Invisible landscapes. Historical research and groundwater

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Le acque sotterranee rappresentano una componente fondamentale delle riserve idriche del pianeta. Nel corso dell'età contemporanea, questa risorsa è divenuta sempre più rilevante nel determinare i modi di produzione, i processi di modernizzazione e le forme di insediamento urbano, assumendo spesso connotati contradditori: a volte fattore complementare, altre volte risorsa del tutto alternativa rispetto ai progetti di infrastrutturazione idrica a larga scala promossi dallo Stato e dalle tecnocrazie idrauliche. Nonostante questi elementi, la storiografia italiana e quella internazionale hanno finora dedicato scarsa attenzione alle acque sotterranee come distinto oggetto di studio. Ciò impone, sotto l'aspetto metodologico, un dialogo serrato con altri comparti scientifico-disciplinari, in direzione di categorie come Antropocene, ciclo idrosociale e *shadow waters*, e un'attenzione alla storiografia internazionale, in particolare a quei contesti nazionali o subcontinentali che si sono confrontati con la presenza di grandi acquiferi sotterranei.
Parole chiave: acque sotterranee, Antropocene, ciclo idrosociale, shadow waters, Stato idraulico, tecnocrazie idriche, storiografia

Groundwater is an essential part of the planet's water reserves. In modern times, this resource has become increasingly important in determining production methods, modernisation processes and urban settlement patterns, often with contradictory connotations: sometimes a complementary factor, other times a completely alternative resource to the large-scale water infrastructure projects promoted by the state and hydraulic technocracies. Yet, Italian and international historiography has so far paid little attention to groundwater as an object of study in its own right. From a methodological point of view, this requires a close dialogue with other scientific disciplines, involving categories such as the Anthropocene, the hydrosocial cycle and shadow waters, as well as a focus on international historiography, looking in particular at the national or subcontinental contexts that have had to deal with the presence of large underground aquifers.
Key words: groundwater, the Anthropocene, hydrosocial cycle, shadow waters, hydraulic state, hydrocracies, historiography

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Groundwater as an object of historiographical research

Groundwater is the invisible part of the hydrological cycle and an essential part of the planet's water reserves. Stored in so-called aquifers, bodies of water enclosed in the rocky layers of the subsoil,[1] its quantity is about twenty-five times greater than that of surface water.[2] In modern times, this specific resource has become increasingly relevant in sustaining and determining production methods, rural modernisation processes and urban settlement patterns. Yet, Italian and international historiography — with some notable exceptions — has so far paid little attention to groundwater as an object of study in its own right, focusing instead on the relationship between human societies and surface water resources, especially the arrangement and exploitation of river courses.[3]

In the last decades of the twentieth century, a number of Italian historical studies have attached great importance to the role of water in the rural development of modern and contemporary society, considering irrigation and land reclamation as vectors of socio-economic transformation and the productive restructuring of the territory.[4] Attention has also been given to the use of water as an energy resource, looking at the progressive ideologies and technocracies that, between the nineteenth and twentieth centuries, saw hydroelectric and industrial transformation as a necessary condition for the country's economic

[1] As is known, these are layers of sand, gravel and limestone that can absorb rain and surface water that penetrate, flow and are deposited there by gravity, depending on the composition, inclination and articulation of the rocks.

[2] Bjørn Kløve et al., *Groundwater dependent ecosystems. Part I: hydroecological status and trends*, "Environmental Science & Policy", 2011, n. 14, pp. 770-781. While there is uncertainty about the data, we know that more than three-fifths of the world's fresh water is stored in glaciers and 13.5 per cent in groundwater aquifers. The remaining 0.5 per cent is contained in lakes, rivers, soil moisture and the atmosphere. See J.A.A. Jones, *Global Hydrology. Processes, Resources and Environmental Management*, Essex, Longman, 1997.

[3] There is a rich historiography on the exploitation and regimentation of rivers. International contributions include Donald Worster, *Rivers of Empire. Water, Aridity, and the Growth of the American West*, New York-Oxford, Oxford University press, 1985; Christof Mauch, Thomas Zeller (eds.), *Rivers in History. Perspectives on Waterways in Europe and North America*, Pittsburgh, University of Pittsburgh Press, 2008; Sara B. Pritchard, *Confluence. The Nature of Technology and the Remaking of the Rhône*, London, Harvard University Press, 2011. On Italy, see Stefania Barca, *Enclosing Water. Nature and Political Economy in a Mediterranean Valley, 1796-1916*, Cambridge, White Horse Press, 2010; Giacomo Bonan, *Le acque agitate della patria. L'industrializzazione del Piave (1882-1966)*, Rome, Viella, 2020.

[4] See Teresa Isenburg, *Investimenti di capitale e organizzazione di classe nelle bonifiche ferraresi, 1872-1901*, Florence, La Nuova Italia 1971; Luciano Segre, *Agricoltura e costruzione di un sistema idraulico nella pianura piemontese: (1800-1880)*, Milano, Banca commerciale italiana 1983; Piero Bevilacqua, Manlio Rossi-Doria (eds.), *Le bonifiche in Italia dal '700 ad oggi*, Rome-Bari, Laterza 1984; P. Bevilacqua, *Le rivoluzioni dell'acqua. Irrigazioni e trasformazioni dell'agricoltura tra Sette e Novecento*, in Id. (ed.), *Storia dell'agricoltura italiana in età contemporanea*, vol. I, *Spazi e paesaggi*, Venice, Marsilio, 1989, pp. 255-278.

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and productive modernisation.[5] Urban history and the history of territory, on the other hand, have insisted on the multiple dimensions of living, dead, natural, artificial, navigable and runoff water, paying particular attention to the dynamics of the so-called 'sanitary city': the construction of water networks, aqueducts and sewage systems, and the municipalisation of these services.[6] Finally, water has been at the centre of environmental history, which has questioned its dimension as a natural resource in relation to the emergence of urban forms of incorporation and metabolism, industrial pollution, catastrophes and the progressive decrease in the availability of drinking water.[7]

Of all these approaches, which have contaminated each other and whose boundaries are not always easy to distinguish, urban history has perhaps insisted most on groundwater, whereas others have focused mainly on river history and land reclamation. Moreover, a holistic approach to watershed management, aimed at analysing the relations between human societies and the hydrological cycle as a whole, has only recently gained ground in Italian and international historiography.[8] This would make it possible to overcome sectional approaches that are limited to *artificial spaces* — such as administrative boundaries — and *arbitrary timescales*, that is, the pre-eminence that many historians have given to the specific moment of surface water flow, to the detriment of other phases of the hydrological cycle, like the subterranean one.

