Circular Water Stories

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

Editors: Inge Bobbink, Monica Veras Morais, Amina Chouairi and Naeema Ali

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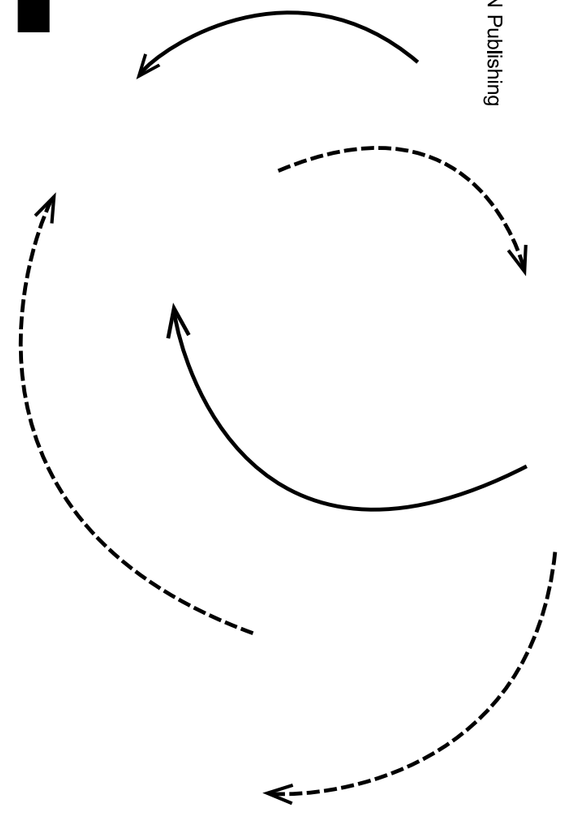
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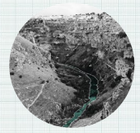
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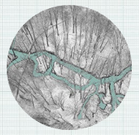
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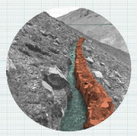
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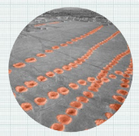
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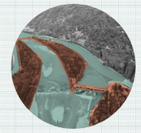
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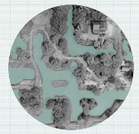
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Fig. 1
The map illustrates the availability and distribution of freshwater on Earth and shows the locations of the Traditional Water Systems mentioned in the book. By the authors.

NOTES A World of Water

1. GIS: Geographical Information System used to collect all kinds of data.
2. Natural Earth.
3. Wetness is often synonymous with moisture (e.g., in the soil) or seen as the opposite of dryness and drought.
4. Dymaxion projecting: a unique, low-distortion map that projects the spherical Earth onto an icosahedron (a 20-sided polyhedron) which is then unfolded into a flat, connected, two-dimensional map.

A World of Water

‘Thousands have lived without love, not one without water.’ (Auden, 1966)

This map illustrates the availability and distribution of freshwater on Earth. It conveys the general idea of water in different regions, derived by crossing and interpreting GIS[1] data on river systems, lakes[2], climate (Beck et al., 2018), and precipitation (Abatzoglou et al., 2018). The map’s base distinguishes sea from land, includes the main rivers and lakes, and is projected onto the Hillshade raster map (Danielson et al., 2011; Wessel et al., 1996) to make the flow direction of the rivers legible. The blue hatch, which is denser in areas with more wetness[3], shows average rainfall expectations distilled by merging and interpreting the climate and precipitation maps and overlaying them onto surface water.

To pursue a more neutral representation of the Earth, we did not use the standard Mercator map projection: a cylinder wrapped around the Equator that is later unrolled, which increases the area distortion as one gets closer to either pole. Instead, we decided to use the Dymaxion projection[4], developed in the 20th century by the architect Buckminster Fuller, which projects the globe onto an unfolded icosahedron, significantly reducing the area distortion, albeit not preserving the canonical north and south directions. This allows us to maintain the proper proportion of regions around the globe and render them politically equal, stripping away ‘global north’ or ‘global south’ connotations.

In this visual impression of Earth’s varied wet and dry conditions, we highlight the rich diversity of traditional water systems analysed within the Circular Water Stories lab. The selection of projects was based on the students’ interests and their connections to the places. All systems, more elaborate than others, are discussed in the book in relation to various water-related aspects. The projects were conducted in different climate zones, soil types, topographical conditions, and cultural contexts.

