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Fig. 1
The Yofyros River flowing through the urban landscape of Heraklion, Crete. Adapted from Armoutaki (2022).

Tracing Wetness

Micro Stories of Invisible Water Systems in Semi-Arid Cultural Landscapes

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Examining the interconnections between natural water cycles and human processes shaped over time by social, cultural, religious, historical, political and economic influences offers valuable insights into traditional and present-day water systems. Often, these insights lie beyond visible water structures and require in-depth site investigations to bring them to light. Three cases that do not have distinguished names, unlike the more widely recognised water-rich systems, are explored in semi-arid landscapes: the Jaguaribe River Basin, Brazil; the Communal Fountain System in Cyprus; and the Water System in Heraklion, Crete, Greece. The micro stories approach reveals lesser-known and often overlooked dimensions of water use and stewardship in these regions. These narratives offer fresh perspectives on large-scale water management, uncovering the hidden human flows that shape invisible water systems. By tracing wetness in addition to mapping water, we discuss the added value of bridging knowledge gaps through diverse storytellers, inspiring water-sensitive approaches attuned to local contexts.

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'There is no such thing as dry land. Wetness is everywhere to some degree. It is in the seas, clouds, rains, dew, air, soils, minerals, plants, animals. The sea is very wet; the desert less so.' (Mathur & Da Cunha, n.d.)

Water connections are not always conspicuous. Cultural landscapes are sometimes partially determined by visible waterworks and other elements. However, the traces show the entanglement of human processes and water cycles, revealing rich water-related cultural expressions. These processes may even challenge the water management logic established by the dominant way of life during the Anthropocene (Escobar, 2016).

Water is more than a mere landscape component, a shared and contested resource, or a mechanism of power and control. It embodies deities and cultural practices, witnessing countless stories of human and nonhuman communities across time and the medium through which many of these narratives are penned. When it comes to water, one should dare to blur the line between land and water, theory and praxis, formal design decisions, and informal practices. Exploration should extend beyond visible water bodies and resist confinement to conventional investigative methods.

In addition to the soil, topography, geomorphology, vegetation, climate, and spatial configuration of human-made systems, stories offer insights into how humans and non-humans perceive and engage with water. An ethereal thread weaves diverse narratives surrounding water, comprising social, cultural, religious, and economic influences. This thread can be seen as an abstract system intertwined with natural and cultural water cycles, which unlike conventional systems, is not defined by clear connections between its components. This forms an invisible water system that is not easily pinpointed or mapped.

What terrain is better for exploring these hidden water narratives than the fleeting shallow waters of semi-arid regions worldwide? Where are these invisible water systems more abundant than those in places where water is scarce? By taking three semi-arid locations as illustrative cases and analysing them in the Circular Water Stories lab, this chapter addresses the challenge of demonstrating how to collect and represent data on invisible water systems. The goal is to inspire transdisciplinary action, spanning design, policymaking, and community initiatives anchored in water-related local knowledge, memories, and practices.

Exposing invisible water systems requires broadening our perspectives by examining these cases through the lens of wetness, a concept adopted for navigating semiarid landscapes. Wetness is often used as a synonym for moisture (e.g., in soil) or in opposition to dryness and drought. Mathur and da Cunha bring the term to the design disciplines when arguing that we inhabit not land or water but a 'ubiquitous wetness' (Mathur & Da Cunha, 2020). This perspective softens the dichotomy between land and water, and invites us to reflect that no strict limits exist between various water bodies and land, except those imposed by humans.

This chapter is organised into three parts. First, it provides a brief overview of the chosen approach—micro-stories—within the constellation of existing explorations that incorporate the cultural dimension of water systems. Next, we present three cases from semi-arid regions around the globe: 1) Jaguaribara, a small town separated from its river in northeastern Brazil, 2) communal street fountains in western Cyprus, and 3) traces of water systems between the Yofyros and Keratos Rivers on the Greek island of Crete. These cases are complementary in terms of their drivers, pressing

influences, and the unique nature of their micro-systems of wetness, inspiring different representation techniques. Ultimately, the chapter reflects on showcased examples, discussing the potential for revealing invisible water systems and the advantages of the adopted techniques.

