḥshiyya authors one of the first agricultural treatises in Arabic. While he attributes this knowledge to the ancient Nabateans in northern Arabia and presents anonymous individuals as his sources, he seems to be inspired by the prevalent agricultural tradition in the Babylon (today's Iraq) during the Sassanian rule. He identifies three classes necessary for managing a farm: the landowner, workers, and the steward who act as an intermediary between the former two. In a part of his book, he offers a detailed and diverse portrayal of a good steward, along with an almanac that outlines step-by-step, timely activities. According to Ibn Waḥshiyya, the reason for such scheduling is that the tasks and well-being of workers need to be adjusted according to seasonal conditions. However, the science of seasons to which Ibn Waḥshiyya refers is not based on the standard astronomical calendar, but rather varies according to each region. He emphasises the importance of local seasonal changes and strongly criticises migrant farmers and the practice of transplanting. The knowledge of seasons and water management presented in this almanac is predominantly regional, as the book's title suggests that the information is assigned to a particular cultural and geographical context. Only towards the end of the text does he mention an anonymous scholar who believes that by considering the equinoxes and solstices, predictions can be made regarding seasonal conditions across different geographical latitudes.²³

Although Ibn Waḥshiyya recommends that a good steward promptly inform a doctor in case of a sick worker, he later suggests that in emergencies, the steward can personally provide treatment based on similar cases. It is also mentioned that one of the reasons of water storage for summer is to adequately hydrate farmers and humidify the atmosphere for health-related intentions. Therefore, it is essential for a supervisor to possess sufficient knowledge in both time-keeping and medicine. Studies suggest that due to the labour crisis that arose in the sixth century CE in Sasanian Iran as a result of disease spreads, this worry should have become a model for

²¹ Donald R. Hill and Ahmad Y. Al-Hassan, "Ingeneria," *Storia Della Scienza* (Vol. III), Capitolo LI. *Enciclopedia Italiana*, 2002, 647–66. Link to the online undated version: https://www.history-science-technology.com/articles/articles%2011.html#_ftn1 (accessed on 8 October 2024). In Yemen before the rise of Islam, irrigation relied on one large dam, whereas the Nabateans in northern Arabia constructed numerous small barriers across wadis to manage limited runoff. The dependence on Yemen's large dam is thought to have caused an economic crisis after its damage, ultimately leading to the collapse of their government. For a recent analysis of the palaeoclimate evidence in this context, see John Haldon and Dominik Fleitmann, "A Sixth-Century C.E. Drought in Arabia: New Palaeoclimate Data and Some Historical Implications," *Journal of Late Antique, Islamic and Byzantine Studies* 3, no. 1–2 (2024): 1–45.

²² For an interesting case study, see Jean-Luc Krawczyk, "The Relationship between Pastoral Nomadism and Agriculture: Northern Syria and the Jazira in the Eleventh Century," in *Production and the exploitation of resources*, ed. Michael G. Morony (Ashgate, 2002), 115–36.

²³ Toufic Fahd, "Managing a Farm According to the Nabatean Agriculture," in *Production and the Exploitation of Resources*, ed. Michael G. Morony (Ashgate, 2002), 169–82, 181.

early Islamic societies, which emphasised the importation of the labour force.²⁴ Such a tradition of integrating seasonal knowledge with health practices is well illustrated in Hesiod's *Works and Days*, which is believed to have served as a precursor to Hippocratic medicine and its strong emphasis on seasonally related diet and treatment.²⁵

Water Management in its Cosmological Context

In the pre-modern Islamic world, water management, with its intricate engineering requirements as reviewed above, was also intricately woven into a broader cosmological framework that encompassed spiritual, social, and cultural dimensions. This interconnectedness highlights the need for careful consideration when interpreting historical sources on the subject. To clarify this perspective, we will proceed with some examples.

A significant collection of almanacs from the Islamic world was authored by Yemeni princesses and elites. The political and administrative roles of these figures have amplified the importance of their works in providing a deeper understanding of their economy. In the 13th century, al-Ashraf 'Umar, who would later become a Rasūlid sultan, wrote a book titled *Enlightenment in the Science of the Stars* (*Kitāb al-Tabṣīra fī 'ilm al-nujūm*), which deals with astronomical, astrological, and prognostic topics, as well as related issues like, water sources and weather predictions. He discusses rainfall periods in two distinct chapters of his work. In the almanac chapter, the calendar system serves as a framework for recording various phenomena, while in a later chapter, the rain periods are highlighted as key markers throughout the year. Interestingly the timing of the rains is described in relation to the risings and settings of specific stars or star clusters, using the *anwā'* system. Alongside stellar indications, the intensity, duration, and effects of the rains – especially on agricultural crops – are documented. Much of the knowledge concerning rainfall periods is linked to traditional Arab expressions about the timing and quality of seasonal rains, as well as their star lore.²⁶

In these almanacs, the common Aristotelian belief in an underground water source is predominant, although there is some disagreement on the timing of its decrease or increase. The quality of water for health, particularly in relation to seasonal changes, is also an important topic in these texts. Seasonal fishing plays a significant role in Yemeni almanacs; for instance, fish caught in autumn are noted as potentially causing health problems for those who consume them.²⁷

Rivers are discussed in regional almanacs even when the authors were living far from those rivers. The Nile frequently appears in the almanacs as a river with healing properties and ideal characteristics, often inspiring poets to praise it. The ramifications of rivers are sometimes attributed to divine power, which is believed to prevent human manipulation of their courses. A fascinating historical account from the ninth century, attributed to a water engineer, illustrates how he and his colleagues persuaded the caliph to abandon plans to divert a branch of the Tigris River toward Samarra in central Iraq for political and civil purposes. Their argument primarily emphasised the importance of maintaining the natural harmony of rivers, advocating against interference with their course.²⁸

²⁴ Michael G. Morony, "Economic Boundaries? Late Antiquity and Early Islam," *Journal of the Economic and Social History of the Orient* 47 (2004): 166–94, esp. 189–90.

²⁵ For a convincing study on this subject, see Claudia Zatta, "Seasons and Human Health in the Hippocratic *Airs, Waters, and Places* and Hesiod's *Works and Days*," *Florentia Iliberritana* 33 (2023): 149–63.

²⁶ For a forthcoming detailed study on al-Ashraf 'Umar's knowledge of rainfalls, see Razieh S. Mousavi and Petra G. Schmidl, "Al-Ashraf 'Umar's *Tabṣīra*. Chapter xxxvi: Rainfalls, Winds, and Agricultural Activities," accepted to be published in *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften*.

²⁷ Daniel Martin Varisco *Medieval Agriculture and Islamic Science: The Almanac of a Yemeni Sultan* (University of Washington Press, 1994), 131.

²⁸ For an English translation of this quotation and an analysis of its context, see Mousavi, "Calculation and Power." While this document is intriguing, it should be considered alongside other historical and archaeological evidence that highlights the large-scale water projects and canal systems constructed by Muslim engineers in the early Islamic centuries. This might suggest that, following a period of extensive resource utilisation, environmental considerations began to hold greater significance for them.

Despite the shared concerns about environmental issues in water management, agriculture, and advanced fields such as astronomy and medicine, these topics have not been generally regarded as interconnected. As discussed here, the understanding of environmental phenomena in Islamic sources, particularly almanacs, is part of a complex cosmological framework and belongs to a broader epistemic structure. This network of themes reflects a scientific effort to link the regularity and predictability of astral motions in the supra-lunar realm with the relatively chaotic atmospheric phenomena beneath the sphere of the Moon, extending further to the terrestrial realm, its spatial organisation, cultivation cycles, and the well-being of living creatures.²⁹ Although the Islamic scientific tradition inherited the concept of four seasons based on equinoctial and solstitial points from other cultures, the Arabs developed a more nuanced understanding of seasonal periods, which was adapted to local environmental changes and astral indicators visible above their horizon.³⁰

Perspectives for Future Studies

The core idea of this paper is to emphasise the integration of the history of science and environmental history to deepen our understanding of environmental humanities by synchronising diverse resources. As Beate Fricke and Andreas Lammer have demonstrated in their recent work on pre-modern weather perceptions, changes in any natural process could not be fully understood without considering its interconnections with other processes, whether visible or not.³¹

Moreover, recent discussions in the Anthropocene field highlight the necessity of analysing environmental, cultural, and scientific factors simultaneously while addressing their ontological foundations. The examples discussed highlight how expectations and knowledge systems influence societal responses to environmental changes. It remains essential to historicise environmental studies before merging them with natural sciences for a clearer understanding of past societies' relationships with nature.³² As Adam Izdebski stresses in his introduction to *Environment and Society in the Long Late Antiquity* (2019), interdisciplinary approaches are key to grasping human responses to ecological shifts throughout history.

The present study by synthesising research on various dimensions of water management and its agricultural practices, such as seasonal dynamics, labour requirements, engineering strategies, regional adaptations, and cultural and religious influences, aimed to emphasise the necessity of situating these practices within a broader cosmological context in Islamic history. This approach features that water management was not merely a technical or economic endeavour but a deeply interconnected system influenced by cultural, societal, and environmental factors. Furthermore, the study highlights the critical role of adopting interdisciplinary methods in environmental history. By integrating perspectives from archaeology, climatology, hydrology, cultural studies, and religious history, it leads us to gain a more nuanced understanding of how human societies responded to ecological challenges and changes over time. This integrative approach also reveals the interplay between natural systems and human agency, providing a deeper understanding of sustainable practices and the cultural ethos that shaped environmental management in historical contexts.

²⁹ Drawing on the work of Daniel M. Varisco, this interconnected cluster of themes is referred to as “seasonal knowledge” in Mousavi and Schmidl, “Al-Ashraf ‘Umar’s *Tabṣira*.”