Let the stories flow, the knowledge ripple, and the insights soak. This book is a confluence of perspectives celebrating how water has shaped our past and present world.

Mapping the Projects

INTERMEZZO

Foreword

Water Remembers

Henk Ovink

Professor Water Cycle Diplomacy and Design Founding Commissioner and Executive Director of the Global Commission on the Economics of Water

There is a profound difference between treating water as a resource and understanding water as a living, interconnected system.

The first view has shaped much of the modern world. It has encouraged us to extract, divert, drain, pipe, price, pollute and, too often, forget. It has divided rivers from wetlands, cities from their watersheds, food from soil moisture, economies from ecosystems, and infrastructure from the communities whose lives depend upon it. It has made water disappear—into pipes, engineered channels, financial models, administrative boundaries and technical silos—until it returns as flood, drought, contamination, scarcity, displacement or conflict.

The second view begins with relationship. It sees the links between rain and forest, soil and food, groundwater and river, upstream and downstream, past and future, people and place. It understands that water moves in cycles rather than sectors; that it circulates as blue water in rivers, lakes, wetlands and aquifers, as green water in soils and vegetation, and as atmospheric moisture that connects landscapes and climates across distances. It recognises that water is at once material and cultural, ecological and economic, technical and spiritual, local and planetary, and values water accordingly.

Circular Water Stories is a compelling invitation to recover this second understanding.

This book is a richly illustrated and carefully constructed body of work that asks us to take traditional water systems seriously as sophisticated forms of landscape intelligence. Across more than thirty cases, the book reveals systems shaped over long periods by climate, topography, soils, hydrology, livelihoods, local knowledge, cultural practices and collective stewardship. It moves across continents and water worlds: from qanats, ponds, stepwells, rice terraces and irrigation landscapes to water meadows, polders, salt fields, fishing systems, urban canals, agricultural landscapes and flood-adaptive settlements.

Its contribution lies precisely in understanding these systems as more than individual structures or transferable technologies. A water system is never merely a canal, tank, sluice, well, terrace, dike, or aqueduct. It is also the land around it; the rain that feeds it; the soil that absorbs, stores and releases water; the vegetation that cools and recycles moisture; the organisms it sustains; the seasonal practices through which it is maintained; and the social agreements that determine access, care, repair and responsibility.

This is what circularity means in its fullest sense. It extends beyond the technical reuse of water to the renewal of relationships: between water and landscape, between use and replenishment, between human needs and ecological limits, and between present benefit and future possibility.

The Global Commission on the Economics of Water has called for a related transformation in how the world values and governs water, the water cycle, and its connections between people and planet. Its central proposition is that the hydrological cycle should be recognised and valued as a global common good. This is a profound shift. It asks us to understand that water cannot be governed as though it were a set of disconnected national, municipal or sectoral resources. Every drop participates in larger systems, and choices in one place can reshape risks and opportunities elsewhere. The stability of the water cycle is foundational to food, energy, health, ecosystems, economies, security and human dignity.

The Commission's framing of the water cycle—as the interdependence of blue water, green water and atmospheric moisture—offers a powerful global language for what the systems in this book have long made visible at the scale of landscape and community. The book's circular drawings translate complex, three-dimensional systems into a legible visual language: climate zone, rainfall, soil, topography, natural flows, human interventions, waterworks, agricultural practices and lived experience can be read together. In doing so, they make it possible to perceive the system.

That work of 'seeing' matters.

The water crisis is not only a matter of insufficient infrastructure, inadequate supply or failed management. It is a crisis of economics, vested interests, bad land-use management, ecosystem degradation, and the depletion of our natural resources way beyond the planetary boundaries. It is also a crisis of imagination and attention. We have become estranged from the socio-ecological systems that sustain us. In many places, water is concealed, abstracted or treated only as a problem to control. Rain is rushed away from urban surfaces instead of being retained, infiltrated or stored. Rivers are approached as drains, borders or delivery channels rather than living systems. Soil moisture, wetlands, forests and seasonal cycles are overlooked, even though they are indispensable to the functioning of the wider water cycle.

The result is a linear economy of water: extract, use, discharge, degrade, defend, rebuild. Its costs are borne unequally, especially by communities with the least influence over the decisions that alter their waters and landscapes.