We hope our contribution inspires future approaches that encompass sociocultural, economic, political, and religious influences shaping water-related contexts. Landscapes are inherently situated, and those undertaking the challenge of investigating water stories on-site will benefit from staying open to exploratory methods—gathering information locally and sharing it globally.

CULTURAL WATERSCAPE EXPLORATIONS

Cultural landscapes carry humans' 'unwitting autobiography,' where traces of human presence are imprinted onto them while fashioning natural landscapes (Lewis, 1976; Kolen & Renes, 2015), paving the way for biographical or narrative approaches (Samuels, 1979). Culture has been entangled in the landscape since its earliest definition (Sauer, 1925)—a land shape made up of physical, social, and mental aspects rooted in a deep sense of place attachment (Verschuure-Stuip, 2021).

Integrating local and cultural aspects aligns with contemporary perspectives on sustainable development. In 2010, culture was recognised as a fourth pillar of sustainable development, alongside people, planet, and profit, and was framed as the overarching dimension of economic, environmental, and social sustainability (Astara, 2014). Acknowledging the cultural dimension as a foundation for sustainability reflects a 'rehabilitation of local expertise' and an appreciation of 'ancestral skills' both essential for fostering community resilience over time (Blond, 2015). However, in the realm of water management, the primary drivers of water supply and drainage over the past few centuries have been largely economic and, more recently, ecological. This suggests that the sociocultural sphere has yet to be adequately represented in sustainable water management (Sharp, 2017).

Bibliographical approaches to research water systems have been adopted to document their richness by highlighting the often-overlooked cultural aspects and facilitating dialogue among professionals, public authorities, and communities, thereby encouraging multidisciplinary engagement (Bobbink & Loen, 2020). Julia Watson's investigations into 'low-energy, low-impact, and low-cost' water infrastructures have amplified local voices and helped disseminate 'traditional ecological knowledge,' which has endured for centuries and may offer answers to contemporary climate change challenges (Watson, 2019). In her exploration of land-water boundaries, Wolff (2021) conducted documentary and field research, developing a method for building landscape literacy through synthetic text and drawing, which conveys the story of San Francisco Bay to a wider audience. All these approaches navigate effectively within both academia and professional practice, fostering knowledge sharing across disciplines and landscape contexts and inspiring local actions driven by community empowerment and supported by political goodwill.

Building on the above, we seek to enhance existing methods of cultural waterscape exploration by using micro-stories as a tool to gather, analyse, and communicate data on invisible water systems. Micro stories gained notoriety in the design disciplines through the work of Secchi & Viganò (2009), who used them to illustrate a new planning structure for Antwerp. In this chapter, micro-stories are short narratives collected in the field on a

very small scale through informal interviews and observations. Represented by a blend of drawings, photo collages, and annotations, they voiced the diverse stories portrayed in each case. Altogether, micro stories are essential for understanding each locality's invisible water system.

WADING IN WETNESS JAGUARIBARA

The Brazilian semi-arid region in the northeast of the country experiences only two distinct seasons: dry and wet. The local fauna and flora have adapted to these conditions, enduring recurrent droughts dating back to the early years of Portuguese colonisation. Since the 1950s, dams, reservoirs, and water channels have been constructed to store and transport freshwater. In this context, the largest water reservoir in Latin America was built in the middle of the Jaguaribe¹ River Basin. The construction of the Castanhão Reservoir, as it is known, required the resettlement of the small town of Jaguaribara, which had been located on the banks of the Jaguaribe River since the 18th century. The original territory of Jaguaribara was submerged, and a new town was rebuilt farther from the river that had been given its name.