³⁰ Another aspect highlighting the cosmological significance of earthly activities is the depiction of the earth in Islamic narratives as a reflection of resurrection and human mortality. For a recent study that explores this concept, particularly through references to religious texts and Persian poetry to examine the relationship between the earth and humanity in pre-modern Islamic literature, see Patric Naeve, “The Anthropomorphic Earth and the Speaking Universe in Islamic Literature,” in *The Elements in the Medieval World. Interdisciplinary Perspectives: Earth* (Brill, 2024), 403–24.

³¹ Beate Fricke and Andreas Lammer, “Einleitung,” in *Verschränkte Welt. Medien, Modelle und Diskurse mittelalterlicher Meteorologie*. Das Mittelalter 29.1, ed. Beate Fricke and Andreas Lammer (Heidelberg University Publishing, 2024), 1–18.

³² Pietro D. Omodeo, Rodolfo Garau, and Giulia Rispoli, “Historical Geoanthropology,” *Journal of Interdisciplinary History of Ideas* 11, no. 22 (2022).

The Iron Crane's Knee Revisited: A Crucial Link between Su Song's Astronomical Clock Tower and Hydraulic Machinery¹

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Introduction

The Water-driven Astronomical Clock Tower (shuiyun yixiang tai, 水运仪象台, henceforth “Clock Tower”), constructed by Su Song (苏颂, 1020–1101) and Han Gonglian (韩公廉, fl. 1086) in 1092 during the Northern Song Dynasty, stands as the zenith of ancient Chinese astronomical instrumentation and marks a significant milestone in horological advancements.² Regrettably, the device was disassembled and relocated to northern China during the Jin-Song War of 1127, after which attempts at reassembly and operation proved unsuccessful. Our current understanding of this remarkable instrument is largely derived from Su Song's treatise, *Xin Yixiang Fayao* (*New Design for an Armillary Sphere and Celestial Globe*, 《新仪象法要》).³ This comprehensive work not only provides a meticulous description of the instrument's structure and functions but also includes over sixty detailed illustrations, establishing it as the most thorough and authoritative source on astronomical instruments in medieval China.

Given that the Clock Tower utilized water flow as its power source and incorporated intricate hydraulic mechanisms, it was widely assumed that this device derived its inspiration from agricultural irrigation technology. This study demonstrates the existence of this knowledge exchange through an analysis of the technical term “iron crane's knee,” which serves as evidence of the cross-disciplinary appropriation from hydraulic technology to astronomical instrumentation. In the historiography of the Clock Tower, Joseph Needham was the first to recognize the potential significance of this term.⁴ However, his interpretation requires correction due to certain inaccuracies in his explanation.

¹ This paper originally appeared in the *Journal of Guangxi Minzu University* (Natural Science Edition) 29, no. 3 (2023): 22–29, under the title “An Examination of Iron Crane's Knee” in *Xin Yixiang Fayao* (in Chinese). Upon significant revisions and expansions, this paper was translated into English and presented at the Eleventh Conference of the European Society for the History of Science Conference in Barcelona, Spain, September 2024. We extend our gratitude to Alberto Bardi, Corinna Guerra, and Pietro Daniel Omodeo for organizing the conference panel and their encouragement in the completion of this article in English.

² For the history of the Clock Tower and Su Song's biography, see Guan Chengxue, Yang Ronggai, Su Kefu, *Research on Su Song, and Xin Yixiang Fayao* (Jilin Literature and History Press, 1991). (in Chinese) 管成学, 杨荣垓, 苏克福, 《苏颂与〈新仪象法要〉研究》(长春: 吉林文史出版社, 1991). For the latest research on the historical significance of the Clock Tower, see David Chang, “Chapter Two India and the Far East Section Two: China to 1900,” in *A General History of Horology*, ed. Anthony Turner, James Nye, and Jonathan Betts (Oxford University Press, 2022), 41–52.

³ This study is based on the modern edition, i.e. Su Song, *Xin Yixiang Fayao*, annotated and translated by Hu Weijia, (Liaoning Education Press, 1996). (in Chinese) 苏颂, 《新仪象法要》, 胡维佳译注, (沈阳: 辽宁教育出版社, 1996). For some English translations of technical terms, refer to Joseph Needham, Ling Wang, and Derek J. de Solla Price, *Heavenly Clockwork: The Great Astronomical Clocks of Medieval China*, 2nd ed. with supplement, vol. no. 1., Antiquarian Horological Society Monograph (Cambridge University Press, 1960), and Hong-Sen Yan, *Reconstruction Designs of Lost Ancient Chinese Machinery*, vol. 3, History of Mechanism and Machine Science (Springer Netherlands, 2007).

⁴ Another scholar who showed great interest in the iron crane's knee was Li Zhichao, who hypothesized that it was a type of device consisting of two rods connected by a spring. However, even he admitted that this was a modern invention, unsupported by original text or other historical materials. See Li Zhichao, *History of Chinese Water Clocks* (Anhui Education Press, 2014), 227–8. (in Chinese) 李志超, 《中国水钟史》(合肥: 安徽教育出版社, 2014), 227–8.



This study begins by elucidating the function of the iron crane's knee within the Clock Tower's escapement mechanism, specifically its great-driving-wheel system. It will then analyse Joseph Needham's (mis)interpretation of this term. Following this, the paper delves into a comprehensive examination of the various applications of "crane's knee" in ancient texts, revealing its usage as a parlance for a chain component in the dragon-bone water lift. Eventually, the study offers a thorough overview of the traditional Chinese hydraulic technologies integrated into the Clock Tower's design.

The Role of the Tian Tiao/Iron Crane's Knee in the Operation of the Water Clock

The Clock Tower stands at a height of 12 meters with a base width of 7.5 meters.⁵ The structure comprises three distinct levels, each with a unique purpose. The ground floor houses an intricate timekeeping mechanism. The entire apparatus is encased in a five-story wooden pagoda, capable of indicating both diurnal (equal hours) and nocturnal (unequal hours) time. The second level featured a celestial globe (*hun xiang*, 浑象), measuring 1.7 meters in diameter, which simulated the daily rotation of the sky. The topmost floor contained an armillary sphere (*hun yi*, 浑仪) with a diameter of 2.4 meters, equipped with a sighting tube that could automatically track the sun's movement. These three components were interconnected through a mechanical system, deriving their power from the great-driving wheel (*shu lun*, 枢轮) situated on the ground floor.

The great-driving wheel has two functions: first, it provides steady power for the timekeeping system and astronomical instruments, much like a water wheel powering a mill; second, it converts the continuous flow of water into intermittent motion, similar to an escapement mechanism in a clock. To ensure sufficient rotational inertia, the wheel is extremely large, with a diameter exceeding 3 meters. Thirty-six water-receiving scoops (*Shou shui hu*, 受水壶) are installed on the edge of the wheel, with each scoop having an iron-pin (*tie bo [ya]*, 铁拨[牙]) protruding from it.

⁵ In his work, Su Song only provided the dimensions of the astronomical instruments and key mechanical components, without offering data on the overall size of the clock tower. Experts' estimates of its size are derived from the sum of the various parts' measurements, resulting in dimensions ranging between 8.8-12.4 meters. Another factor affecting the calculation results is the choice of standard for converting Song dynasty lengths into metric units. In fact, different length measurements were prevalent during the Song dynasty. Here, we adopt the conclusion accepted by Li and other scholars that one *chi* (尺) equals 0.311m, see Li Zhichao, *The Water-Powered Astronomical Clock Tower: A History of Ancient Chinese Astronomical Clocks* (University of Science and Technology of China Press, 1997). (in Chinese) 李志超, 《水运仪象志: 中国古代天文钟的历史》(合肥: 中国科技大学出版社, 1997).

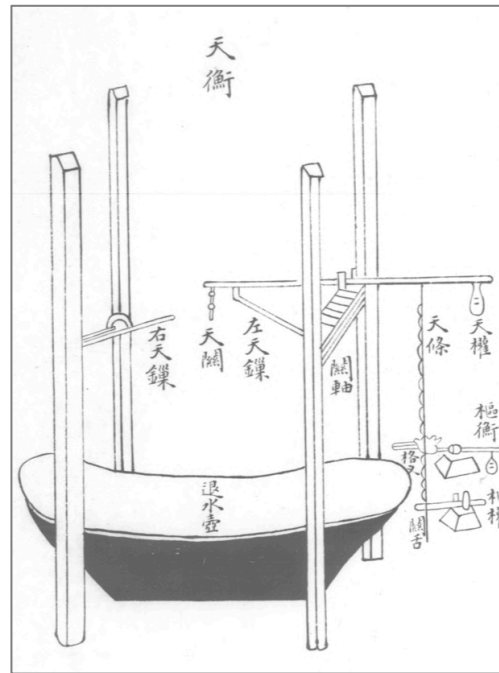


Figure 1. Illustration of the upper-balance lever and other structures in *Xin Yixiang Fayao*. The vertical line with a series of semicircles is the *tian tiao*, iron crane's knee. From Su, *Xin Yixiang Fayao*, A Qing dynasty manuscript (Book III, p. 26, National Library of China, Beijing).

The water driving the great-driving-wheel is first lifted to a certain height using manpower and mechanical devices, then enters the celestial reservoir (*Tian Chi*, 天池). In a single intermittent movement, water flows from the celestial-reservoir into the constant-level tank (*ping shui hu*, 平水壶) and then through a siphon (*ke wu*, 渴乌) into one water-receiving scoop. This scoop rests on the lower-balancing lever (*shu heng*, 枢衡). When the scoop contains little water, the lever system remains balanced and stable. However, when the scoop fills, it presses down on one end of the Lower-balancing lever. At this point, the Iron-pin on the scoop pushes down on the trip lever, which moves the celestial chain (*tian tiao*, 天条). As the celestial chain moves, the upper-balancing lever (*tian heng*, 天衡) rises along with the upper stop (*tian guan*, 天关). The left upper lock (*zuo tian suo*, 左天锁) then opens, allowing the great-driving wheel to rotate until the next water-receiving scoop contacts the lower-balancing lever.⁶ During this process, the upper- and lower-balancing levers, along with the trip-lever, all return to their initial positions and stop the wheel. The mechanism thus transforms the continuous flow of water into the intermittent motion of the wheel.