The relationship between humans and groundwater has been decisive not only because it has enabled societies to meet the challenges posed by climate and hydrological conditions. It has also underpinned processes of rural and urban modernisation, the development of unique forms of culture and power, the explosion of social and political conflicts, the emergence of specific forms of administrative power and, finally, the dawn of a dramatic environmental and social crisis caused by the over-exploitation and pollution of groundwater aquifers, with very serious consequences for surface water and climate change as a whole.[9]

[5] See Giuseppe Barone, *Mezzogiorno e modernizzazione. Elettricità e bonifica nell'Italia contemporanea*, Turin, Einaudi, 1986; Piero Bevilacqua, *Environmental intervention and water resource management in the history of the Mezzogiorno*, "Modern Italy", 2000, n. 1, pp. 63-71.

[6] See Augusto Ciuffetti, *L'acqua nella storia*, "I frutti di Demetra", 2007, n. 14, pp. 37-46; Lucia Nuti, *Le alterne fortune dell'acqua nella storia del territorio*, "Storia urbana", 2009, n. 125, pp. 5-9.

[7] See Simone Neri Serneri, *Incorporare la natura: storie ambientali del Novecento*, Rome, Carocci, 2005; Ercole Sori, *Per una storia del metabolismo urbano*, "Storia urbana", 2007, n. 116, pp. 5-6; Gabriella Corona, S. Neri Serneri (eds.), *Storia e ambiente: città, risorse e territori nell'Italia contemporanea*, Rome, Carocci 2007; Federico Paolini, *Firenze 1946-2005. Una storia urbana e ambientale*, FrancoAngeli, Milan, 2014.

[8] See Giacomo Parrinello, *Per una storia ambientale della circolazione delle acque nel bacino del Po. Note su una ricerca in corso*, "Altronovecento", 2016, n. 28.

[9] See Esha Zaveri et al., *Invisible water, visible impact. Groundwater use and Indian agriculture under climate change*, "Environmental Research Letters", 2016, n. 8, pp. 1-13.

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From a methodological point of view, the relative scarcity of historical reconstructions requires an in-depth dialogue with other scientific disciplines, starting with hydrogeology, historical geography and political ecology. The aim of this article is also to broaden the view to international historiography, in particular to those fields that have shown an interest in large underground aquifers: from the Ogallala or High Plains Aquifer in the United States via the Great Artesian Basin in Australia to India.[10] I will offer a first overview of the available methodological-analytical tools to understand their usefulness and relevance for the Italian case.

Groundwater: between hydrogeology and history

Our ability to tackle the shortage of surface water by using groundwater dates back to ancient times and developed in different regions of the world: from Europe to China, from Arabia to the Mediterranean basin. Various techniques were used to extract this water from the depths of the earth, also in relation to the specific types of aquifers, which can be divided into phreatic and artesian aquifers.

The former consist of 'unenclosed' aquifers — that is, not covered by impermeable upper layers — which subject these waters to the same pressure as the atmosphere at the surface. This prevents them from rising spontaneously to ground level if reached by a well or through drilling. Generally located in the more superficial parts of the subsoil, phreatic aquifers are more exposed to pollutants and infectious agents from the surface, often leading to unhealthy conditions. However, it is precisely because they are more easily accessible that this kind of water has been the subject of traditional constructions, such as simple wells, from which water was drawn by human or animal powered norias, fountains and the *qanāt*. The latter were widespread mainly in the Mediterranean and date back to Roman or Arab times. They consisted of short vertical tunnels, similar to wells, connected by a single horizontal underground channel and dug at a slight slope to collect the water flowing underground.[11]

[10] These three contexts obviously do not cover all territorial areas affected by large aquifers, but they seemed the most promising in terms of the historiographical production and circulation in international literature. See, respectively, John Opie et al., *Ogallala. Water for a Dry Land*, Lincoln, University of Nebraska Press, 2018 (third edition); Joseph M. Powell, *Plains of promise, rivers of destiny: water management and the development of Queensland 1824-1990*, Brisbane, Boolarong Publications, 1991; Tushaar Shah, *Taming the Anarchy. Groundwater Governance in South Asia*, London, Routledge, 2009.

[11] See Andrew M. Watson, *The Arab Agricultural Revolution and Its Diffusion, 700-1100*, "The Journal of Economic History", 1974, n. 1, pp. 8-35; Ramón Martínez-Medina et al., *Research on qanats in Spain*, "Water History", 2018, n. 10, pp. 339-355 and Majid L. Khaneiki, *Qanat and territorial cooperation in Iran*, "Water History", 2018, n. 10, pp. 185-206.

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By contrast, artesian aquifers are bodies of water that are usually deeper — hence healthier — than phreatic aquifers, in which water runs through an inclined plane between two impermeable rock layers and is consequently subject to strong hydrostatic pressure, as if it were flowing through a pipe. The peculiarity of this condition lies in the fact that, once a well is dug deep enough to reach the aquifer, the water rises spontaneously and its upward force can sometimes cause it to gush out even beyond the surface of the ground, thus avoiding the need for norias or expensive and fragile drainage pumps. This phenomenon, which describes the functioning of so-called 'salient waters', was typical of wells dug since the late Middle Ages in the Duchy of Modena and the Artois region in northern France — hence the term 'Modenese' or 'artesian' wells. The exploitation of artesian waters was 'rediscovered' in the first decades of the nineteenth century, mainly thanks to advances in drilling techniques — making it possible to reach and exceed depths of 500 metres — and hydrogeological knowledge in France and England, which spread with extraordinary rapidity to the rest of Europe and the United States.[12] In fact, between the eighteenth and nineteenth centuries, the search for new sources of water supply had become fundamental to the needs of a rapidly growing European population, to supply water to cities and support the progress of the industrial revolution.[13] Ultimately, we could say that a contemporary history of groundwater began with the European rediscovery of artesianism in the 1920s.

Finally, we must consider one last type of groundwater: 'fossil water'. These non-renewable water reserves were formed thousands or millions of years ago as a consequence of the normal hydrological cycle, only to be trapped and sealed underground by powerful telluric currents, without the possibility of being further 'recharged' from the surface. In international historiography, the best-known examples of the exploitation of this specific type of resource concern non-European aquifers, such as large portions of the above-mentioned Ogallala and the Great Artesian Basin in Australia.[14] Discovered at the end of the nineteenth century, these two huge fossil water reservoirs were subjected to very high rates of exploitation, especially in the

[12] I am referring to the works of the French Abdon Garnier, an engineer of the Corps des Mines, and Louis-Étienne Héricart de Thury, a member of the *Académie royale des sciences*, who were instrumental in the start of an 'artesian industry' in France and its dissemination in Europe. See A.-J.-F. Garnier, *L'art du fontainier sondeur et des puits artésiens*, Paris, Huzard, 1822; L.-É. Héricart de Thury, *Considérations géologiques et physiques sur la cause du jaillissement des eaux des puits fores ou fontaines artificielles*, Paris, Bachelier, 1829.