A return to an imagined past is not the alternative. Traditional systems emerged from histories, ecologies, social arrangements and relations of power. They should not be stripped of context, copied as design motifs or appropriated as a source of technical 'solutions' without recognising the people and knowledge systems that sustained them. The deeper lesson they offer is not replication; it is humility. It is learning how to understand context, recognise interdependence, honour stewardship, work with natural cycles, share responsibility, and plan beyond the short horizon of the next project, electoral cycle or investment return.

This book is especially valuable because it joins historical understanding with contemporary design practice. It treats drawing as a form of inquiry. The circularity drawings and the wider Illustrative Method provide a way to analyse and communicate complex water systems across scales. They show water's visible and invisible routes; the relation between technical components and ecological processes; the connection between human practices, spiritual and cultural life, and landscape form. The act of drawing becomes an act of careful attention—and, potentially, a means of reopening dialogue between communities, designers, engineers, researchers and public institutions.

That possibility is urgently needed.

Through Water as Leverage, including the work in Chennai, we sought to approach water as a catalyst for inclusive and transformative urban development rather than as a hazard or a sectoral problem. Chennai's water crisis cannot be understood apart from its historical water landscapes: tanks, wetlands, rivers, canals, groundwater, coastal dynamics and patterns of urbanisation. The work asked how a city could reconnect with these systems—how water bodies, ecological corridors, public space, housing, mobility, health, livelihoods and climate resilience could be considered together.

The answer was to learn from the intelligence of systems that had understood storage, recharge, retention, distributed resilience and adaptation to variability. It was to build partnerships capable of linking local knowledge and community priorities with public policy, technical expertise, design capacity and finance. Water as Leverage starts with a simple conviction: when water is seen as a threat, we build barriers around it; when water is understood as a source of life and connection, it can help organise a more resilient, equitable and beautiful future.

The same conviction informed Rebuild by Design after Hurricane Sandy. Recovery had to become an opportunity to understand the deeper systems that create vulnerability, to connect design with governance and investment, and to place communities at the heart of shaping their own futures.

Resilience is not a technical add-on. It is a process of changing how choices are made: who is invited into the room, what knowledge counts, which risks are recognised, what futures are valued, and where resources flow. Those questions now reach beyond the city, the watershed and even the nation-state.

Robert Macfarlane's Is a River Alive? gives these questions a vivid and unsettling human form. In the Ecuadorian cloud forest, he encounters a landscape in which a river, its tributaries, forest, mountains, people, mining concessions and law are not separate matters. They are one sustaining system. The threat of mining therefore extends beyond the individual site and the pollution generated. It reaches into the integrity of the watershed: into the river's waters, the forest's capacity to hold and release moisture, the

lives and livelihoods sustained by these flows, and the possibility of a future in which the river can continue to be itself.

Macfarlane's account invites us to see several rivers at once: the visible river moving through the land; the green river held in soil, roots and vegetation; and the aerial river of moisture travelling through the atmosphere. This is both a literary image and a hydrological truth. It closely echoes the Global Commission on the Economics of Water's understanding of an interconnected hydrological cycle—one whose stability underpins ecosystems, food, livelihoods, health, economies and security.

Amid the pressure and peril of extractive development, Macfarlane recalls hope. Not optimism without evidence, nor faith that someone else will solve the problem, but a committed hope rooted in relationship, memory and defence. It is hope expressed by those who know the river as a living presence and who therefore refuse to regard its destruction as inevitable.

That is the kind of hope this book makes available to us: practical, place-based and intergenerational, beginning with learning again how to see, value and care for the water systems that sustain life. It is a hope grounded in evidence, practice and place. It is carried by the systems documented here, by the communities whose knowledge and stewardship have enabled them, by students and researchers who have learned to read waterscapes anew, and by the editors and contributors who have made these stories accessible through an open, visual and comparative body of work. The book's commitment to open access is particularly significant: it positions these stories not as a closed archive of expertise but as a shared resource for learning, dialogue and action.

The challenge before us is to connect this local intelligence to the wider architecture of global cooperation.

We have no shortage of international commitments. The Sustainable Development Goals, the Paris Agreement, the Global Biodiversity Framework and successive water agendas all recognise, in different ways, that human wellbeing depends upon healthy ecosystems, climate resilience, equity and shared responsibility. But commitments alone do not create delivery. Too often, implementation remains fragmented: water is separated from food, land, energy, climate, biodiversity, finance and urban development; local practices are separated from national planning; and ambitious statements are separated from the budgets, regulations, institutions and political choices that determine real outcomes.