Wetness tracing in Jaguaribara began with aerial images. In the dry season, before the water evaporates, percolates, or is fully consumed, it is collected in low-lying areas, leaving visible marks on the surface. The amoeboid shapes of dried ponds create an unusual pattern, alongside the geometric aquaculture tanks along the riverbanks, the winding water channels, and the meandering river. The new town stands out amidst range-land, with farmlands stretching to the north and south. Dominating the scene is the vast Castanhão Reservoir, in contrast to the arid surroundings, where resilient native vegetation clings to moisture in thalwegs. (Figure 2)

These diverse forms of water frame the region's microstudies (Veras Morais, 2020). To navigate them, we must first recall traditional agricultural practices along riverbanks, where the inhabitants of Jaguaribara relied on river plains for their livelihoods. They fished with nets, cultivated crops along the banks, and grazed nearby cattle. Relocating the town away from the river disrupted the primary means of production. The resettlement plans included promises to modernise and expand fishing, agriculture, and grazing, aiming to boost the region's economic development. However, the conditions and solutions imported from other areas have struggled to adapt to the local landscape and culture. As a result, the town has entered an economic recession and is now facing a population decline.

Fig. 2
(left) Satellite image of the Castanhão Reservoir, the Jaguaribe River and Jaguaribara (adapted from Google, 2020-e); (right) visible wetness (adapted from Veras Morais, 2020).

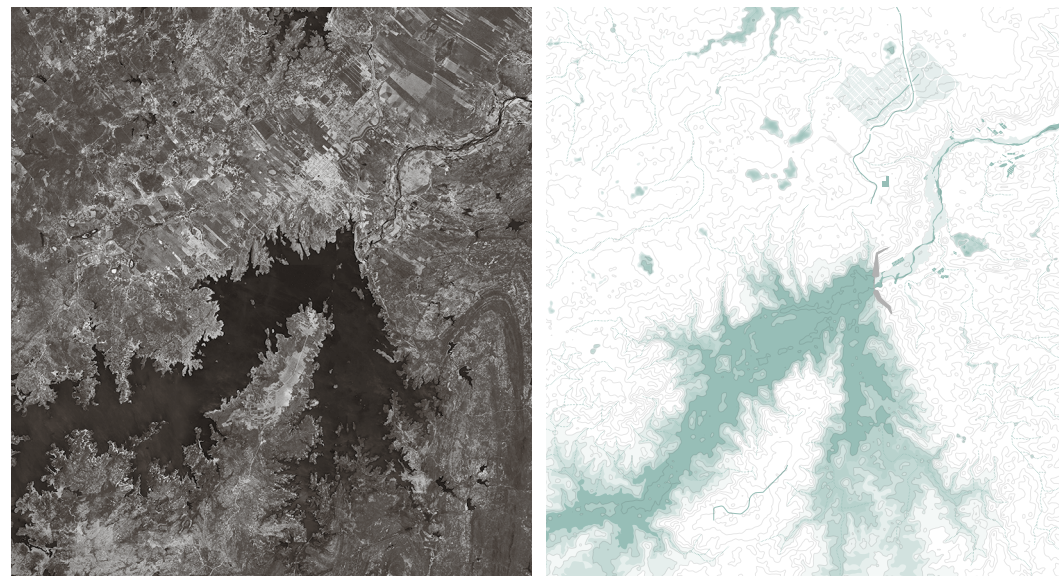
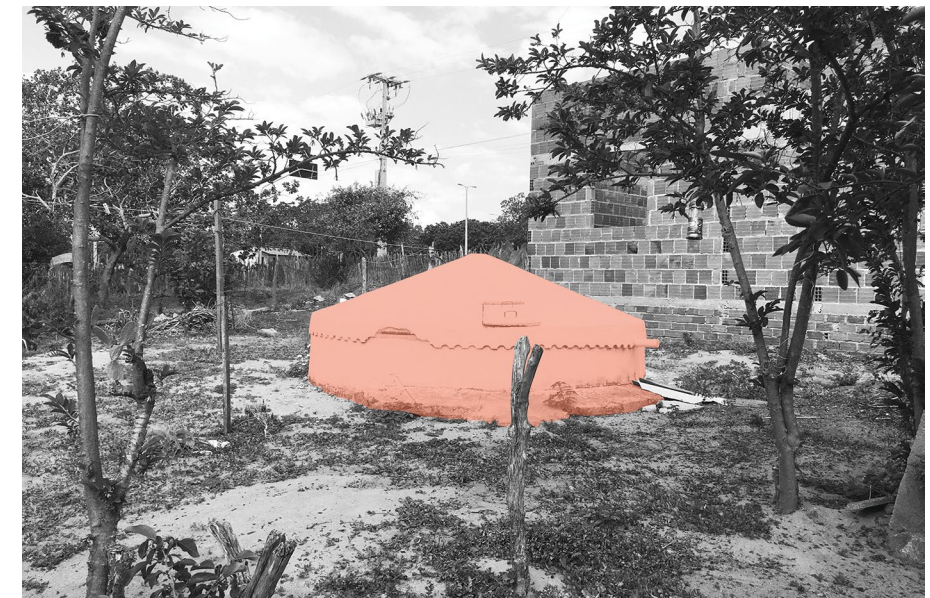