Based on the preceding explanation, it is evident that the *tian tiao* serves as a crucial component, connecting the upper-balancing lever and the trip lever. In ancient Chinese, the word *tiao* typically denotes a long, slender rod or stick. However, the illustration portrays the *tian tiao* as a thin line with a series of small semicircles (Figure 2), suggesting a more complex structure than a simple rigid rod. Furthermore, Su Song's annotation in the introduction of *tian tiao*, which states "That is, the *tie hexi* (铁鹤膝), literally 'iron crane's knee'."⁷ All this prompts new questions: what is the meaning of the "iron crane's knee" in this context? Does this new term contain a key clue for understanding the *tian tiao*?

⁶ Su Song provides a detailed discussion of this process, see Su Song, *Xin Yixiang Fayao*, 224; Needham, Wang, and Price, *Heavenly Clockwork*, 44–5.

⁷ Su Song, *Xin Yixiang Fayao*, 219; Needham, Wang, and Price, *Heavenly Clockwork*, 41.

Joseph Needham's Interpretation of the Tian Tiao/Iron Crane's Knee

In 1956, Joseph Needham, Wang Ling, and Derek J. Price published an article in *Nature*, revealing their research on the Clock Tower for the first time. Although the authors did not discuss any details of the mechanical terminology in the article, we can clearly see in an illustration that the tian tiao was drawn as a straight line, implying that it was understood as a rigid rod.⁸

The content of this article became the subject of Needham's presentation at the Eighth International Congress of the History of Science held in Florence in September of the same year. Coincidentally, at that conference, Professor Liu Xianzhou (刘仙洲, 1890–1975), a historian of ancient Chinese mechanics from Tsinghua University, also gave a talk on Su Song's Clock Tower, with the title "Chinese inventions in horological engineering."⁹ After obtaining his doctoral degree from the University of Hong Kong in 1918, he taught mechanical engineering at several universities in northern China. In the 1920s, he began researching the history of Chinese tradition machines and mechanism, covering mechanical applications in various areas such as transportation, agriculture, irrigation, textiles, printing, timekeeping devices, and military technology. These studies established his position as a pioneer in this field.¹⁰

In his book *Heavenly Clockwork: The Great Astronomical Clocks of Medieval China* published in 1960, Needham recalled that he and Liu discussed what exactly the *tian tiao* or iron crane's knee was. Eventually, Liu convinced him to accept that the "celestial rod was really a chain." Needham admitted that, in their initial reconstruction plan, interpreting the tian tiao as a rod was entirely based on a literal reading of the character *tiao*. The drawback of this approach was that a rigid rod could only provide an upward pushing force, thus the tian tiao would have to be placed on the side of the trip-lever's fulcrum further from the pivot wheel, which contradicted the illustration in Su Song's book.¹¹ Liu's interpretation not only made all the components consistent to their positions in the illustration, but also explained why the tian tiao was drawn with that form of a string of semicircles.

Needham was not satisfied with this. In his view, Su Song's added annotation of "iron crane's knee" must have implied the mechanism of a chain, thus it was particularly worth investigating its origin. In his subsequent explanation, he found a line of poetry from the 3rd-century poem "Wudu Fu" (Ode to the Wu Capital, 《吴都赋》) that reads "the crane's knees at the home," and, combined with later commentaries, pointed out that the "crane's knee" here refers to a type of weapon – *mao* (矛), that is, the spears. Then, he cited the military work *Wujing Zongyao* (*Complete Essentials for the Military Classics*, 《武经总要》) written in 1044, pointing out that this spear was a type of *chui mao*, meaning a war-flail, a weapon consisting of a handheld shaft and a heavy object, connected to each other at their ends by a metal chain. He finally concluded that, "with this background gained, it is easy to see how naturally it would have occurred to artisans making a machine of linked rods and chains to use the expression 'iron crane bird's knee'."¹²

⁸ Joseph Needham, Wang Ling, and Derek J. Price, "Chinese Astronomical Clockwork," *Nature* 177, no. 4509 (March 1956): 600–602. The *tian tiao* appears in Figure 4.

⁹ The lecture was published as Liu Xianzhou, "On the Invention of Time-keeping Apparatus," *Journal of Tsinghua University* 3, no. 2 (1957): 57–70. (in Chinese) 刘仙洲, "中国在计时器方面的发明," 《清华大学学报》3, no. 2 (1957): 57–70.

¹⁰ For Liu's biography and his research on the history of mechanics, see Feng Lisheng, "Establishment and Inheritance: Liu Xianzhou and Research on the History of Mechanical Engineering in China at Tsinghua University," *Studies in the History of Natural Sciences* 36, no. 2 (2017): 167–79. (in Chinese) 冯立昇, "开拓与传承: 刘仙洲与清华大学的机械史研究," 《自然科学史研究》36, no. 2 (2017): 167–79.

¹¹ Needham, Wang, and Price, *Heavenly Clockwork*, 57, n. 2.

¹² Needham, Wang, and Price, *Heavenly Clockwork*, 56, n. 2.



Upon closer examination, Needham's interpretation appears to be inaccurate. The *Wujing Zongyao* refers to the weapon in question as *tie lian jia bang* (铁链夹棒), of which the literal meaning is "stick connected by iron chains." The term *chui mao* never occurs in the text. Moreover, in ancient Chinese weaponry, spears and war-flails were distinct categories. Spears, characterized by a pointed end, were designed for thrusting. In contrast, war-flails, consisting of a chain attached to a weighted object, were employed for swinging and striking. This latter weapon eventually evolved into the modern-day *nunchaku*. In addition, Needham also mentioned two other usages of the term "crane's knee," which appear in the study of poetic meter and in traditional Chinese medicine,¹³ but he did not further elaborate on the reasons for the significance of these usages.

Crane's Knee as an Image-Based Metaphorical Symbol

Needham failed to realize that in traditional Chinese knowledge systems, the term "crane's knee" was not limited to referring to any specific object; rather, it was a metaphorical symbol based on imagery, used to represent anything with similar visual characteristics. A prominent feature of the crane bird's knee is the patellar ligament, which looks like a bump in the knee. Cranes, like other birds, have a unique leg structure adapted for their lifestyle. The bump is composed of the patellar tendon or other connective tissues. It helps with the bird's mobility, particularly for standing, walking, and feeding. It provides the necessary support and leverage for the muscles and tendons involved in these movements. Compared with the crane's slender leg bone, the bump is more conspicuous. The ancient Chinese captured this characteristic of the crane's knee and used it to name or describe both concrete objects and abstract concepts that are protruding in the middle and slender at both ends. A survey of ancient texts reveals that this usage appears in various contexts.

In the 10th-century work *Sun Pu* (*Manual of Bamboo Shoots*, 《笋谱》) by monk Zanning (赞宁, d. 996), a type of bamboo named "crane's knee" was recorded.¹⁴ Li Kan's (李衍, 1244–1320) *Zhu Pu* (*Manual of Bamboo*, 《竹谱》) also mentions that this bamboo "has a protrusion in the middle and is often used for walking sticks."¹⁵ No later than the 10th century, a type of low table called the crane's knee table became popular in China. The legs of this table protruded in the middle, resembling the joint of a crane's knee. The Linxi Museum houses a crane's knee table manufactured during the Liao Dynasty (907–1125). Images of this type of furniture also appeared in the Mural paintings in the tomb of Wang Zhicheng (862–923) in Baoding, Hebei and the Baoshan Mural Painting (c. 923) in Chifeng, Inner Mongolia.¹⁶ The crane's knee spear mentioned by Needham also belongs to this category. This type of spear has a protruding part in the middle of its piercing head. The design not only enlarges the puncture wound but also makes it easier for the user to withdraw.

In traditional Chinese Medicine, *hexi feng* (鹤膝风, literally "crane's knee wind")¹⁷ refers to the swelling and pain in the knee joint, with the upper leg and lower foot connected to the knee becoming emaciated, resembling the knee of a crane. This condition corresponds to modern medical diagnoses of the knee joint, including effusion in

¹³ Needham, Wang, and Price, *Heavenly Clockwork*, 56, n. 2.

¹⁴ Zanning, *Sun Pu*, Wenyuange Edition of *Siku Quanshu*, 25. (in Chinese) 赞宁, 《笋谱》, 文渊阁四库全书本, 25.

¹⁵ Li Kan, *Zhu Pu*, Volume 5, Wenyuange Edition of *Siku Quanshu*, 5. (in Chinese) 李衍, 《竹谱》卷五, 文渊阁四库全书本, 5.

¹⁶ Zhang Zhihui, "From 'Crane's Knee Table' to 'Revolving Table': Furnitures in *Shiyi Shier Tu*," *Forbidden City*, no. 12 (2018): 112–25. (in Chinese) 张志辉, "从'鹤膝桌'到'圆转桌'《一是一二图》中的家具," 紫禁城, no. 12 (2018): 112–25.

¹⁷ Needham mentioned this usage, noting that his collaborator, Dr. Lu Gwei-djen (鲁桂珍, 1904–1991), informed him of this fact. This is unsurprising, given that Lu's father was an accomplished practitioner of traditional Chinese medicine. Needham, Wang, and Price, *Heavenly Clockwork*, 56–7, n. 2.

the knee joint cavity and rheumatoid arthritis of the knee. According to current research in history of medicine, this concept first appeared in the works of the 12th-century physician Liu Wansu (刘完素, c. 1100–1180).¹⁸

Evidence suggests that the medical application of the term “crane’s knee” likely predates current records. This inference is supported by the term’s earlier use in artistic contexts to describe certain maladroitness. For instance, the calligrapher Wang Xizhi (王羲之, 303–361)’s *Bishi Lun* (*The Art of Calligraphy Brushwork*, 《笔势论》) advises that “the turning point of a stroke should maintain harmony, avoiding extremes such as the slenderness of a wasp’s waist or the disproportionate bulkiness of a crane’s knee.”¹⁹ Similar metaphors also appear in poetics. For example, Kūkai (空海, 744–835), a Japanese monk who studied in China, in his work lists “twenty-eight maladies” of poetry composition, among which: “Fourth, Crane’s knee: In poetry, the fifth character of a five-character poem should not have the same sound as the fifteenth character, meaning the two ends are thin and the middle is thick, resembling a crane’s knee.”²⁰

From the above discussion, it can be seen that “crane’s knee” is a symbolic term widely used by Chinese intellectuals, artists, and practitioners. The following section will explain that it was also used to refer to a chain structure in a type of traditional Chinese hydraulic machinery.