[13] See F.E. Bruce, *Approvvigionamento idrico*, in Charles Singer (ed.), *Storia della tecnologia*, vol. 5, *L'età dell'acciaio. Circa 1850-1900*, Turin, Boringhieri, ed. 1982, pp. 562-568.

[14] On the Ogallala, see J. Opie et al., *Ogallala. Water for a Dry Land*, cit.; William Ashworth, *Ogallala Blue. Water and Life on the High Plains*, New York, W.W. Norton and Co., 2006; Geoff Cunfer, *On the Great Plains. Agriculture and Environment*, College Station, Texas A&M University Press, 2005. On the Great Artesian Basin, see the aforementioned J.M. Powell, *Plains of promise, rivers of destiny*, cit.

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middle decades of the twentieth century, so much so that they were brought to the brink of irreversible consumption.

The Anthropocene, the hydrosocial cycle and groundwater

An environmental history of groundwater should start with a discussion of the notion of the Anthropocene, its potential and its epistemological limits.[15] Over the last 20 years, the Anthropocene has developed into a theoretical space where scientific knowledge and humanistic disciplines have been able to compare their respective protocols and adopt shared languages, contributing to overcoming the nature-culture subdivision.[16] The analysis of the degrees of change in carbon dioxide emissions and their stratification in the soil and subsoil has led mankind to consider the human species as a climatic and geological force, especially in the wake of phenomena such as modern colonialism and the early stages of industrial revolutions. The claim that nature and its laws remain indifferent to human action has gradually been abandoned.

On the other hand, some scholars have challenged the idea that humans, as a species, have an unclear responsibility, drawing attention to the role that social and racial inequalities have played in triggering the climate and ecological crises. As a result, alternative concepts such as 'Capitalocene' or 'Wasteocene' have been proposed.[17] Gaining awareness of a specific geological and climatic role of humanity, but above all the due consideration that different class and social status conditions produce different ecological footprints, has offered a starting point for historicising the relationship between society and the hydrosphere, also with regard to the theme of water[18] In the last two decades,

[15] See Christophe Bonneuil, Jean-Baptiste Fressoz, *La terra, la storia e noi. L'evento Antropocene*, Rome, Treccani, 2019 (original edition Paris, Éditions du Seuil, 2013). For the historical debate on the topic, see Gabriella Corona*, Natura e società: una sfida per gli storici*, "Meridiana", 2021, n. 100, pp. 35-56; Salvatore Adorno, *Storia e Antropocene*, "Mestiere di Storico", 2020, n. 1, pp. 67-72; Giacomo Bonan, *Gli storici e l'Antropocene: narrazioni, periodizzazioni, dibattiti*, "Passato e presente", 2018, n. 104, pp. 129-143.

[16] See Helmuth Trischler, *The Anthropocene. A Challenge for the History of Science, Technology, and the Environment*, "Naturwissenschaften, technik und medizin", 2016, n. 24, pp. 309-335.

[17] See, among others, Jason W. Moore (ed.), *Anthropocene or Capitalocene? Nature, history, and the crisis of capitalism*, Oakland, Pm press, 2016; S. Barca, *Forces of reproduction. Notes for a counter-hegemonic Anthropocene*, Cambridge, Cambridge University Press, 2020; Marco Armiero, *Wasteocene. Stories from the global dump*, Cambridge, Cambridge University Press, 2021.

[18] See the study by Andrea Zinzani, *L'Ecologia politica come campo di riconcettualizzazione socio-ambientale: governance, conflitto e produzione di spazi politici*, "Geography Notebooks", 2020, n. 3, pp. 33-50. See also Tom Perreault et al., *The Routledge Handbook of Political Ecology*, London-New York, Routledge, 2015; Erik Swyngedouw, *Social Power and the Urbanization of Water: Flows of Power*, Oxford, Oxford University Press, 2004; David Harvey, *Justice, Nature and the Geography of Difference*, Wiley Blackwell, 1996.

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English-language historiography has particularly insisted on the notion of the hydrosocial cycle or 'waterscape'; an intense exchange with political ecology, social geography, anthropology and sociology has considerably broadened the epistemological potential and multiplied the possible use of this notion. It consists mainly of understanding the connections between water flows and power relations, looking in particular at the mechanisms of water governance and their impact on social balances and ecological reproduction processes.[19] This connection has thus far been analysed from different perspectives: for example, by looking at the role that the market and capitalist production have played in shaping urban environments, or the emergence and consolidation of intellectual, ideological, economic and political patterns that have favoured unequal forms of appropriation and access to water.[20]

A part of English-language historiography has focused on two prevalent themes. The first has examined the role of hydraulic infrastructure policies and the bureaucratic-administrative governments that presided over them in constantly favouring specific social interests or mediating between private and publicist visions of water use.[21] A second aspect concerns the relationship between the water end uses and hydrological cultures, in urban as well as rural and colonial contexts. In this vein, a predominantly culturalist reading of modes of water appropriation has, for example, emphasised the socially constructed nature of concepts such as 'scarcity'. This does not mean denying the hydrological and climatic constraints that underlie droughts and famines, but rather understanding the extent to which and how the very concept of scarcity is historically derived from specific hierarchies between civil, irrigation and industrial uses. The construction of the concept of 'scarcity' would ultimately serve to legitimise forms of appropriation and discrimination in accessing water.[22]

When applied to groundwater, these indications have various methodological implications. It is not just a matter of highlighting the geological impact that drilling has had on underground aquifers, as the American hydrogeologist W. Todd Jarvis did when he asked what the real purpose is of policies to protect underground water resources, whether 'groundwater [is] stored and

[19] See Jamie Linton, Jessica Budds, *The hydrosocial cycle. Defining and mobilizing a relational-dialectical approach to water*, "Geoforum", 2014, n. 57, pp. 170-180; Jamie Linton, *What is Water? The History of a Modern Abstraction*, Vancouver, UBC Press, 2010; Karen J. Bakker, *A political ecology of water privatization*, "Studies in Political Economy", 2003, n. 70, pp. 35-58.