Fig. 3
Rainwater harvesting in Jaguaribara. The cistern is semi-buried to keep the water at a mild temperature until it can be manually extracted and purified for consumption. Adapted from Veras Morais (2020).



The residents were thus compelled to shift from cultivation along the banks of the Jaguaribe to farming in areas where soil retains moisture, favoring low-lying points and roadsides where rainwater is collected. The itinerant farmer prepares the land by burning the existing vegetation just before the rainy season, sowing seeds, and planting seedlings with the first raindrops. Native vegetation also provides the essential moisture for grazing. Shepherds led their cattle to graze on grasses and shrubs in vacant lots and at the town's edges, unaware that this contributes to long-term desertification.

In the new town, houses are well connected to the water supply system, yet residents often avoid using expensive tap water. Instead, they rely on rainwater harvesting, an alternative that is widely used throughout Brazil's semi-arid region. Water was collected from the roof gutters and stored in semi-buried concrete cisterns in back gardens (Figure 3). Making collected water safe for consumption is a laborious process. Water is drawn using a bucket, boiled to kill microbes and bacteria, and then stored in a clay vessel before filtration. The clay vessel and filter cooled the water to six degrees Celsius. The most common cistern has a capacity of 16,000 litres, which is sufficient for the annual water needs of a household of up to four people. However, given irregular rainfall, many families resort to unregulated wells. Just outside the town, the newly irrigated farm plots highlight the shortcomings of Jaguaribara's resettlement plan. Exotic grasses with faster growth rates are planted to feed livestock, but require frequent and substantial watering. Water was pumped from the waterways and sprayed into air. However, low water availability and high energy consumption make this process costly, ultimately reducing farm productivity. Spraying water is also counterintuitive in regions where 88% of the water loss occurs through evapotranspiration.

Fish farming was initially a promising strategy in the resettlement plan of the new Jaguaribara. In the first two years at the new location, a cage aquaculture system was established within the reservoir, making the town the region's largest producer of tilapia, a popular freshwater fish. However, fluctuations in water pressure and temperature due to strict water flow control, combined with an excess of organic matter in a water-renewal-limited environment, ultimately led to the collapse of aquatic life in that sector of the river. Hatchery tanks located downstream of the dam, initially used to breed tilapia for the cage aquaculture system, now offset the environmental imbalance caused by the dam. Water is continuously pumped from the river to fill the excavated tanks, returning through a drain that regulates the water level and ensures constant renewal. However, the hormones added to the fish feed are released back into the river. (Figure 4)

These micro-stories bring to light an often-overlooked narrative surrounding the construction of the dam and the town’s resettlement. With its 6.7 billion cubic metres of storable water, Castanhão was intended to stabilise water supply fluctuations across the region. However, the human flows within this system reveal the nuanced impacts of large-scale top-down approaches on communities in vulnerable locations. The micro stories also highlight the gaps in the Jaguaribara resettlement plan—a project focused on ‘profit’ but less attentive to ‘people’ and ‘planet,’ and largely overlooking local culture and landscape conditions. Altogether, these micro stories form a regionally specific narrative that echoes familiar experiences worldwide, in which autocratic landscapes are reshaped by ambitious projects that are often cloaked in democratic processes. (Figure 5)

BRIEF CHRONICLES OF CYPRIOT COMMUNAL FOUNTAINS

No more than a month separates wet winters from long, hot, and dry Cypriot summers. Rainfall was unevenly distributed, with heavy concentrations in the Troodos Mountains that tapered off as it reached the coast. Since the island’s earliest history, drought and water scarcity have posed challenges. Over the centuries, various conquerors have also sought solutions, adapting their knowledge of water management to the island’s limited resources. Over time, countless techniques and approaches have been implemented, many of which remain visible and effective.