Crane’s Knee as a Chain in Dragon-Bone Water Lift

The key clue suggesting that the crane’s knee is a chain comes from an unexpected work: *Taixi Shuifa* (*Hydraulic machinery of the West*, 《泰西水法》) co-authored by Sabatino de Ursis (1575–1620) and Xu Guangqi (徐光启, 1562–1633) in 1612. Sabatino de Ursis was an Italian Jesuit. He arrived in Beijing in 1607 and collaborated with Matteo Ricci (1552–1610) and Xu to translate several Western scientific works, including the first six books of Euclid’s *Elements*. Drawing on the work of Italian engineer Agostino Ramelli (1531–c. 1610), *Taixi Shuifa* introduced to China for the first time the Western water lifting devices such as the Archimedean screw and pumping tube.

When introducing the Archimedean screw, the two authors gave the machine a very Chinese name – “dragon tail.” The naming might be due to two reasons. First, the spiral blades of the Archimedean screw do indeed resemble the coiled tail of a dragon. Second, in traditional Chinese mythology, the dragon is a magic creature that brings water and rain. That’s why the traditional Chinese water-lifting device is called the “dragon bone.” The authors stated that, compared to traditional Chinese machinery, the “dragon tail” has a significant advantage. This is because wind and water can corrode the crane’s knee and paddle blades in the water-lifting device, causing the machine to malfunction, but the dragon-tail does not have these structures.²¹ This statement clearly indicates that the crane’s knee is a component in traditional Chinese water-lifting devices.

¹⁸ Liu Wansu, *Huangdi Suwen Genming Lunfang*, in Complete Medical Works of Liu Wansu, ed. Song Nailiang (Beijing: China Traditional Chinese Medicine Press, 2006), 26. (in Chinese) 刘完素,《黄帝素问直明论方》, 载于宋乃亮编,《刘完素医学全书》, (北京: 中国中医药出版社, 2006), 26. For a study of the concept in the history of medicine, see Pan Zheng, “Research and Reflections on Hejifeng in Ancient Chinese Medical Texts from the Ming and Qing Dynasties,” *Jiangsu Journal of Traditional Chinese Medicine*, no. 6 (2015), 71–4. (in Chinese) 潘峥:《关于鹤膝风的明清时期中医古籍研读和思考》, 《江苏中医药》, no. 6 (2015), 71–4.

¹⁹ Wang Xizhi, “Treatise on Brush Strokes,” in Chen Si (ed.), *Shuyuan Jinghua*, Volume 1, Song Dynasty Edition, 10. (in Chinese) 王羲之,《笔势论》, 载陈思编《书苑菁华》卷一, 宋刻本, 10.

²⁰ Tsuboi Kunizo (ed.) “Complete Works of Kobo Daishi,” Tsuboi Rousho, Meiji 33.7. National Diet Library Digital Collections <https://dl.ndl.go.jp/pid/819264> (accessed 2024-9-3) (in Chinese and Japanese) 壺井国三編『弘法大師全集』, 壺井老舖, 明33.7. 国立国会図書館デジタルコレクション.

²¹ “又向所言风与水, 能败龙尾之车也, 在鹤膝斗板。龙尾者, 无鹤膝, 无斗板。器居水中, 环转而已。” (Regarding what was said about wind and water being able to damage the dragon tail machine, it is in the crane’s knee and paddle blades. The dragon tail has no crane’s knee and no paddle blades. The device simply rotates in the water) from Sabatino de Ursis and Xu Guangqi, *Taixi Shuifa*, in Li Zhizao (ed.), *Tianxue Chuhan: Qibian*. (in Chinese) 《泰西水法》, 载李之藻编《天学初函·器编》.

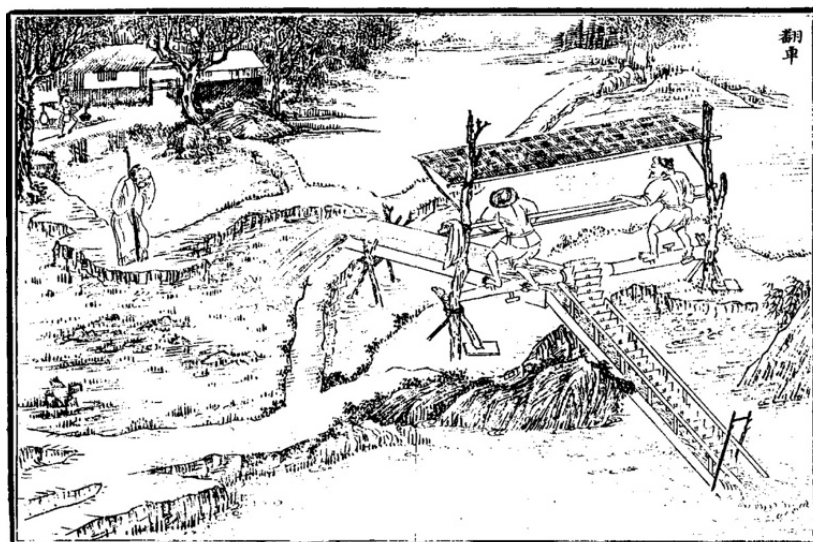


Figure 2. Illustration of the fan che, or dragon-bone water lift. From Wang, Nong Shu (Book XVIII, Edition of Siku Quanshu).

In the dragon-bone water lift, the “crane’s knee” is the chain that connects the upper sprocket and the lower sprocket. The machine can be powered by hand or foot to turn the upper sprocket. (Figure 2) Through the transmission of the “crane’s knee” – namely, the chain – the lower sprocket is rotated. The lower sprocket is installed underwater. The scratch board on the lower sprocket carries water up to the path board, and the blades on the chain push the water up through the path board to the shore.²² This chain is made up of a series of wooden strips. One end of each strip is convex, while the other end is concave. The strips are connected by thin axles to form a chain. Due to the thin axles protruding compared to the wooden strips, it resembles the shape of a crane’s knee, hence its name.

This water-lifting device has a long history in ancient China. Wang Zhen (王祯, 1271–1333) recorded it as *fan che* (翻车, literally “turning wheel”) in his *Nong Shu* (*Treatise on Agriculture*, 《农书》). It was invented by Ma Jun (马钧, c. 200–265) of the Han Dynasty, initially more like a toy that allowed children to easily water their vegetable gardens. In Wang’s era, people called this machine the “dragon bone,” which was widely used in field irrigation. It was praised by the author that “among all water-lifting tools with mechanical devices, only this turning wheel is the most convenient and efficient.”²³

Although intellectuals of Song Dynasty generally lacked interest in mechanical technology, they were evidently very familiar with this machine and its structure, as reflected in their poems. Su Song’s colleague, the great man of letters in Song Dynasty Su Shi (苏轼, 1037–1101), once vividly described the structure of the dragon bone water wheel in his poem: *Piece by piece, like crows holding each other’s tails; segment by segment, like the bones shed by a snake* (翻翻联联衔尾鸦, 莘莘确确蜕骨蛇). The poet and official Mei Yaochen (梅尧臣, 1002–1060), in his series of poems about agricultural tools, dedicated a specific poem to the dragon bone: *It turns like a moving wheel, it drinks as a rainbow over river and hill. With the power to bring timely rain, it ensures the ripening of grain* (既如车轮转, 既如车运转).

²² For a description of the dragon bone water wheel structure and its modern reconstruction, see Kuo-Hung Hsiao and Hong-Sen Yan, *Mechanisms in Ancient Chinese Books with Illustrations* (Springer International Publishing, 2014), 195–9.

²³ Wang Zhen, *Annotated Translation of Nong Shu*, translated and annotated by Miao Qiyu and Miao Guilong (Qilu Press, 2009), 630–1. (in Chinese) 王祯, 《农书译注》, 缪启愉、缪桂龙译注 (济南: 齐鲁书社, 2009), 630–1.

又若川虹饮。能移霖雨功，自致禾苗稔。). Su Song's contemporary, the political reformer Wang Anshi (王安石, 1021–1086), also wrote: *The dragon bone made a hoarse noise, the peasants' life was truly arduous* (龙骨已呕哑，田家真作苦).

Through these examples, we have reason to infer that Su Song must have been very familiar with the dragon bone water wheel, and considered the chain structure “crane’s knee” to be common knowledge. That is why he used this term to interpret the structure of the celestial-chain, and specifically added “iron” to emphasize the difference in materials between the two.