[20] See Jessica Budds, *Whose scarcity? The hydrosocial cycle and the changing waterscape of La Ligua river basin, Chile*, in Michael K. Goodman, Maxwell T. Boykoff, Kyle T. Evered (eds.), *Contentious Geographies: Environment, Meaning, Scale*, Ashgate, Aldershot, pp. 59-68.

[21] See Ruth A. Morgan, *The Anthropocene as Hydro-social Cycle. Histories of Water and Technology for the Age of Humans*, "Journal of the International Committee for the History of Technology", 2017, n. 23, pp. 36-53.

[22] Ruth A. Morgan, James L. Smith, *Premodern Streams of Thought in Twenty-First-Century Water Management*, "Radical History Review", 2013, n. 116, pp. 105-129, here p. 106.

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captured by wells […] or the "container", the aquifer that stores groundwater'.[23] Above all, it is necessary to understand how — in modern times — an inextricable and ephemeral relationship has developed between the exploitation of surface water reserves and the use of groundwater, where the two elements have at times alternated, at other times integrated. The greater anthropic pressure on this or that stage of the hydrological cycle has depended on the type of response that very precise economic and social conditions have given to environmental and territorial constraints, starting with the existing power relations between different classes and groups. Other factors have followed from this: the emergence of hierarchies in the allocation of water flow rates in favour of civil, irrigation or industrial uses; the construction of cultural systems in which scarcity has become the regulating and legitimising criterion for access that is often unequal or inequitable; the role of public policies in supporting the dynamics of private appropriation or in correcting them to the benefit of mixed systems, directed at public principles of collective access. For example, some strands of urban history and the history of territory have studied groundwater from these perspectives, showing how, between the nineteenth and twentieth centuries, landowners in the Palermo area made massive use of artesian wells to enhance citrus production, only to then reject both the hypotheses of consortium management of water resources and aqueduct projects; as a matter of fact, such measures would have weakened their control over groundwater and, therefore, over modernisation processes.[24]

Shadow water, the invisible resource: knowledge, techniques and beliefs

The culturalist strand of English-language historiography, especially Australian historiography, has developed the concept of 'shadow water' proposed by historical geography in the wake of Val Plumwood's reflections on so-called 'shadow places'. The Australian ecofeminist philosopher has insisted on the 'dematerialisation' of places, highlighting how contemporary cultures, practices, beliefs and traditions are increasingly detached from the material and environmental conditions that make life possible.[25] Losing track of this means fuelling social behaviour and expectations of consumption that are often unsustainable and unrealistic, and that consider neither the work done by other social groups nor the ecological limits of the biosphere itself. Eco-socialist

[23] W. Todd Jarvis, *Contesting Hidden Waters. Conflict resolution for groundwater and aquifers*, London-New York, Routledge, 2014, p. 18.

[24] See, for example, Francesco D'Amaro, *Il mercato dell'acqua. Politica, istituzioni e conflitti nel distretto agrumicolo di Bagheria (XX sec.)*, "Meridiana", 2011, nn. 71-72, pp. 271-291.

[25] See Val Plumwood, *Environmental Culture. The Ecological Crisis of Reason*, London, Routledge, 2002.

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and ecofeminist thought has taken this conflict on in terms of the opposition between the sphere of production and that of the reproduction of life, and the tendency for the latter to be subjected to the former.[26] From this perspective, the dematerialisation of political and production structures would cancel any idea of agency, of individual and collective responsibility but also of the role played by the biogeochemical sphere, ultimately pushing us 'to misunderstand our lives, and thus engender a false consciousness that justifies appropriation'.[27]

Building on Plumwood's insights, some sectors of historical geography and political ecology have interpreted the hydrosocial cycle through the concept of shadow water.[28] In other words, the attention has turned to the political, social and cultural processes that have led to the privileging of the use of certain types of water (e.g. river, lake, spring, phreatic or artesian water, etc.) at the expense of others, and to certain forms of appropriation at the expense of others, which have meanwhile become marginal. Shadow waters can be conceptualised in a 'vertical' way, considering that surface water has historically been exploited and regulated more than groundwater, but also in a 'horizontal' way, since certain forms of water resource use — a demonstration of the *genius loci* of local or indigenous communities (e.g. cisterns, fountains, wells, qanāt, etc.) — have gradually been abandoned to make way for policies implemented on a larger scale, from dams to aqueducts. A historical approach to the concept of shadow water can thus help to reconstruct the ways in which knowledge and technical innovations have emerged and become dominant, supporting particular power structures, technological and energy levels, and forms of control over water resources.

The implications for groundwater are obvious; these resources are, by their very nature, difficult to perceive. During the nineteenth and twentieth centuries, this 'invisibility' not only posed technical and theoretical problems in understanding groundwater circulation, determining the location and depth of aquifers and measuring flow rates, but it also fuelled — for a long time — the perception that aquifers were supposedly perennial or infinite nature, a harbinger of serious ecological and climatic effects.[29]

The development, in the nineteenth and twentieth centuries, of knowledge and technology aimed at mapping and exploiting aquifers seems to have played a dual, contradictory role: to better understand how water circulates underground but also to provide an incentive for their ever more intensive exploitation. From the first half of the nineteenth century, demographic, manufac-

[26] S. Barca, *Forces of reproduction*, cit.

[27] V. Plumwood, *Environmental Culture*, cit., p. 142.

[28] See Jessica McLean et al., *Shadow waters: making Australian water cultures visible*, "Transactions of the Institute of British Geographers", 2018, n. 43, pp. 615-629. On shadow places, see Val Plumwood, *Shadow places and the politics of dwelling*, "Australian Humanities Review", 2008, n. 44, pp. 139-150.

[29] For an analysis of the Indian case, see E. Zaveri et al., *Invisible water, visible impact*, cit.