In the 1940s, while Cyprus was still a British Crown colony, a water system was established to supply domestic water to rural villages and irrigate agricultural fields. This irrigation system consists of open channels that carry river water to fields. Given the high temperature and significant evaporation, additional systems are required to maintain the water supply. Furrows were used to ensure even distribution, supporting an efficient and cost-effective surface irrigation method.

Supplying potable water to rural villages requires a feat of engineering. In Pomos village, spring water was drawn directly from the ephemeral Teratsia source on the Paphos Mountain. After filtering naturally through layers of Cypriot limestone, it was temporarily stored in an enclosed tank at the base of a mountain. From there, it travelled through underground pipes,

Fig. 4
Vernacular fish farming tanks downstream of the Jaguaribe River. Fry and fingerlings are collected with fishing nets and a sieve called *puçã* and kept in cages, shielded from birds by nets tied to wooden posts. Adapted from Veras Morais (2020).



Fig. 5
From top to bottom: (1) Collection and purification of rainwater stored in a cistern through boiling and filtration using a clay filter; (2) pasture and agriculture on vacant land within the urban area and its surroundings (left); (3) traditional farming practices once common along the riverbanks (right); (4) channelling and pumping water from the river to supply irrigated farms; (5) pumping and channelling water from the river to aquaculture tanks, with the water returning to the river through a drainage system. Adapted from Veras Morais (2020).

winding its way over considerable distances to reach an elevated concrete tank near the village. This system freed families from the daily burden of hauling water jugs on donkey back. Nevertheless, the spring water did not reach the tap of the household. Instead, it was directed towards communal street fountains in the village’s main square. (Figure 6)

Every rural village had at least one communal street fountain, providing drinking water during the rainy months from October to March. While men worked in the fields and cultivated crops to sustain their families, it was the women who gathered household water each morning. At the fountain, they filled their large, bulb-shaped terracotta jugs, known as *stamna*, and hoisted them onto their shoulders to walk home. Water was stored in even larger terracotta vessels called *pitharia*, from which it was drawn as needed throughout the day. (Figure 7)

Morning gatherings around the fountain were vital for the women. These daily rituals offered more than just water; they were moments of sharing news, exchanging wisdom, lending support, and building connections. In a society that is both patriarchal and private, these gatherings foster a strong sense of female solidarity and community.

Over time, the water system was modernised with the introduction of household piped water. While most communal street fountains have been deactivated, a few remain in operation and continue to attract those seeking inexpensive, pure, and chemical-free water. Whether in use or not, fountain structures still stand in most coastal villages, serving as reminders of this historic water system, a legacy echoed in local architecture. The Cypriot lime-stone arches in the fountains—a reinterpretation of the English four-centered arch—were replicated at house entrances and interior rooms. Ornamental backyard faucets, designed to resemble smaller versions of these fountains, became a common feature, paying homage to the old system.

The female narratives within this often-overlooked yet essential part of the water system may be more deeply rooted in Cypriot culture than one might imagine. Many people retain terracotta jugs and large vessels in their homes as decorative pieces, sometimes unknowingly preserving their history as vital water elements in this invisible branch of the system. Traces of women’s roles in the Communal Fountain System also appear in lullabies, underscoring the enduring cultural significance of women as water bearers—a living memory woven into the collective imagination of Cypriot Villages. (Figure 8)

Fig. 6
Communal fountain
in the streets of a rural
village in Cyprus.
Adapted from
Georgiadou (2023a).