Conclusion: Application of Hydraulic Machinery Knowledge in Su Song's Water Clock

When the Clock Tower began to operate, the massive wooden timekeeping system and the bronze celestial globe and armillary sphere would rotate simultaneously, which means the mechanical power output from the driving wheel must have been very large. This is one of the major differences between the Clock Tower and the Greek and Islamic water clocks, which only needed to drive a dial and some ingenious, albeit smaller and lighter, automatic devices.²⁴ During the Song Dynasty, vertical waterwheels had become commonplace, serving both agricultural irrigation needs and as power sources for various grain processing equipment, including mills and trip hammers. Given this widespread adoption of hydraulic technology, it is reasonable to infer that the design and construction of the driving wheel in Su Song's Clock Tower likely drew inspiration from these established mechanisms.²⁵

A further illustration of Su Song's application of hydraulic engineering knowledge is evident in the Clock Tower's water-elevation system. The water that enters the great-driving wheel is initially elevated to a specified height, that is the celestial reservoir, via the lower-water-lifting wheel (*sheng shui xia lun*, 升水下轮) and upper-water-lifting wheel (*sheng shui shang lun*, 升水上轮).²⁶ These water-lifting mechanisms bear a striking structural resemblance to the *tong che* (筒车, literally “buckets wheel”).²⁷ *Tong che* is the traditional Chinese version of the noria, utilizes the force of water flow to transport water from lower to higher elevations using buckets affixed to the wheel's periphery. In the Clock Tower, the lower- and upper-water-lifting wheels are equipped with 8 and 16 buckets respectively, and are manually driven, equivalent to combining two buckets' wheels for use. It is noteworthy that Wang Zhen, in his *Nong Shu*, employed the same term *tian chi* (celestial reservoir) to describe the receptacle for elevated water in the bucket wheel system.²⁸ Both the similar mechanical structure and shared nomenclature indicate a potential cross pollination of ideas between astronomical instrumentation and hydraulic machinery.

In conclusion, Su Song's Astronomical Clock Tower represents a pinnacle of 11th-century Chinese mechanical engineering. Our analysis of the term “iron crane's knee” provides compelling evidence of knowledge transfer between astronomical instrumentation and hydraulic machinery. Furthermore, it offers valuable insights into the conceptual framework and technical vocabulary employed by Song Dynasty scholars when discussing mechanical innovations.

²⁴ For a comparative study of ancient water clocks, see Zheng-Hui Hwang, Hong-Sen Yan, and Tsung-Yi Lin, “Historical Development of Water-Powered Mechanical Clocks,” *Mechanical Sciences* 12, no. 1 (February 19, 2021): 203–19.

²⁵ Needham, Wang, and Price, *Heavenly Clockwork*, 109.

²⁶ Su Song, *Xin Yixiang Fayao*, 223–4; Needham, Wang, and Price, *Heavenly Clockwork*, 42–3.

²⁷ Hsiao and Yan, *Mechanisms in Ancient Chinese Books with Illustrations*, 116.

²⁸ Wang Zhen, *Annotated Translation of Nong Shu*, translated and annotated by Miao Qiyu and Miao Guilong (Qilu Press, 2009), 634–5. (in Chinese) 王祯,《农书译注》, 缪启愉、缪桂龙译注 (济南: 齐鲁书社, 2009), 634–5.

Utopia and Insularity in Ibn Tufayl's *Hayy Ibn Yaqzan*: Towards a Neso-Anthropology¹

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Introduction

The concept of utopia has long been intertwined with the imagery of islands, suggesting a deep-seated connection between idealized visions and insular landscapes. This enduring association underscores the island's unique role as a symbol of both isolation and perfection in utopian thought. This article reexamines the twelfth-century Arabic philosophical work *Hayy Ibn Yaqzan* (Alive Son of the Vigilant),² authored by Ibn Tufayl (1105–1185), through the lens of contemporary environmental debates. *Hayy Ibn Yaqzan* has historically sparked significant discourse surrounding autodidacticism, the interplay between science and religion, and their reconciliation.

By situating *Hayy Ibn Yaqzan* within the broader context of modern environmental challenges, this study aims to reinterpret the philosophical and ecological dimensions of the text. Employing a cross-cultural historical approach, the paper explores the nexus between insularity and utopian ideals as proposed by Ibn Tufayl and assesses its relevance to ongoing discussions about humanity's relationship with nature. This re-examination contributes to a deeper understanding of how historical and philosophical perspectives can inform contemporary environmental discourse.³

The article proposes a new framework – referred to as “neso-anthropology” – to analyse the island's multifaceted significance. The term “neso” derives from “nesology,” the study of islands, an approach that incorporates aesthetic, geopolitical, and anthropological aspects of insularity.⁴ By focusing on the broad anthropological dimensions of islands from a historical perspective, this paper will first scrutinize the core themes of *Hayy Ibn Yaqzan* and then trace its influence and reinterpretation across different cultural contexts.

Subsequent sections will explore how *Hayy Ibn Yaqzan* has been appropriated and reinterpreted over time, particularly in debates about education and knowledge. Additionally, the paper will assess how the text contributes to current environmental discourse, advocating for a rethinking of metaphysical inquiry as an open-ended pursuit that emphasizes environmental responsibility. By highlighting the ecological wisdom embedded in *Hayy Ibn Yaqzan*,

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² Lenn Evan Goodman, *Ibn Tufayl's Hayy Ibn Yaqzan: A Philosophical Tale*. Translated with an Introduction and Notes. Updated Edition, with a New Preface and Bibliography (Chicago University Press, 2009); Avner Ben-Zaken, *Reading Hayy: A Cross-Cultural History of Autodidacticism* (Johns Hopkins University Press, 2011).

³ Even in articles with a data-driven, scientific approach to environmental problems, the stress is on the need for new ideas, that is, utopias. For instance, Rob Hope writes: “New ideas are needed to shift from financing infrastructure to funding maintenance of safe water services” (“Four Billion People Lack Safe Water,” *Science* 385, no. 6710 [2024]: 708–709).

⁴ Antonis Balasopoulos, “Nesologies: Island Form and Postcolonial Geopoetics,” *Postcolonial Studies* 11, no. 1 (2008): 9–26. This approach to nesology contrasts with Grant McCall's notion of “nissology”: Grant McCall, “Clearing Confusion in a Disembedded World: The Case for Nissology,” *Geographische Zeitschrift* 84, no. 2 (1996): 74–85. While McCall's nissology emphasizes an empirical and isolated study of islands, nesology expands this focus to incorporate complex dialogues between various cultural and political discourses.



the study underscores the potential of its harmonious vision of human–nature relationships as a model for addressing today's complex environmental challenges.

Ibn Tufayl: Biographical and Historical-Intellectual Overview

There is little data on the life of Ibn Tufayl. Born in 1105/1010 in Guadix, near Granada, during the height of the Islamic Golden Age, Ibn Tufayl was a polymath whose contributions spanned philosophy, medicine, astronomy, and literature. His full name, Abu Bakr Muhammad ibn Abd al-Malik ibn Muhammad ibn Tufayl al-Qaisi, reflects his Andalusian Arab heritage. Ibn Tufayl was deeply influenced by the intellectual environment of Al-Andalus, where scholars had access to a rich blend of Greco-Roman, Persian, and Indian knowledge. This period was marked by a flourishing of scientific and philosophical inquiry, supported by the patronage of the Almohad caliphate. Ibn Tufayl served as a court physician and advisor to the Almohad ruler, Abu Yaqub Yusuf, which allowed him to engage with leading scholars of his time, such as Ibn Rushd (Averroes).⁵

The period during which Ibn Tufayl lived, often referred to as the Islamic Golden Age, was marked by a flourishing of intellectual and cultural activity across the Islamic world. Al-Andalus, the region where Ibn Tufayl was born and worked, was a particularly vibrant center of learning, where scholars had access to an extraordinary confluence of Greco-Roman, Persian, and Indian knowledge. This environment fostered a rich tradition of philosophical inquiry, heavily influenced by Neoplatonism, Aristotelianism, and the broader corpus of Islamic philosophy.⁶

Ibn Tufayl's role as a court physician and advisor to the Almohad ruler Abu Yaqub Yusuf placed him at the heart of this intellectual milieu. His *Hayy* reflects the synthesis of diverse philosophical traditions that characterized Al-Andalus, particularly the integration of rational inquiry with spiritual and mystical dimensions of knowledge. This synthesis is evident in the way *Hayy* navigates the tension between reason and revelation, a theme that would resonate deeply with later European thinkers.

The intellectual environment of Al-Andalus was not only marked by philosophical diversity but also by a commitment to empirical science and observation. This commitment is reflected in Ibn Tufayl's emphasis on sensory perception and empirical inquiry as the foundation of *Hayy*'s intellectual development. The broader context of scientific inquiry in Al-Andalus, including advances in astronomy, medicine, and natural philosophy, provided a fertile ground for the development of the ideas presented in *Hayy*.

Hayy stands within a broader tradition of philosophical allegories in Islamic thought, where fictional narratives are used to explore complex metaphysical and ethical questions. This tradition includes works such as Avicenna's *Salaman and Absal* and *The Book of Healing*, which similarly use allegory to convey philosophical ideas. Ibn Tufayl's contribution to this genre is unique in its emphasis on autodidacticism and the journey of the individual towards knowledge and spiritual enlightenment.

The allegorical structure of *Hayy* allows Ibn Tufayl to engage with the philosophical debates of his time, particularly those concerning the nature of knowledge, the relationship between reason and faith, and the role of empirical observation in the acquisition of knowledge. The narrative can be seen as a response to earlier Islamic philosophical works, offering a synthesis that challenges the strict dichotomies often presented in these debates.

⁵ Lawrence I. Conrad, *The World of Ibn Tufayl: Interdisciplinary Perspectives on Hayy ibn Yaqzan* (Brill, 1996); Ben Zaken, *Reading Hayy*.

⁶ Dimitri Gutas, *Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and Early Abbasid Society (2nd–4th/8th–10th centuries)* (Routledge, 1998); Dimitri Gutas, "The Study of Arabic Philosophy in the Twentieth Century: An Essay on the Historiography of Arabic Philosophy," *British Journal of Middle Eastern Studies* 29, no. 1 (2002): 5–25; Maribel Fierro, *The Almohad Revolution. Politics and Religion in the Islamic West During the Twelfth-Thirteenth Centuries* (Variorum, 2012).

In particular, Ibn Tufayl's engagement with Neoplatonism is evident in the progression of Hayy's intellectual journey, which mirrors the Neoplatonic ascent of the soul towards the divine. However, Ibn Tufayl departs from strict Neoplatonism by emphasizing the importance of empirical knowledge and the integration of different modes of knowing. This integration reflects a broader trend in Islamic philosophy towards a more holistic understanding of knowledge, one that would later influence European thinkers during the Renaissance and Enlightenment.