Coalitions of the willing have an important role to play. They can build momentum, bring together unlikely partners, demonstrate what is possible and move faster than formal institutions sometimes allow. But coalitions of the willing need an architecture. They need to connect local action with national systems; design with finance; knowledge with decision-making; and immediate action with enduring accountability. They must strengthen—not bypass—the multilateral capacity needed to care for the global common goods upon which all countries depend.

Water offers a vital foundation for that architecture. It is where the local and global meet most concretely. It reveals that climate resilience is inseparable from water-cycle resilience; that equity is central rather than supplementary; that financial decisions have ecological and social consequences; and that no country can secure its own water future while the planetary water cycle is destabilising.

The stories in this volume do not provide one universal model. Their power lies in their diversity. They teach us that the most durable answers are situated: shaped by local ecology, culture, practice and governance. But they also disclose principles with wider relevance. Work with water cycles, not against them. Retain, replenish and reuse rather than extract and waste. Recognise that infrastructure is ecological and social as well as technical. Make water visible. Learn from those who have cared for a place across generations. Build systems of shared stewardship. And judge success not by short-term efficiency alone, but by whether water, land, ecosystems and communities can flourish together over time.

This is the circularity we need today: a civic, ecological and ethical cycle of reciprocity, repair, responsibility and renewal.

May these stories travel widely. May they help us see more clearly. And may they inspire the courage to create water futures that are not only more resilient, but more just, alive and deeply connected to the systems that sustain us.

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Part I

Circular Water Stories an Ongoing Discovery

WATER!

About the Book and How to Navigate It

Inge Bobbink[1], Monica Veras Morais [2], Amina Chouairi [3] and Naeema Ali [4]

This book explores WATER—not only as a vital resource, but as a cultural, ecological and technological force that shapes landscapes and is often transformed by human ingenuity. It presents a curated selection of traditional, human-made water systems from around the world, offering insights and reflections for researchers, designers, and a wider audience.

Many of these water systems represent context-sensitive, low-tech solutions that emerged through centuries of adaptation to specific landscapes and climate. As UNESCO's International Hydrological Programme emphasises, such practices embody intangible cultural heritage and local ecological knowledge that remain highly relevant to addressing today's challenges of water scarcity, water quality, and climate resilience (UNESCO, 2019). Rather than approaching traditional knowledge solely as a matter of looking to the past, this book, written from a landscape architectural perspective, situates it as a living archive of landscape and ecological design intelligence. Aligning with the vision of several international organisations like UNESCO, the IPCC, and the World Bank Group, our body of work argues that traditional water systems should not be understood as individual structures or technologies. They are landscape systems shaped by ecological processes, cultural practices, technical knowledge, and human stewardship, offering timeless lessons of resilience, balance, and long-term adaptation. By engaging with them critically, we can carry forward their insights to create sustainable and equitable water futures in a rapidly changing world.

1 Dr ir. I. Bobbink, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands, i.bobbink@tudelft.nl
0000-0002-3130-7369
2 Dr ir. M. Veras Morais, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands;
0000-0002-0223-7429
3 Dr ir. A. Chouairi, Landscape Architecture and Spatial Planning, Department of Environmental Sciences, Wageningen University & Research, the Netherlands;
0000-0003-3218-0782
4 Ir. N. Ali, Witteveen+Bos, United Arab Emirates
0000-0002-3498-3397

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Global climate discourse, such as the 2023 UN Water Conference, has increasingly positioned water at the centre of the planetary crisis and the actions required to address it. Initiatives such as Water as Leverage (WAL), led by the Dutch Ministry of Foreign Affairs, and policies such as Singapore's Active, Beautiful, Clean (ABC) Water Policy exemplify this shift towards understanding water as a complex, interconnected system. Traditional water systems provide inspiring precedents for advancing contemporary water-sensitive urbanism and climate adaptation. Their value lies not in their direct replication but in understanding the context-specific principles, relationships, and management arrangements that have enabled them to function over time. This moment presents a timely opportunity to bridge local practices with global decision making, contributing to sustainable development at all scales.

UNESCO frames water security as both a technical and cultural challenge, emphasising that infrastructural solutions must be accompanied by strategies that engage communities and sustain traditional knowledge (UNESCO, 2019). These perspectives reinforce the use of water as a design agent and cultural medium. By learning from traditional water systems and embedding their principles into contemporary design practices, we can create landscapes and infrastructures that are more resilient, adaptive, and socially meaningful.