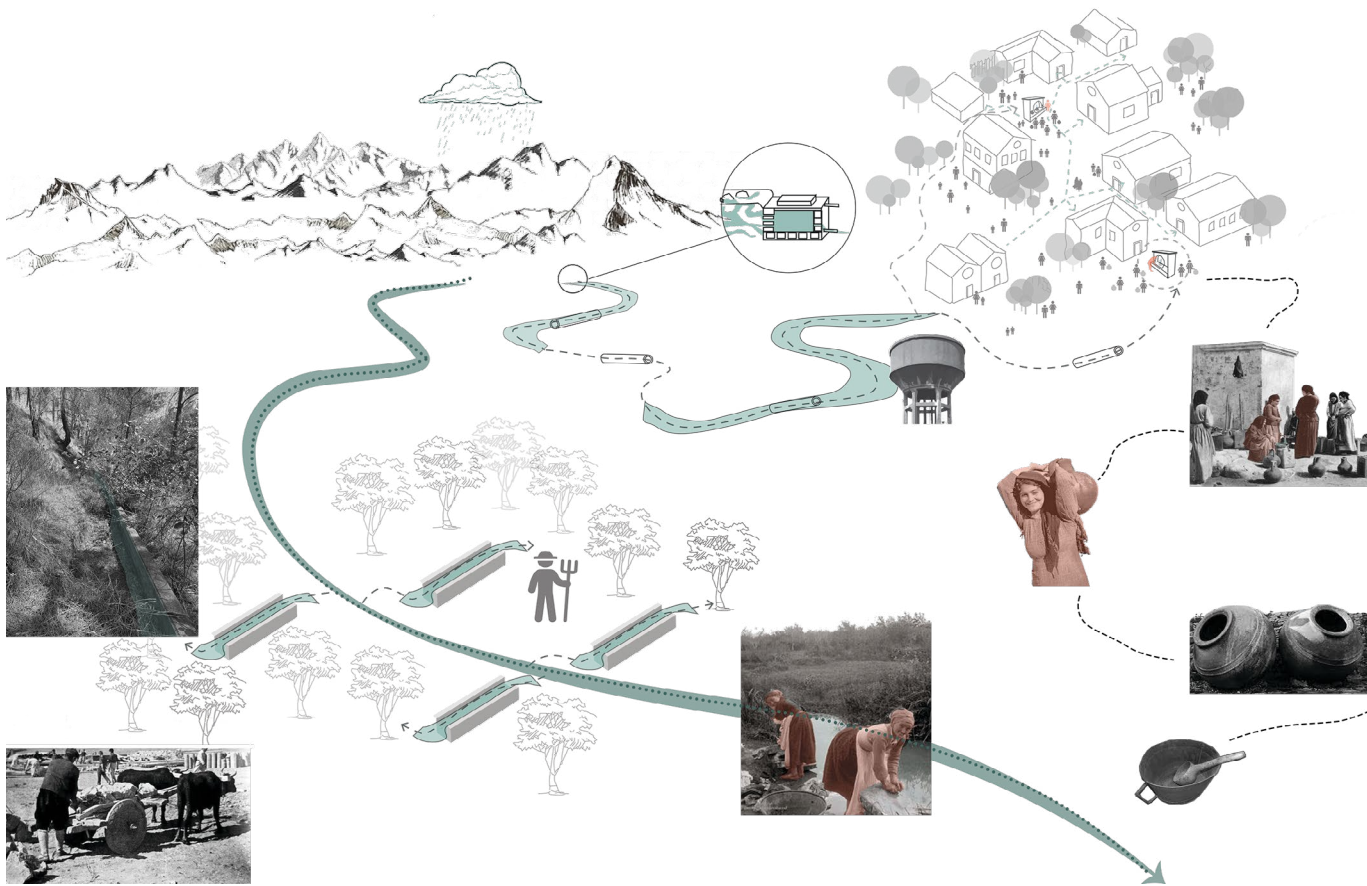


Fig. 7
Routes from the Teratsia
Spring in the Paphos
Mountains to Potos
village. Image by Xenia
Georgiadou, adapted
from Georgiadou
(2023b).