Hayy's intellectual development in *Hayy* can be seen as a microcosm of the broader philosophical trajectory of human knowledge. The narrative traces Hayy's journey from the basic sensory perception of his environment to the highest forms of metaphysical speculation and mystical union with the divine. Each stage of this journey represents a different mode of knowing, and together they offer a comprehensive model of human epistemology.

The first stage, sensory perception is foundational for Hayy's understanding of the world. Through careful observation of his environment, Hayy learns to distinguish between different kinds of objects and to understand the basic principles of life and motion. This stage emphasizes the importance of empirical observation and the role of the senses in the acquisition of knowledge.

As Hayy's understanding deepens, he moves to the stage of rational analysis and scientific inquiry. Here, Ibn Tufayl presents Hayy as a proto-scientist, who formulates hypotheses and tests them through experimentation. This stage reflects the broader Islamic tradition of scientific inquiry and the emphasis on rational analysis as a means of uncovering the underlying principles of the natural world.

The final stages of Hayy's intellectual development involve philosophical contemplation and mystical experience. These stages represent the culmination of Hayy's journey, where he moves beyond empirical and rational knowledge to engage with the deeper metaphysical questions of existence. Through contemplation and introspection, Hayy arrives at a conception of the divine as the prime mover and ultimate source of all being. This stage reflects the Neoplatonic influence on Ibn Tufayl's thought, but it also emphasizes the integration of rational and mystical ways of knowing.

The Nexus between the Island and Learning in Hayy Ibn Yaqzan

Hayy is not merely a story of self-discovery but a philosophical allegory that addresses fundamental questions about human existence, knowledge, and the nature of the divine. As anticipated, the tale resembles the Neoplatonic tradition, which emphasizes the ascent of the soul towards the divine through intellectual and spiritual purification.⁷ Still, firsthand experience is crucial in climbing the ladder of knowledge.

The island where Hayy grows up (Waqwaq/Ceylon) serves as a microcosm for the world, allowing Ibn Tufayl to explore the relationship between the individual and the cosmos. The island's natural environment provides Hayy with all the resources he needs to survive and thrive, illustrating the interconnectedness of all life forms and the harmony of the natural world.

Hayy's self-sufficiency on the island contrasts sharply with the dependence on external authorities that characterizes human society. By learning directly from nature, Hayy exemplifies the ideal of autodidacticism, demonstrating that true knowledge comes from within and through direct engagement with the world.

⁷ *Hayy Ibn Yaqzan* has significant intertextual connections with other philosophical and literary works, both within the Islamic tradition and beyond. For example, the story shares themes with Plato's renowned Allegory of the Cave (in Plato's *Republic*), which depicts the journey from ignorance to enlightenment. Like Plato's prisoners, Hayy begins in a state of ignorance and gradually ascends to higher levels of understanding. In the Islamic tradition, Hayy's journey mirrors the Sufi path of spiritual purification and union with God. Sufi mystics emphasized the importance of direct, experiential knowledge of the divine, which parallels Hayy's mystical experiences.

Hayy's intellectual development can be divided into several stages, each representing a different mode of knowing. The stages can be summarized as follows:

- **Sensory Perception and Empirical Observation:** Initially, Hayy learns about the world through his senses. He observes the behavior of animals, the growth of plants, and the movements of celestial bodies. His curiosity leads him to conduct experiments, such as dissecting the gazelle, which provides him with foundational knowledge about anatomy and physiology.
- **Rational Analysis and Scientific Inquiry:** As Hayy's understanding deepens, he begins to formulate hypotheses and test them through systematic experimentation. He discovers principles of physics, chemistry, and biology, developing a rudimentary scientific method. His rational analysis allows him to uncover the underlying causes of natural phenomena.
- **Philosophical Contemplation and Metaphysical Speculation:** Moving beyond empirical observation, Hayy engages in philosophical contemplation. He ponders the nature of existence, the cause of motion, and the relationship between the material and immaterial realms. Through introspection, he arrives at the concept of the prime mover, a necessary being that imparts order to the cosmos.
- **Mystical Experience and Spiritual Realization:** The culmination of Hayy's journey is his mystical union with the divine. He transcends rational thought and enters a state of spiritual ecstasy, experiencing the divine presence directly. This stage represents the ultimate goal of human existence according to Ibn Tufayl: the realization of one's unity with the source of all being.

Hayy Ibn Yaqzan as a Tale to Express Autodidacticism

Ibn Tufayl's tale describes a process of autodidacticism. The protagonist is a child, Hayy. Two narrative variants are proposed. He is either the son of a princess or born by spontaneous generation and grows up on a desert island, as the unique inhabitant therein. The island is called, as mentioned, Waqwaq (perhaps Ceylon), a mythological island beyond the horizons of climates and civilizations. On it, by means of his own understanding, Hayy is able to discover all kinds of truth and knowledge.

The study of the heavens plays an essential role in Hayy's inquiries; he is able to ascertain the mechanics of celestial bodies without the help of others. The paragraphs devoted to this question mainly deal with the philosophical sides of cosmology (e.g., the souls of celestial bodies, their influence on the sublunary world). Nevertheless, a passage in which he mentions that the celestial bodies can move either around their own center or around another center suggests that, in spite of what Biṭrūjī says, the author may have accepted eccentrics at some stage.

Most importantly, the idea that knowledge must be acquired through observation, experimentation, and thought was not completely new, but it had not been expressed as clearly and forcefully before. This claim is introduced by Tufayl through the life of Hayy, the only human inhabitant of an equatorial island. As he grows up, Hayy analyses his environment and develops knowledge by thinking about his observations and experiences. In this way, he acquires not only technology and natural sciences but philosophy and theology as well. Therefore, the message it conveys is that knowledge does not need authority, be that the teaching of old philosophers or the revelation in holy books.

In the introduction, Tufayl mentions four forerunners, three of them Persian: al-Farabi (Alfarabi), who lived in the 10th century, and Ibn Sina (Avicenna, Avicena) and al-Ghazali (Algazel), of the 11th century. His only local source was Ibn Bajjah (Avenpace), who was born in Saragossa and lived in Granada and other neighbouring cities when Ibn Tufayl was a young man, but they never met.

The tale then turns into a sort of treatise that recapitulates in a single human being the history of science and technology up to about his times.



In the narrative, Hayy embarks on a broad exploration. He starts by dissecting the gazelle that nurtured him and subsequently other animals. Through this process, he understands, by trial and error, that the essence of life resides within the heart, from which it animates the sensory and motor faculties, departing the body upon death. This observation leads him to engage with the natural world practically, deriving insights through mimicry of animals and plants.

Hayy independently develops rudimentary versions of various technological advancements, including toolmaking, clothing, shelter construction, and animal domestication. In addition, His journey prompts contemplation on the relationship between theoretical knowledge and practical application. For Hayy, speculative science emerges subsequent to practical implementations, evolving autonomously from them.

His pursuit of knowledge follows a trajectory from the specific to the general, from tangible instances to abstract concepts, and from incidental occurrences to fundamental principles. This methodology allows him to formulate the concept of animal species, recognizing similarities among groups of individuals.

While Hayy's observations reveal commonalities between plants and animals, such as nutrition and growth, he also acknowledges nuanced distinctions. He identifies corporeality as a shared attribute among living and non-living entities, leading to the conception of a higher order encompassing all objects, regardless of their specific properties. Drawing from Aristotle's insights, Hayy postulates about the vegetative and sensitive souls that animate living beings.

Midway through his life, Hayy shifts his focus from the sensory world to the realm of intellect, rediscovering philosophical arguments about the prime mover and the nature of the soul. This transition propels him towards mysticism, as he endeavours to emulate the celestial bodies in his pursuit of spiritual enlightenment. Hayy's ascetic lifestyle reflects his dedication to mystic ecstasies, achieved through rigorous self-denial and contemplation of God. His encounter with Asal, a devout hermit, underscores the convergence of Hayy's insights with those derived from religious revelation, albeit surpassing Asal's spiritual attainment. Their attempt to share their wisdom with society proves futile, leading them back to a life of solitude. Ibn Tufayl's narrative, though suffused with religious reverence, hints at underlying tensions between reason and revelation. The tale's reception posed challenges for Ibn Tufayl, yet it encourages readers to pursue independent inquiry, fostering a spirit of intellectual autonomy.

The Reception of Hayy

Hayy was translated into Hebrew sometime in the 13th century, marking a phase in the dissemination of Arabic philosophical texts from Spain, across Catalonia, and over the Pyrenees Mountains to Provence, resulting in a wave of translations, particularly of Averroist writings, into Hebrew and Latin. These translations sparked local controversies among philosophers and theologians at the University of Paris and within Jewish communities in Provence-Catalonia. More than a century later, in 1348, Moses Narbonni arrived in Barcelona.

The study of philosophy, however, encountered strong objections from leading conservative scholars in Provence and Catalonia. They sought to restrict philosophy's access to mature, educated men and issued an excommunication decree prohibiting the teaching of philosophy to young boys. In response, leading scholars in Perpignan argued for and justified the study of philosophy. There was no better text available to challenge the excommunication decree and promote self-education than Hayy, the story of a boy who derived philosophical principles through trial and error and exploration of nature. In his commentary on Hayy, titled *Yehiel Ben-'Uriel*, Narbonni not only defended the pedagogical argument that philosophy could be taught to younger boys but also provided his community of Perpignan with additional evidence in favor of self-education, sudden insight, and experimental exploration of nature. Interest in self-education surged following Narbonni's commentary, with Hayy becoming known to readers through his work in Hebrew and Latin. During the 15th century, manuscripts of Narbonni's commentary circulated among Jewish communities in Barcelona, Provence, and Italy. In the 1480s,

Jochanan Alemanno, whose manuscript of *Yehiel Ben-'Uriel* contained extensive marginalia, emerged as the key figure in the translation and dissemination of *Yehiel Ben-'Uriel* into Latin.