This study was conducted between 2019 and 2025 in the Circular Water Stories (CWS) lab, a graduate design research studio at the Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands. Within this research framework, international master students in Landscape Architecture have explored traditional water systems in diverse geographical settings. These investigations formed the basis of their thesis projects, which culminated in speculative design proposals linking landscape architectonic thinking with resilient water management practices. These investigations formed the basis of this book. Analytical materials from more than 30 traditional water systems across different parts of the world were used to conduct comparative studies, providing even greater insight into how water shapes ecological, cultural, and spatial systems and vice versa. In doing so, the book serves as a guide for the next generation of designers and engineers, especially landscape architects who must navigate the intersections between water, ecology, and urbanisation in a warming world. Our work also seeks to contribute to a landscape approach to contemporary water challenges, one that understands water not as an isolated technical issue but as part of interconnected ecological, spatial, cultural and governance systems.

WATER IS UNIVERSAL

This book engages with water systems across multiple spatial and experiential scales. Every drop of water participates in the global hydrological cycle and is mobilised for diverse purposes, ranging from drinking and irrigation to navigation and recreation. At a more intimate level, water is encountered through sensory and cultural practices such as touching, tasting, listening, playing, and worshipping. However, as we studied these layers, we observed that these fluid relationships are increasingly under strain.

Even in countries such as the Netherlands, where two-thirds of the land lies below sea level and water has played a central role in shaping both the landscape and daily life, the bond between humans and water is being tested. Through our research on traditional water systems, it is evident that water represents more than a challenge of flooding, scarcity, pollution, or inadequate infrastructure. It also reflects a deeper relationship that the Dutch seem to have lost.

At its core, the book reflects on a growing disconnection among humans, communities, more-than-human life, and water itself. Modern societies are increasingly alienated from the socio-ecological systems that sustain them, and this detachment extends to the built environment where water infrastructure is often hidden or abstracted (Berkes & Folke, 1998; Moffatt & Kohler, 2008; Ramaswami et al., 2012). In some places, the absence of shared responsibility among governmental bodies, communities, and individuals undermines sustainable water stewardship. A significant portion of the global urban population relies on bottled water for consumption, while denying access to clean, swimmable rivers due to severe pollution (UNESCO, 2019). In water-scarce regions, rainfall often runs off impermeable surfaces instead of infiltrating the ground or being stored for future use. This challenge is exacerbated by the decline of localized knowledge and collective institutions for managing water resources (Ostrom, 1990; Berkes, 1999). Consequently, unsustainable water management reflects a broader failure to design environments that foster human-water interactions, ecological resilience, and social awareness.

From a landscape architectural perspective, water is a fundamental force that structures (urban) landscapes across multiple scales. It functions simultaneously as a site-specific feature and a component of broader socio-ecological systems, linking ecological, social, and economic processes (Corner, 1999; Orff, 2016).

The potential of landscape architecture and ecological design lies in the integration of natural processes, including water cycles, into form and space. This enables water, as part of the landscape, not only to shape landscapes physically, but also to cultivate meaningful relationships between people and places, contributing to community formation and collective identity. Integrating these design perspectives can help to address the detachment between people and water, making it legible, interactive, and adaptive.

Motivated by the desire to identify water systems that continue to embody and reinforce these qualities, this study focused on traditional water systems. Notably, the existing, long-lasting water systems are not isolated interventions; they are dynamic, living frameworks that shape the land, integrate human activity, and promote sustainable futures. These aspects are presented in multiple drawings in the book. By demonstrating how they integrate ecological knowledge, cultural practices, and human stewardship across scales, they present an alternative model for landscape design that views water as an integral, systemic element within both natural and built environments (Boelens, 2014; UNESCO, 2019).

A COLLECTION OF LONG-LASTING WATER SYSTEMS

Given the diverse international backgrounds of graduate students, they were encouraged to investigate enduring water systems in their countries of origin. Many of these systems were developed in response to agricultural needs as early human settlements depended on reliable water sources to sustain food production. Over time, these systems evolved through adaptation to physical, social, ecological, and climatic conditions, initially by trial and error and later through the exchange of knowledge between communities. A defining principle of their development and maintenance was simplicity: ensuring accessibility and encouraging widespread community participation. This inclusivity fostered both stewardship and equitable

benefit sharing. At that time, a strong awareness of humanity's interdependence with the ecosystem was deeply embedded in daily life.