The feminist perspective of Cyprus’s Communal Fountain System opens a fresh understanding of this Traditional Water System. This insight emerged through conversations with locals, especially those who had long preserved and shared these stories. By weaving them into these micro-stories, the collective and ancestral memory of women’s role in the system comes into view, standing alongside the known water infrastructure. In doing so, the invisible aspects of the system, often dismissed as unimportant, are given space and recognition. This representation is vital, as what remains unseen or unspoken can easily fade from memory and be lost to time.

FOLLOWING ECHOES BETWEEN CRETAN RIVERS

Crete faces water scarcity because of its antiquity. The Iraklion, the island’s largest city and administrative capital, originated as a seaside settlement between the Yofyros and Keratos rivers, which once supplied the city with fresh water. Over centuries, Crete’s strategic location in the Mediterranean has attracted numerous civilisations, each leaving a mark that enriched the island’s cultural heritage.

With the advent of modern infrastructure, Traditional Water Systems were gradually deactivated, and water structures and practices fell into disuse, turning the landscape into a palimpsest of lost water heritage.

Navigating this landscape of forgotten structures and practices required in-depth site investigations that traced human activity over time and built upon prior research on Crete’s traditional water management. Mapping lost heritage revealed a fragmented narrative of water management across the territory between rivers. A new interpretation of the Yofyros River emerges through a diachronic reading of the site, where traces of human activity serve as storytellers of the river’s micro-stories.

Στείλε με μάνα μάνα στο νερό να σου το φέρω δροσερό τζι' αν δε στο φέρω φέρω καθαρό την νιότη μου να μεν χαρώ.	Send me, mother, oh mother to the water to bring you fresh water And if I will not bring, bring you clean water may I not enjoy my youth.
Στη βρύση μάνα μάνα μου έφτασα τζαι το σταμνί μου γέμωσα τζι άξαφνα παρα-παραπάτησα τζαι το σταμνί μου τσάκισα.	After I got, mother, oh mother to the fountain and after I filled up my jug Suddenly I mis-misstepped and I broke my jug.
Δεν είναι είναι παρα-παρα πάτημα παρά του νιού αγκάλιασμα παρά του νιού αγκάλιασμα δεν είναι είναι παραπάτημα.	It's not a mis-misstep but a young man's hug but a young man's hug it's not a misstep.
Κόρη μου δεν ήταν ήταν σωστό το' μάθεν ούλλον το χωρκόν το' μάθεν ούλλον το χωρκόν κόρη μου δεν ήταν ήταν σωστό.	My daughter, this wasn't, wasn't right the whole village found out the whole village found out My daughter, this wasn't, wasn't right.
Στείλε με μάνα μάνα στο νερό να σου το φέρω δροσερό τζι' αν δε στο φέρω φέρω καθαρό την νιότη μου να με χαρώ.	Send me, mother, oh mother to (bring some) water to bring you fresh water And if I will not bring, bring some fresh water may I not enjoy my youth.

Fig. 8
Lullabies reflecting
the cultural memory
of women's role in
collecting water.
Translation by Xenia
Georgiadou.

At first glance, the steep upstream section of the Yofyros River seems largely unaffected by human activity, except for the remnants of an old building complex. Here, a former watermill and chapel blend quietly with the native vegetation along the slopes. These structures were once part of an extensive complex of ancient olive groves and vineyards, which are now unused and overtaken by nature. The water mill suggests a nearby water source, and its position reveals the remains of an old water tank. Originally, water flowed through a wall conduit to power a stone mill, supplying the energy required to drive a second mill. Together, these watermills transformed olives into oil and grapes into must, serving the community well under Venetian rule in the early 20th century.

Agricultural fields dominate the midstream section of the rivers. Large-scale irrigation initially became possible with the construction of a dam in 1960, but it quickly fell into disuse. While the dam continues to regulate the flow of the river and store water, it lost its role in irrigation by the 1990s, as agricultural expansion demanded a more efficient mass-water collection system. At that time, deep boreholes were drilled to tap into the groundwater, providing the vast quantities required for irrigation. Over time, this shift led to aquifer degradation and associated issues, as groundwater replenishment could not keep pace with extraction rates.