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turing and urban development, along with changes in habits and domestic consumption, required a considerable increase in the volumes of water needed to meet the growing and diversified needs of society, including civil, agricultural and industrial uses.[30] This gave a strong impetus to the advancement of hydrological techniques and knowledge, more refined and less tied to empirical and amateur practices, whose scientific development was also fuelled by the eighteenth- and nineteenth-century 'great flowering' season of geology.[31] Hydrogeology, the so-called science of groundwater, thus emerged, which developed in different ways across the country and responded to different stimuli and incentives from local and state authorities.[32] After all, action was required to respond to the serious problems of urban hygiene, which developments in bacteriology attributed to sewage and putrid water, especially with the spread of diseases such as typhus and cholera.[33]

London and Paris were among the first European cities to adopt an 'organicist' vision of water flows, building underground networks aimed at creating a circularity between white and black water, between water supply and disposal, capable not only of supplying water to homes but also of removing sources of infection from neighbourhoods through the discharge of water.[34] This is also why the intensive use of available springs close to the cities proved to be increasingly insufficient, not to mention unsafe, and it became necessary to add new flows from more distant sources by building urban aqueducts and digging deeper wells.[35] Consequently, major advances were made in hydraulic engineering throughout the nineteenth century, with the development of pumps, turbines and hydraulic rams.[36] The serialisation of these innovations and their international dissemination thanks to universal exhibitions and ministerial

[30] See Francesca Socrate, *Borghesie e stili di vita*, in Giovanni Sabbatucci, Vittorio Vidotto, *Storia d'Italia*, vol. 3, *Liberalismo e democrazia 1887-1914*, Rome-Bari, Laterza, 1995, pp. 362-442.

[31] See Martin Guntau, *The emergence of geology as a scientific discipline*, "History of Science", 1978, n. 4, pp. 280-290; François Ellenberger, *Histoire de la géologie*, t. 2, *La Grande Éclosion et ses prémices, 1660-1810*, Paris, Lavoisier, 1994.

[32] Until now, Italian historiography has been mainly interested in the development of hydrology as a science of hydrographic basins. See Giacomo Parrinello, *Charting the Flow: Water Science and State Hydrography in the Po Watershed, 1872-1917*, "Environment and History", 2017, n. 1, pp. 65-96. See Nicholas Howden, John Mather (eds.), *History of Hydrogeology*, New York, Taylor & Francis Group, 2013.

[33] See Roger Schofield et al. (eds.), *The Decline of Mortality in Europe*, Oxford, Clarendon Press, 1991.

[34] See Guido Zucconi, *La città contesa. Dagli ingegneri sanitari agli urbanisti (1885-1942)*, Milan, Jaca Book, 1989. On the British case (one of the most studied ones), see Carlo F. Antonelli, *Acque sporche. Londra e il "Metropolitan Board of Works". 1855-1865*, "Storia urbana", 1992, n. 61.

[35] See F.E. Bruce, *Approvvigionamento idrico*, in C. Singer, *Storia della tecnologia*, cit., pp. 562-568.

[36] J. Allen, *Ingegneria idraulica*, in C. Singer, *Storia della tecnologia*, cit., pp. 532-561.

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competitions gradually changed how groundwater was drawn from the subsoil, while the expansion of geology and hydrogeology allowed for an increasingly accurate identification of aquifers.

These developments have fostered a better understanding of the interactions between the hydrological cycle and the geological arrangement of the subsoil, supporting the creation of professional bodies and water technocracies on a municipal or state basis, as has happened in recent decades. As a result, the popular knowledge and practices of the *pozzàri* and *fontanieri* — heirs to ancient techniques for building wells and fountains — soon became 'spectral' practices, marginalised or subjected to the new technologies.

It is true that some of these practices proved more resistant to processes of assimilation, most notably dowsing. In modern times, the conviction that some people — equipped with the so-called divining-rod — could sense the presence of water underground has at various stages been reconsidered and influenced by scientific suggestions and hypotheses such as 'mesmerism', the discovery of biological electricity, the belief that minerals and water emanated radiation that could be perceived by man and, last but not least, spiritualism and late nineteenth- and early twentieth-century idealism.[37] Although dowsing was mainly practised by the lower classes, in Italy its use was supported by prominent figures such as Bernardino Lotti and Paolo Vinassa de Regny, the doyens of Italian geology.[38] It permanently failed to establish itself as a scientific discipline close to the Second World War, following lively debates and international congresses throughout the 1930s.

There is one last aspect that obstructed the full development and vulgarisation of groundwater extraction processes. In fact, over the centuries, water became associated with a sacred symbolism that was often linked to sanctity and calendric rituals, through which societies and communities sought to discipline and explain a hostile nature, exorcising phenomena such as disease, scarcity, drought, aridity, overflows and floods.[39] For instance, water gushing out from the ground has long been associated with the miracles of saints, who allegedly made fresh and healthy springs gush water. Other times, popular folklore attributed an evil power to the water of rivers, springs and foun-

[37] Studies on dowsing have mainly focused on the link with discoveries in electromagnetism between the eighteenth and nineteenth centuries. See Luca Ciancio, *La resistibile ascesa della rabdomanzia. Pierre Thouvenel e la "Guerra di Dieci Anni"*, "Intersezioni", 1992, n. 2, pp. 267-290; Lucia De Frenza, *I sonnambuli delle miniere. Amoretti, Fortis, Spallanzani e il dibattito sull'elettrometria organica e minerale in Italia (1790-1816)*, Florence, L.S. Olschki, 2005. On the link between dowsing, positivism, spiritualism and idealism, see Simona Cigliana, *Spiritismo e parapsicologia nell'età positivistica*, in *Storia d'Italia. Annali*, vol. 25, *Esoterismo*, Turin, Einaudi, 2010, pp. 521-546.

[38] See Donata Brianta, *Europa mineraria. Circolazione delle élites e trasferimento tecnologico, secoli XVIII-XIX*, Milan, FrancoAngeli, 2007.

[39] See Tonino Ceravolo, *Sacralità dell'acqua, possessione e culto dei santi*, in V. Teti (ed.), *Storia dell'acqua,* Rome, Donzelli, 2003, pp. 99-112.

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tains, often guarded by beasts and spirits that constantly had to be killed or won over.[40] It is no surprise, then, that secularisation processes were linked to extraction processes, as emerges from the records, which reveal the fears of local populations in the face of the first drilling operations, which were looked upon with suspicion if not as a sacrilegious action.

'Knowledge that disinhibits'

We can better understand the reasons for this contradictory role of knowledge and technology if we consider the criticism of the notion of technical rationality and so-called reflexive thinking. According to Danilo Zolo, the development of scientific knowledge has made it possible to extend the range of possible experiences for *homo sapiens* but without increasing their certainty, because 'as theoretical knowledge expands and, accordingly, practical skills grow, new horizons open up, laden with unforeseen problems, which stimulate more risky attempts at explanation, less guaranteed by previous knowledge'.[41] This incremental process tends to increase, rather than decrease, the uncertainty and complexity in which human societies are immersed.