In the early 1490s, Giovanni Pico della Mirandola encountered one of these circulating manuscripts and had it translated into Latin for the first time. Pico, a wild prodigy himself who seized every opportunity to challenge authority and social convention, met Jochanan Alemanno in Florence in 1488. Alemanno introduced him to Hayy while Pico was completing the *Heptaplus*, where he first mentions Ibn-Tufayl and first focuses on the biblical Adam as the original self-learner who directly explored and understood nature.⁸

After the death of Pico's patron, Lorenzo de Medici, in 1492, various astrological predictions foretold the destruction of Florence, likening it to biblical Sodom, due to its tolerant attitude towards sodomy and homosexuality prevalent during Lorenzo's era, where adolescent boys played a central role in Florentine homosexual street culture. Once Savonarola took control of the city, both these boys and the men who engaged with them faced persecution. Troubled by the astrological predictions, Pico secluded himself in his suburban villa and wrote his condemnation of astrology. In Hayy's story, he found support for his ideas about natural magic as the practice of natural philosophy and as a form of platonic love, using the Andalusian novel to illustrate that firsthand experience shapes the lives of young boys. Pico's unpublished translation of Hayy soon influenced local Renaissance culture. Antonio Fregoso, a contemporary Italian poet, read it and transformed the philosophical novel into a poem titled *De lo istinto naturale*, praising natural instinct as the primary guide for the self-educating life.

Giambattista della Porta, in his work *Magia naturalis* (1558), expanded on Pico's concept of natural magic as a practical method for exploring nature, providing a list of experiments and observations on the natural world. He laid out his self-learning methodology by describing how the knowledge of secrets depends on observing the world's motion, state, and fashion, as well as the birth, growth, and decay of things. Della Porta took his methodology a step further by using it as a study program for his close circle. In 1580, he founded a scientific society called the *Academia Secretorum Naturae* (Academy of the Secrets of Nature), commonly known as the *Otiosi* (Men of Leisure), aimed at studying the secrets of nature. To gain membership, individuals had to demonstrate new discoveries in the natural sciences. Pope Paul V disbanded this utopian academy in 1578.

In early modern England, autodidacticism resonated within the emerging utopian tradition. In 1510, Thomas More translated the *Vita de Pico*, Gianfrancesco Pico della Mirandola's biography of his famous uncle. More engaged with other sources before writing *Utopia*, satirically criticizing authoritative modes of learning. In 1509, Erasmus of Rotterdam dedicated a satirical oratory to More, following the style of the Greek satirist Lucian, whose work Erasmus and More had recently translated into Latin. Through a series of ironic speeches, Erasmus highlighted the transition in icons of wisdom from old men to children. More's preoccupation with mystical practice and poetry culminated in the publication of *Utopia*, depicting a society on a remote island where inhabitants replaced contemplative life with active exploration guided by reason, establishing a government based on collective goodwill.

Rather than relying on the transmission of ideas or metaphysical premises, More envisioned the philosophical foundations of his utopia as growing from the grassroots. Children and education played central roles, with adults instilling useful principles in children's minds at a tender age. More also depicted the Utopians' lively exploration of nature, considering the study of physics as one of the most enjoyable and profitable parts of philosophy. He envisioned God as an inventor who exposed the universe to creatures capable of contemplating it, suggesting that those who admire nature are more acceptable to God than those who view it with indifference.

⁸ Brian Ogren, "The Forty-Nine Gates of Wisdom as Forty-Nine Ways to Christ: Giovanni Pico della Mirandola's *Heptaplus* and Nahmanidean Kabbalah," *Rinascimento* 49 (2009): 27–43; Eugenio Garin (ed.), *Giovanni Pico della Mirandola - De hominis dignitate - Heptaplus - De ente et uno* (Vallecchi, 1942), 51.

More extended the plea for self-education by urging 16th-century humanists to derive philosophy from firsthand experience, without relying on metaphysical foundations.

More was the first European writer to use the island parable to advocate utopian societies pursuing happiness through independent learning and self-discovery. Subsequent generations followed suit: Tommaso Campanella's *City of the Sun* and Francis Bacon's *New Atlantis* transformed this political program for active self-discovery into revolutionary programs of natural philosophy. They presented the pursuit of happiness as a gradual discovery of the self through the exploration of nature.

Despite similarities, the locations of these utopian islands varied. Hayy's island, Waqwaq, situated autodidacticism near its imaginary origins, represented the oriental philosophy of the Indian Ocean region. For Thomas More, the island lay somewhere in the Atlantic Ocean, in the New World. Campanella's *City of the Sun* was also in the Indian Ocean, on the mythical island of Taprobane, near Serendib (Sri Lanka), where "Adam's footprint" was said to be found after his fall from grace. Campanella depicted a society following Brahma and Pythagoras, with values essential for societal functioning imprinted on children's minds, achieving a political order built from the ground up.

When children reached six years of age, the Solaris of Taprobane taught them natural philosophy and mechanical science, considering those who further studied nature to be noble and renowned. They believed that knowledge of politics and nature was essential for rulers, unlike those who gained knowledge solely from books and remained unlearned and unskilled. Campanella's children possessed intellects prompt and expert in every branch of knowledge and studied sciences with greater facility than scholars from other nations.

Campanella's association with Giambattista della Porta's *Academia Secretorum Naturae* inspired Federico Cesi to establish the first academy of sciences, the *Accademia dei Lincei*, in 1603. The society sought to unravel the secrets of nature through free experiment, challenging the contemporary authorities, such as those intellectuals reading Aristotle, Ptolemy, and the Bible literally, to establish a new science based on firsthand experience.

Galileo Galilei sought Cesi's help in publishing his discoveries, leading to the publication of his observations on sunspots under the auspices of the Linceian Academy. Francis Bacon continued the Lincei's mission, advocating for reliance on firsthand experience and establishing the island utopia concept off the coast of Peru in the Pacific Ocean. Bacon's *New Atlantis* placed self-education at the intersection of rational experimental practice and mystical practice, aiming for union with nature and communion with God.

Pico and Bacon's followers promoted reliance on firsthand experience, rejecting blind adherence to authority and advocating exclusive reliance on self-discovery of nature. This plea for self-education spread through the 17th century, capturing the minds of English natural philosophers who sided with Parliament in the Civil War.

Edward Pococke employed the trope of the self-learner to secure his academic career, translating Hayy into Latin, *Philosophus autodidactus*, in the early 1670s and presenting him as a medieval precursor to experimentalism. *Philosophus autodidactus*, translated into various European languages, became accessible to Enlightenment philosophers such as Locke, Spinoza, Leibniz, and Huygens, who saw it as a medieval representation of their arguments for self-directed discovery of nature and shaping the best possible worlds.⁹

Locke and Rousseau contributed to transforming *Philosophus autodidactus* from a program of natural discovery into a general educational program. Locke outlined liberal education in *Some Thoughts Concerning Education*, emphasizing individual learning and transformation. Rousseau proposed a natural education program in *Emile* as a means of social mobilization. John Stuart Mill extended this trend to industrial societies, suggesting that

⁹ G. A. Russell, "The Impact of the *Philosophus autodidactus*: Pocockes, John Locke and the Society of Friends," in *The 'Arabick' Interest of the Natural Philosophers in Seventeenth-century England*, ed. G. A. Russell (Brill, 1994): 224–265.

investing in general education could combat poverty and overpopulation by transforming people into civilized and useful citizens. The emphasis on education also found its way into children's literature, where narratives of wandering prodigies exploring the world became common. In modern times, the search for self on a desert island symbolized a critique of modern alienation and the quest to overcome constructed psychic barriers acquired from modern culture. Thus, pleas for self-education resonated beyond philosophical discussions, arising from struggles over knowledge control between individuals and establishments.

The migration, circulation, and reception of *Hayy* illustrate the evolving social and individual control over knowledge. These historical nexuses intertwined, shifting social control from establishments to individuals and fostering the development of the "modern man" as a solitary, self-controlled individual who relies on reason and nature for knowledge. Autodidacticism emphasized the need for self-control, replacing traditional authorities with nature, reason, and natural instincts as sources of knowledge.

Away from the philosophical tradition, it is likely that *Hayy's* tale inspired the famous *Robinson Crusoe* (1719–1720). The iconic protagonist of Daniel Defoe's classic novel epitomizes the concept of autodidacticism through his remarkable journey of self-reliance and learning. Stranded alone on a remote island after a shipwreck, Crusoe is forced to adapt and survive by his own wits and ingenuity. With no formal education or guidance, he becomes his own teacher, learning essential skills, such as building shelter, hunting, farming, and navigation, through trial and error. Crusoe's relentless pursuit of knowledge and self-improvement is evident in his meticulous journal-keeping and his determination to master various disciplines. His resourcefulness and resilience in the face of adversity reflect the essence of autodidacticism, as he transforms his isolated existence into a platform for personal growth and intellectual development. Through Crusoe's story, Defoe not only celebrates the human capacity for self-education but also underscores the transformative power of learning through experience and self-discovery.

In sum, the translation of *Hayy* into Latin in the 17th century had a profound impact on European thought. The text was read by prominent philosophers and scientists, who saw it as a vindication of the power of human reason and the potential for self-directed learning. John Locke, for example, drew on Ibn Tufayl's ideas in his *Essay Concerning Human Understanding*, where he argued that the mind is a *tabula rasa*, or blank slate, that acquires knowledge through experience.

The Enlightenment's emphasis on reason, empiricism, and individual autonomy can be traced, in part, to the influence of *Hayy*. The text provided a model for the integration of scientific inquiry with philosophical and theological reflection, encouraging a holistic approach to knowledge.

In contemporary humanities, *Hayy* continues to be relevant, particularly in discussions about the nature of consciousness, the limits of human knowledge, and the relationship between science and spirituality.¹⁰ The tale's emphasis on empirical observation and rational analysis resonates with the scientific method, while its mystical dimension invites reflection on the role of intuition and transcendence in human understanding.