In contrast to the upper and middle sections, the flat downstream area of Yofyros is highly urbanised. The city has expanded into the river flood-plains, constantly contending with water-related nuisance. In this section, a few remnants of old water structures tell their story. Instead, issues of environmental degradation, water safety, and social inequality speak volumes about the impact of the loss of connections between people and water, revealing the shortcomings of failed water management logic.

The micro-stories assembled for the Yofyros River reveal a gradient of human impact on the river's natural dynamics, which gradually intensifies over time. This lost water heritage encompasses not only the physical remnants of ancient practices and structures—tangible markers of a bygone era—but also an intangible legacy: a gentler, less invasive way of interacting with natural water systems for human benefit. This layered, abstract heritage becomes more apparent as one journey from the largely left untouched

Fig. 9
The flow of the Yofyros
River: nature (top),
fields (middle), and city
(bottom). Adapted from
Armoutaki (2022).



Fig. 10
Biographical representation of the Yofyros River landscape. Image by Emmanouela Armoutaki.



upper reaches of the river to the heavily urbanised downstream sections where the effects of modern water management practices are starkly evident. Together, these stories expose the fading bonds between people and water, respectively. (Figures 9 and 10)

REFLECTING UPON THE REVEALED

Acknowledging that 'tracing wetness' involves more than mapping moisture in the landscape, this chapter explores new perspectives on water systems by looking beyond visible structures. Semi-arid cultural landscapes provide fertile ground for investigating wetness, as they reveal unique interactions between people and water. Through micro-stories, this added layer expands our understanding of known water systems, uncovering often-suppressed narratives.

In each of the three cases discussed, micro-stories emerged from different sources and through various processes. In Jaguaribara, diverse water forms provided a framework for investigation. By interviewing locals and observing practices across different sites, it became possible to understand and represent the formal and informal water flows that coexist in the region. In Cyprus, oral stories shared by matriarchs filled knowledge gaps about the water journey from the mountains to people's homes, adding depth and color to the understanding of the traditional Communal Fountain System. In Crete, traces in the landscape—from remnants of old structures to current patterns of human occupation—serve as storytellers, offering fresh perspectives on both present and past water systems linked to the river. To convey these 'invisible water systems,' each case draws on a blend of photographs, collages, drawings, and even lullabies, creating a layered representation that complements the mapping of visible water systems.

Altogether, these micro-stories uncover aspects that are otherwise overlooked by regional data and are untraceable through conventional mapping methods. In Jaguaribara, they highlight the struggles of a community cut off from its traditional water practices and reveal the effects of technocratic and autocratic regional water management on peripheral realities, illuminating the forces shaping the region's waterscape beyond ecological processes and large-scale infrastructure. In Cyprus, micro stories from a recent past that still echo today reveal a feminist perspective on rural village water systems, shedding light on the essential role of women as providers and on their social lives beyond the home in a highly patriarchal society. In Crete, these micro-stories offer a new reading of the river landscape as a layered palimpsest, where the evolving relationship between people and water is made tangible through biographical representation.

Added knowledge is essential to understanding the complexities of today's landscapes, revealing layers of the past that explain the present. Engaging with these overlooked narratives provides insight into the forces that have shaped the waterscapes over time. This awareness provides more than a retrospective glance; it lays the groundwork for envisioning future landscapes that honor the diverse voices within each site, both human and non-human alike.

NOTES

Tracing Wetness

1. The name *Jaguaribe* originates from the Indigenous Tupi language, meaning 'river of jaguars', where *iagúara* means 'jaguar', 'y' means 'river' or 'water', and *-pe* means 'in' (Navarro, 2013). The

name alludes to the presence of large felines along the river, particularly during the dry season, as Jaguaribe was the last river in the region to run dry.

Circular Water Stories

Revealing the Wisdom of Traditional Water Systems for Today's Challenges

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