These types of considerations have helped to problematise the basic misunderstandings inherent in the paradigm of sustainable development and the idea that technical rationality itself — which is partially responsible for the current ecological crises — may not only restore compromised ecosystem balances but also push towards new horizons of development. Philosophers such as Jean-Baptiste Fressoz have highlighted how nineteenth-century positivism or twentieth-century productivism was by no means unaware of the limits and distortions of 'progress'. Nevertheless, nineteenth- and twentieth-century societies were supposedly incapable of implementing their reflexivity because of the multiple logics behind the 'normalisation' of risk, which was based on a complex apparatus of technical rules, procedures and narratives that ended up producing a 'knowledge that disinhibits', destined to make technological modernity acceptable.[42] It is in this sense that Fressoz and historians such as Stefania Barca have recently advanced positions that are critical of the linear visions and great diachronic oppositions suggested by Beck and Giddens's sociology of risk, according to which postmodern reflexivity would, instead, allow present-day societies — unlike those of the past — to limit and reabsorb the abnormal effects of scientific and technological development.

[40] See Paolo Sorcinelli, *Storia sociale dell'acqua. Riti e culture*, Milan, Bruno Mondadori, 1998.

[41] Danilo Zolo, *Il principato democratico. Per una teoria realistica della democrazia*, Milan, Feltrinelli, 1992, pp. 30-31.

[42] See Jean-Baptiste Fressoz, *L'apocalypse joyeuse. Une histoire du risque technologique*, Paris, Le Seuil, 2012.

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Fossil energy, fossil water

As we have seen, the structuring of technical-scientific knowledge and the development of technological innovations have also encouraged the indiscriminate exploitation of groundwater resources, not only because of the easier and cheaper access to drilling and pumping machinery, especially since the 1950s and 1960s, but also as a result of the progressive implementation of rural electrification and the replacement of coal by oil as the main fossil energy source. Starting from the aforementioned case study of Ogallala, Green and Watson have thus highlighted the role of fossil energy sources in accelerating the extraction of water from underground aquifers.[43] Green pointed out that, between the nineteenth and twentieth centuries, improvements in drilling techniques and the shift from windmills to the construction of fossil fuel pumps changed the very meaning of irrigation, seen increasingly 'as a means of increasing production rather than as a last resort against crop failure'.[44] Drawing on the 'social metabolism' paradigm, Watson also stressed that the shift from labour-intensive to fossil fuel-intensive irrigation in the United States allowed farmers to make extraordinary productivity gains as early as the mid-twentieth century, transforming the American central plains into a non-renewable landscape. Fossil fuel was used to exploit the fossil water of the Ogallala, which was extracted and converted, in turn, into a 'significantly larger energy assembly', that is, the biomass of crops and livestock.[45]

Yet, it cannot be said that the changes induced by the non-renewable torsion of the American High Plains did not emerge from the earliest stages of this profound transformation. We need only think of the so-called Dust Bowl, a series of sandstorms that struck this part of the United States in the 1930s, caused by a combination of over-exploitation of the soil due to cultivation transformations brought about by underground irrigation and periods of extraordinary drought, generating strong waves of migration.[46] Nor did the exhaustion of the High Plains' underground aquifers — which became clear as early as the mid-1970s — prompt all states affected by the presence of these fossil waters to take the same measures; instead, they responded to the same systemic problem with fragmented approaches and different policies.

[43] See Andrew M. Watson, *"The Single Most Important Factor". Fossil Fuel Energy, Groundwater, and Irrigation on the High Plains, 1955-1985*, "Agricultural History", 2020, n. 4, pp. 629-663; Donald E. Green, *Land of Underground Rain. Irrigation of the Texas High Plains, 1910-1970*, Austin, University of Texas Press, 1973.

[44] D.E. Green, *Land of Underground Rain*, cit., p. 147.

[45] A.M. Watson, *"The Single Most Important Factor"*, cit., p. 630 onwards.

[46] Paul Bonnifield, *The Dust Bowl: Men, Dirt, and Depression*, Albuquerque, University of New Mexico Press, 1978.

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Groundwater, property rights and the nation-state

The reflection developed so far requires an examination of the role of powerful actors, public policies and legal and administrative systems. During most of the nineteenth century, especially in countries like France and Italy, the influence of the Napoleonic civil law tradition categorically linked groundwater to the "surface right", on the basis of which ownership of the land extends to the subsoil. Adopted by the Italian Civil Code of 1865, this approach excluded underground aquifers from public forms of exploitation and protection, creating what has become known as the 'boundary dilemma'.[47] This refers to the discord between the highly mobile nature of a resource flowing underground and the fixed and artificial nature of land allotment or administrative and legal boundaries — an aspect that not only weakened aquifer protection systems but also made the exploitation practices of these resources conflicting.[48] For example, the multiplication of drilling projects in the same area has often led to the depletion, interruption or exhaustion of the flow rates of neighbouring wells that were previously drilled, and in some cases also to a reduction in the flow rates of rivers.

From the end of the nineteenth century onwards, especially in the Italian case, the emergence of the state as a regulator and builder of large-scale water systems, starting with the Apulian Aqueduct and the recourse to hydroelectric power, contributed to further changing the framework.[49] Public interventionism led to the emergence of a social and economic polarisation between surface and underground water extraction, formalised by the Bonomi decrees of 1916,[50] which provoked a conflict — sometimes overt, sometimes hidden — between solutions based on the strategy of large reservoirs and aqueduct transfers for electro-irrigation purposes, on the one hand, and those based mainly on the exploitation of local resources, including groundwater, on the other. In this sense, future research should seek to capture the different articulations between the modernisation attempts associated with large public water systems and those reflected in private and proprietary approaches.[51]

[47] W. Todd Jarvis, *Contesting Hidden Waters*, cit.

[48] On the Italian case, see Federico Caporale, *Acque pubbliche ed acque private tra Otto e Novecento*, in Massimo Galtarossa, Laura Genovese (eds.), *La città liquida. La città assetata. Storia di un rapporto di lunga durata*, Rome, Palombi, 2014, pp. 253-272.

[49] For a definition of 'hydraulic civilisation', see Karl A. Wittfogel, *Oriental Despotism. A Comparative Study of Total Power*, New Haven, Yale University Press, 1957.

[50] See Carlo G. Lacaita (ed.), *Bonomi e Omodeo. Il governo delle acque tra scienza e politica*, Manduria, Lacaita, 2010.

[51] See Luigi Masella, *Acquedotto pugliese. Intervento pubblico e modernizzazione nel Mezzogiorno*, Milan, FrancoAngeli, 1995. See also my own study, *Il governo delle acque in Puglia. Dagli anni Settanta a oggi*, published in Anna Lucia Denitto, *Gli assi portanti. La Puglia. L'acqua*, Naples, Guida, 2012, pp. 101-161, which used the Apulian case to examine the attempt of the water technocracies involved in this extraordinary intervention to find a balance between the exploitation of surface water and that of groundwater.