Re-reading *Hayy* in the Anthropocene: Introducing Neso-anthropology

The cross-cultural history of *Hayy* reveals, as Avner Ben-Zaken articulates, that "rather than a loss of control, autodidacticism highlighted the need for self-control. It shifted the mechanisms of control from society to the

¹⁰ Enrique Cerdá-Olmedo, "Ibn Tufayl (Abentofail) and the Origins of Scientific Method," *European Review* 16, no. 2 (2008): 159–67; Murad Idris, "Producing Islamic philosophy: The Life and Afterlives of Ibn Tufayl's *Hayy ibn Yaqzan* in Global History, 1882–1947," *European Journal of Political Theory* 15, no. 4 (2016): 382–403. Sofiane Maafa, "The Island of Enlightenment: An Eco-critical Analysis of *Hayy Ibn Yaqzan*," *AABHATH Review* 7, no. 1 (2022): 633–48.

individual, replacing history, tradition, and metaphysics with nature, reason, and natural instincts as the ultimate sources of knowledge.”¹¹

In this context, the interplay between utopia and insularity remains relevant to contemporary readers of the 21st century. Hayy begins his exploration of cosmology from a position of individuality, marking the first step towards environmental responsibility. The current environmental crisis underscores the tension between human beings and nature. Hayy addresses this by observing natural elements, with water emerging as the most precious. This leads Hayy to discover the heavens, emphasizing the interconnectedness of these spheres.

In the Anthropocene debates,¹² a divide exists between those advocating for metaphysical approaches and those supporting immanence – such as the use of Gaia in various discourses and Yak Hui’s concept of *Cosmotechnics*.¹³ The history of *Hayy* underscores human centrality in knowledge processes and their implications, aligning with traditional historical materialism. This resonance is significant because the humanist tradition inspired by *Hayy* is similarly cited by contemporary scholars.

Among recent conceptual proposals, *geopraxis*, introduced by Pietro Daniel Omodeo, stands out for its humanistic framework, immanence, and alignment with historical materialism.¹⁴ This concept builds upon the humanistic tradition culminating in the philosophy of praxis as understood in Gramscian terms. Geopraxis advocates a new eco-socialist humanism, which emphasizes critical reflection and historical awareness. Instead of seeking to escape our roots, it is crucial to focus on the material, ideological, and psychological structures shaping our historical being to act and transcend the given conditions. “If this past is not understood, it becomes an insurmountable ideological force.”¹⁵

Interestingly, Pico della Mirandola, a notable influence on geopraxis, argues that humanity’s dignity lies not in a predetermined essence but in the power of choice. Human beings, devoid of fixed essences, have the autonomy to shape themselves and their world. Pico’s critique of astral determinism is thus a defence of human autonomy and the ability to shape one’s future, countering the notion that human prospects are determined by objective data.¹⁶ Pico’s critique mirrors Ibn Tufayl’s challenge to radical Sufi mystics of his time. Notably, Pico cites Ibn Tufayl among the authors consulted for his *Heptaplus*. Within the humanistic tradition, Omodeo’s concept of becoming historically aware can be categorized as a form of autodidacticism. Future research should explore the similarities and differences between these approaches.

In *Hayy*, the concept of autodidacticism emerges prominently as a means by which humans, endowed with the power of reason, can pursue knowledge through first-hand experience. This reliance on experience is intricately linked to the relationship between natural elements and the heavens, with water playing a particularly significant role. Only after engaging deeply with natural elements does Hayy turn his attention to the heavens. The nexus of utopia and insularity provides the framework within which Hayy develops his individuality and his pursuit of knowledge, mediated through the connection between the microcosm and the macrocosm. This can be encapsulated by the concept of neso-anthropology.

¹¹ Ben-Zaken, *Reading Hayy*, 138.

¹² Although a contested term, Anthropocene is useful to describe the idea of the planetary transition that occurred in the 20th century. For instance, this is argued by Jan Zalasiewicz, Julia Adeney Thomas, Colin N. Waters, Simon Turner, and Martin J. Head, “The Meaning of the Anthropocene: Why It Matters even Without a Formal Geological Definition,” *Nature* 632 (2024): 980–4.

¹³ Yuk Hui, *The Question Concerning Technology in China: An Essay in Cosmotechnics* (Urbanomic, 2016).

¹⁴ Pietro Daniel Omodeo, “Geopraxis: A Concept for the Anthropocene,” *Journal of Interdisciplinary History of Ideas* 11, no. 22 (2022): 1–52.

¹⁵ Omodeo, “Geopraxis,” 40.

¹⁶ Omodeo, “Geopraxis,” 21–2.

Ibn Tufayl's intellectual legacy has permeated European literature from the Renaissance to Modernity. The most pertinent contemporary discourse where these themes are relevant is the Anthropocene debate. In this context, Omodeo's concept of geopraxis stands out for its deliberate engagement with humanistic traditions to address historical awareness and problems. This process of historical awareness mirrors a form of autodidacticism. Although Omodeo does not directly cite Hayy, there are notable resonances, including the fact that Pico della Mirandola, an author referenced by Omodeo, was influenced by Hayy. The Anthropocene provides a platform for re-examining the central themes of self-education depicted in Hayy within a new historical and philosophical framework, warranting a reinterpretation.

Unlike geopraxis, Hayy does not reject metaphysics. Instead, it incorporates metaphysical elements without necessarily adhering to an immanentist view, despite its foundation in first-hand experience. Thus, in the Anthropocene, Hayy represents a vision of humanity in which environmental responsibility is crucial but does not exclude engagement with metaphysics. This metaphysical engagement, however, diverges from the notion of religion as an opiate. In Hayy, metaphysics remains an open-ended project.

A significant distinction between Tufayl's utopia and later interpretations is that Tufayl's original work posits that theology should inform politics, whereas subsequent literary works often separate these spheres. Tufayl's work, therefore, while influential in narrative terms, does not constitute the foundational intellectual tradition of the utopian genre; rather, it inspired elements that were significantly transformed in subsequent works.

Re-reading Tufayl in the context of the Anthropocene offers a novel perspective, suggesting that theological concerns can inform political considerations. This approach is innovative, distinguishing itself from attempts to restore or conserve existing traditions. This is the challenge that Tufayl's work presents in our current age of crisis. In the context of utopian tradition, this represents a new avenue for exploration, but it remains a topic for political and theological specialists to address further.

In contrast to current approaches to the environmental crisis and the Anthropocene – such as Yuk Hui's transcendentalism in *cosmotechnics*, Renn's *geo-anthropology*, and Pico's humanism in Omodeo's *geopraxis* – the novelty of Hayy lies in its metaphysical possibilities. This distinction sets neso-anthropology apart from geopraxis and geo-anthropology. Further exploration is needed to fully understand how Hayy's emphasis on self-discovery proposes a form of metaphysics that avoids becoming an opiate-like system, instead contributing to a responsible approach to environmental stewardship.

Conclusion

The article has considered *Hayy Ibn Yaqzan* as a significant work that bridges historical and contemporary discourses on knowledge, metaphysics, and environmental responsibility. It underscores the relevance of re-reading the text in the Anthropocene, suggesting that Hayy* offers a unique perspective on the interplay between utopia, insularity, and autodidacticism. The study distinguishes the concept of "neso-anthropology" from other contemporary approaches to the environmental crisis, such as geopraxis and geo-anthropology, by emphasizing its metaphysical possibilities without reducing them to mere ideology. The paper advocates for further exploration of *Hayy Ibn Yaqzan*'s themes in the context of modern environmental thought, proposing that the narrative's focus on self-discovery and metaphysical inquiry can contribute to a more responsible approach to ecological challenges.

Neso-anthropology, as proposed in this article, is a framework for analysing the philosophical and ecological significance of islands within the broader context of human knowledge and environmental responsibility. The term "neso" comes from "nesology," which is the study of islands, and it incorporates aesthetic, geopolitical, and anthropological aspects of insularity.

Key Aspects of Neso-Anthropology

Neso-anthropology works by using the island as a metaphor and analytical tool to explore how isolated environments can reveal broader truths about human existence and our responsibilities toward the planet. It suggests that studying islands and their unique ecosystems, alongside the philosophical narratives associated with them, can offer valuable lessons in sustainability, self-sufficiency, and the integration of knowledge across different domains. This approach encourages a holistic understanding of environmental issues, blending empirical observation with philosophical reflection, and ultimately aims to foster a more responsible and informed engagement with the natural world.

1. The Island as a Microcosm

In *Hayy Ibn Yaqzan*, the island setting serves as a microcosm for the world, allowing the protagonist, Hayy, to engage in a process of self-discovery and knowledge acquisition. The island's isolation makes it an ideal setting for exploring the relationship between the individual and the cosmos, emphasizing how a confined environment can mirror larger ecological and philosophical systems.

2. Interconnection Between Humanity and Nature

Neso-anthropology highlights the interconnectedness of human beings with their natural environment. In *Hayy Ibn Yaqzan*, Hayy's development – from basic sensory perception to philosophical contemplation – illustrates how direct engagement with nature leads to a deeper understanding of both the physical world and metaphysical truths.

3. Autodidacticism and First-Hand Experience

A central theme in neso-anthropology is the emphasis on autodidacticism, or self-directed learning. The framework values knowledge gained through personal experience and interaction with one's surroundings, rather than relying solely on external authorities. This mirrors the way Hayy, isolated on the island, learns about the natural world and the divine through observation and experimentation.

4. Integration of Metaphysics and Ecology

Unlike some contemporary approaches to environmental studies that may focus purely on material or immanent perspectives, neso-anthropology integrates metaphysical elements. It explores how philosophical inquiries into the nature of existence and the divine can inform and enhance our understanding of environmental responsibility.

5. Application to the Anthropocene

In the context of the Anthropocene – a term denoting the current geological age characterized by significant human impact on the planet – neso-anthropology offers a way to rethink humanity's relationship with nature. It proposes that the insights from *Hayy Ibn Yaqzan* can be applied to modern ecological challenges, advocating for a harmonious vision of human-nature relationships.