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In our case, the starting point is the debate that developed from Wittfogel's well-known theses on the characteristics of the 'hydraulic civilisation', according to which the construction and management of large water infrastructures in the past led to the centralisation of power, the emergence of influential technocratic bodies and, not least, the configuration of new territorial hierarchies between central, marginal and submarginal regions, centred on the division between water providers and receivers.[52] Moreover, international historiography has repeatedly highlighted how production systems based on the exploitation of groundwater have been associated with lower rates of regulation or with an explicit decision by public authorities to refrain from managing their dynamics; large 'appropriators', in particular, have benefited from this attitude, as in the cases of the Kings River Valley, South-East Asia and the Conca d'Oro in Sicily.[53] Indeed, after having made the necessary investments, well owners maintained arbitrary, continuous and free access to a precious resource, especially in arid regions, and often managed to discriminate against other users and control the productive uses of the water. Especially in the countryside, the shift from 'appropriators' to 'expropriators' gave well owners a conditioning power over other social classes, controlling and directing modernisation processes.[54] Drilling also enabled a kind of 'autonomous' and individual — or 'anarchic', according to Shah — irrigation, while the aqueduct strategy meant that farmers were subjected to the state or had to cooperate within collective bodies.

It is therefore understandable that the role of the public sector has been viewed with suspicion, both in its regulatory function and in that of promoting large infrastructures. The regulatory modalities applied in the past have, in fact, included the introduction of minimum distances when drilling wells, scheduling time frames for irrigation, setting quantitative limits on draining, paying incentives for efficient use and measures that, from time to time, denied new beneficiaries access to the resource or forced old drillers to share their wells.[55] On the other hand, partnerships, management bodies and water schemes involved increasing shares of collective control, as well as forms of fiscal and financial contributions.

[52] See Thierry Ruf, *Le façonnage des institutions d'irrigation au XXe siècle, selon les principes d'Elinor Ostrom, est-il encore pertinent en 2010?*, "Natures Sciences Sociétés", 2011, n. 4, pp. 395-404.

[53] See, respectively, Kate A. Berry, *Fleeting fame and groundwater. Isolation and water in Kings River Valley, Nevada*, "Water History", 2009, n. 1, pp. 59-74; T. Shah, *Taming the Anarchy*, cit.; F. D'Amaro, *Il mercato dell'acqua*, cit.

[54] In this regard, see the observations of Alfred G. Cuzán, *Appropriators versus Expropriators. The Political Economy of Water in the West*, in Terry L. Anderson (ed.), *Water Rights. Scarce Resource, Allocation, Bureaucracy, and the Environment*, San Francisco, Ballinger, 1983, pp. 13-43.

[55] Rebecca S. Roberts, *Groundwater Management Institutions*, in David E. Kromm, Stephen E. White, *Groundwater Exploitation on the High Plains*, Lawrence, University Press of Kansas, 2021 (first ed. 1992), pp. 88-109.

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Hence, during the twentieth century and at various stages, a tension between bureaucratic centralisation and the political autonomy of peripheries developed with regard to aqueduct systems and local underground waters; this tension was also visible in the emergence of water management models based on geographical and purely water-related criteria and no longer just administrative ones. It has been emphasised, for example, how the adoption of the hydrographic basin led to the legitimisation of technical-scientific bodies in the state administration, the so-called water bureaucracies or "hydrocracies", often to the detriment of local representative institutions.[56]

In addition, state intervention in water management — especially when based on the construction of large aqueduct systems — also had the potential to transfigure traditional territorial hierarchies, reorganising national and regional space in an essentially dualistic scheme between tributary and beneficiary territories. If, as has been observed, the rise of models based on hydrographic scales, major infrastructure transformations and the role of technocracies has often led to the emergence of state and nation-building processes in the exploitation of rivers,[57] we could instead argue that the modes of exploitation and use centred on local and underground waters have, if anything, produced territorialised identities, closely correlated with localisms and narrative constructions of place, and with the suggestions of territorial 'primates' derived from archaeology, speleology and mining.[58]

A possible periodisation of the Italian case

It is possible to historicise groundwater, especially in the Italian case, if we combine at least four issues: the role of the state, technocracies and administrative bodies that have presided over hydraulic policies; the degree of technical-scientific development in relation to political choices; economic-productive dynamics and secularisation processes as prerequisites for social consensus on the appropriation of groundwater resources; and, finally, energy transformations and their impact on water harvesting techniques and the use of aquifers. These elements allow us to make a periodisation into at least three main phases, with inevitably porous caesuras and transitions, namely between the mid-nineteenth century and the present day, but which can be further distinguished — especially on a regional and territorial basis.

[56] Giacomo Bonan, *Riflessi sull'acqua. Ricerca storica e biografie fluviali*, "Contemporanea", 2019, n. 2, pp. 317-328, here p. 326; François Molle et al., *Hydraulic bureaucracies and the hydraulic mission. Flows of water, flows of power*, "Water Alternatives", 2009, n. 2, pp. 328-349.

[57] Tricia Cusack, *Riverscapes and National Identities*, Syracuse, Syracuse University Press, 2010; Dorothy Zeisler-Vralsted, *Rivers, Memory, and Nation-Building. A History of the Volga and Mississippi Rivers*, New York-Oxford, Berghahn Books, 2014.

[58] See Angela Quattrucci, *Mondi sotterranei e mito: il fantastico e il magico nell'arte mineraria e metallurgica*, "Ricerche storiche", 2018, n. 3, pp. 15-38.

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Between the mid-nineteenth century and the First World War, the construction of the sanitary city and the agricultural irrigation function represented the two main — albeit not exclusive — conditions for the exploitation of the artesian aquifers.[59] This phase is mainly characterised by the predominantly privatistic approach of the Civil Code of 1865 to the issue of subsoil rights, overlapped by administrative centralisation and the convergence of the agrarian crisis and modernisation, two phenomena that gradually strengthened the state's role in the water sector against a background of bureaucratisation processes aimed at identifying and classifying public waters.[60] Groundwater had to contribute to urban metabolism and irrigation, which was necessary for the productive modernisation of the countryside. Moreover, changes in the role of public authorities in the urban context came about when water services were municipalised and with municipal socialism itself, leading to the creation of urban aqueducts and sewers; the liberal state provided the impetus for the construction of extensive aqueduct systems such as the Acquedotto Pugliese.[61]

Yet, between the nineteenth and twentieth centuries, as industrial development took precedence, the water-energy binomial became increasingly dominant over the original needs of sanitation and irrigation.[62] First oil exploration and then the great hydroelectric transformation projects affected the cataloguing, regulation and use of national water resources, with specific impacts on the condition of groundwater. An important sign was the decision, in March 1911, to give public support to oil exploration on national territory, a protectionist regulation that sparked opposition from socialists and liberalists, in particular from Einaudi, who polemicised against the 'state drillers'.[63] The regulation of oil exploration not only accelerated the development of drilling and extraction techniques, which inevitably had an impact on hydrogeological techniques and knowledge but also anticipated a boom in the role of the state during the war and the consequent strengthening of the Italian industrial appa-

[59] S. Neri Serneri, *Storia dell'ambiente e città contemporanea*, cit.

[60] Guido Melis, *Storia dell'amministrazione italiana. 1861-1993*, Bologna, il Mulino, 1996, especially from p. 123 onwards; Alice Ingold, *Cartografare le acque come risorse «naturali» nell'Ottocento. La* Carta idrografica d'Italia *e gli ingegneri delle miniere*, "Contemporanea", 2010, n. 1, pp. 3-26.

[61] There is a large body of literature on the municipalisation of water services. Here, it is worth mentioning Giorgio Bigatti, *Strategie di approvvigionamento e gestione dei servizi idrici nell'Italia liberale*, "Ricerche storiche", 2000, n. 3, pp. 659-681.

[62] See Teresa Isenburg, *Acqua e Stato. Energia, bonifiche, irrigazione in Italia fra 1930 e 1950*, Milan, FrancoAngeli, 1981.

[63] Paolo Macini, Ezio Mesini, *La prima Legge petrolifera nazionale: Luigi Einaudi e i "Trivellatori di Stato" (1911)*, in *UNMIG 1957-2017, 60° dell'Ufficio Nazionale Minerario per gli Idrocarburi e le Georisorse*, 2017, pp. 52-53. On hydroelectric power, see Giacomo Parrinello, *Systems of Power: A Spatial Envirotechnical Approach to Water Power and Industrialization in the Po Valley of Italy, ca. 1880-1970*, "Technology and Culture", 2018, n. 3, pp. 652-688.

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ratus.[64] In fact, water meant more and more electrical conversion, a new energy source that could free the country from coal imports. This trend was decreed in the Bonomi reform of 1916 that made the main national rivers — which could be used for hydroelectric purposes — public, while secondary tributaries, groundwater and spring sources remained private.[65]

The subjugation of water to the demands of energy and industrial development thus opened up a dualism between surface and underground water sources that would manifest itself with particular intensity from the 1920s and 1930s onwards, until the entire 30 years of the so-called "great acceleration" of the post-war era. Indeed, during this long period, land reclamation, colonisation and irrigation remained important elements of national water policies.[66] On the one hand, groundwater legislation was intensified, for example by Royal Decree No. 1972 of December 1921 on the granting of subsidies for drilling and the subsequent "Testo unico sulle acque" of December 1933. These measures were designed to make groundwater the main source of irrigation, initially to resolve the high level of social conflict and then with a more explicit focus on modernising the countryside in order to make the rural areas more competitive. Despite concerns about the 'depletion' of aquifers, which had already emerged at the end of the 1920s, this mixture of objectives would be picked up again after the Second World War, especially in southern Italy. On the other hand, surface water was subjected to the goal of energy transformation, mainly at the insistence of electrical industrialists, who managed to steer the state's main legislative measures in this direction.[67] This phase, which shows some continuity between the Fascist period and the post-war era, gradually came to an end during the 1960s and 1970s. This was initially a result of the gradual decline of the hydroelectric regime due to the availability of oil on the global

[64] See Francesco Gerali et al., *Historical study of geosciences and engineering in the oilfields of the Emilia-Romagna region in the socio-economic context of post-Unitarian Italy (1861-1914)*, "Geological Society", *History of the European Oil and Gas Industry*, 2018, n. 465, pp. 305-332.

[65] See Renato Giannetti, *La conquista della forza. Risorse, tecnologia ed economia nell'industria elettrica italiana (1883-1940)*, Milan, FrancoAngeli, 1985; Giovanni Bruno, *Capitale straniero e industria elettrica nell'Italia meridionale (1895-1935)*, "Studi Storici", 1987, n. 4, pp. 943-984; *Storia dell'industria elettrica in Italia*, vol. 1, *Le origini: 1882-1914*, edited by Giorgio Mori, Rome-Bari, Laterza, 1992.

[66] See Mauro Stampacchia, *Ruralizzare l'Italia! Agricoltura e bonifiche tra Mussolini e Serpieri (1928-1943)*, Milan, FrancoAngeli, 2000; Rolf Petri, *Le campagne italiane nello sviluppo economico*, in Jordi Canal, Gilles Pécout, Maurizio Ridolfi (eds.), *Sociétés rurales du XX siècle. France, Italie et Spagne*, Rome, École française de Rome, 2004, pp. 75-104.

[67] See Bruno Bezza (ed.), *Energia e sviluppo. L'industria elettrica italiana e la Società Edison*, Turin, Einaudi, 1986; *Storia dell'industria elettrica in Italia*, vol. 2, *Il potenziamento tecnico e finanziario, 1914-1925*, edited by G. Mori, Rome-Bari, Laterza, 1993; vol. 3, *Espansione e oligopolio: 1926-1945*, edited by Giuseppe Galasso, Rome-Bari, Laterza, 1993; vol. 4, *Dal dopoguerra alla nazionalizzazione, 1945-1962*, edited by Valerio Castronovo, Rome-Bari, Laterza, 1994.

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market at decreasing prices, followed by the definitive end of the season of the "hydraulic state", builder of vast intersectoral water systems, especially in the South.

Over the past decades, the industrial/irrigation dichotomy between surface and underground water resources has gradually weakened, as water resources as a whole have been reduced to a tool for disposing of civil or industrial waste and for cooling production plants at very low prices, thus ensuring considerable savings in investment.[68] With the introduction of the concession, the state relinquished its role as arbiter, while high rates of exploitation and pollution have turned groundwater into an ecological problem.

Translated by Andrea Hajek

[68] Salvatore Adorno, Simone Neri Serneri (eds.), *Industria, ambiente e territorio: per una storia ambientale delle aree industriali in Italia*, Bologna, Il Mulino, 2009.

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