In the selected case studies, preference was given to traditional water systems that harmonised with natural environments and did not produce adverse ecological impacts. Well-known examples such as the Mexican Chinampas were included, alongside less widely recognised systems such as the flooded meadows in the eastern Netherlands and England, or the Amunas water channels in the Andes of Peru. Resilience is non-negotiable, which is exactly what these systems champion. For example, the Sea Salt Fields on the island of Hainan in China also function as natural breakwaters that absorb wave energy during high tides, stabilise the shore, and simultaneously support mangroves and other marine species. Dutch polder–boezem and India's below-sea-level farming systems are designed to adapt to fluctuating water levels, allowing them to remain functional even during heavy rains. Systems such as the Honghe Hani Rice Terraces in China and Kampung Naga in Indonesia utilise gravity-fed irrigation and wastewater recycling, ensuring that every drop of water falling within the village is captured and recycled, thereby creating circular water cycles. Similar circularity values are also embedded in the Chinampas Agrosystem in Mexico, where human-made islands built from lake sediments and organic matter continuously recirculate water and nutrients between canals, soils, crops, and aquatic life.

CWS research also reflects a deep interest in the management structures and technical components of traditional water systems in relation to the landscape, as well as their circular characteristics and lived experiences surrounding their use. This title signals an integrative approach that values both technological and sociocultural dimensions, seeking to understand how these systems function in cyclical ways within ecological and communal contexts. 'Circular' refers here to the sustainable management of water through continuous cycling within natural and anthropogenic processes without degradation, depletion, or waste. It prioritises the reuse and reintegration of water in ways that preserve quality, support ecological resilience, and meet human needs across multiple domains. Central to this concept is the idea of closed-loop systems, in which water serves functions such as irrigation, sanitation, and spiritual practice, while remaining balanced within local environmental and cultural frameworks. The term 'stories' reflects the embeddedness of water in cultural, social, and spiritual narratives. It highlights the role of water not merely as a resource, but also as a central actor in shaping human-environment relations across time.

SPIN-OFF

Ongoing research is presented on an eponymous web-based platform[1], which is visited by professionals, designers, and researchers worldwide. The traditional water system analysis published on the site follows the representation format of the Illustrative Method. The Illustrative Method is a tool used to analyse Traditional Water Systems. The term 'traditional' emphasises the focus on water systems that have functioned for hundreds of years. This method was designed as an educational tool for landscape architecture graduates at TU Delft. This ensures that these water systems are analysed using the same criteria and are consistently represented (Bobbink et al., 2022). Since the project's inception, several articles have been published and additional opportunities have arisen to showcase the work.

The results of the first studio on traditional water systems were shown at the Faculty of Architecture and the Built Environment, TU Delft, in 2019 (Figure 1). Drawings of the Angkor Vat Hydraulic City, Cambodia (Thienvutichai, 2019), were exhibited in the 'We, the Rivers' exhibition at the Musée des Confluences in Lyon, France.[2] The museum integrated various visual materials produced in the studio, such as maps, diagrams, and glossary elements, into its audiovisual system to explain the ancient city's hydraulic infrastructure. In 2025, circular drawings of seven case studies were displayed in the Indigenous Intelligence: Ancient Knowledge in Contemporary Design Exhibition at TU Delft (Figure 2). A curated selection of this work, including contributions from the CWS lab, was also featured at the Venice Architecture Biennale, Italy, 2025, underscoring the growing significance of indigenous knowledge in shaping forward-looking design discourse. A drawing based on an analysis of Rome's traditional water system is featured in Walking Rome's Waters (Wentworth Rinne, 2025). This inclusion highlights the continued relevance of traditional water systems and underscores the importance of preserving their legacies in contemporary contexts. In March 2024, some Alumni and I were invited to visit the National Institute of Technology (NIT), Calicut, India, to conduct a workshop for students, during which the Illustrative Method was introduced, and some aspects of the method were covered. In the 'Stories from Akalapuzha' chapter, the workshop is discussed as an example of how the CWS reaches out into the world. In April 2025, Chie-Peng Chen[3] invited me to deliver a keynote lecture at the conference of Taoyuan Ponds System International Forum Taiwan on the contemporary significance of traditional water systems worldwide. The visit also included a field trip to the Taoyuan Plain, where Chen's research team collaborated with local communities for over three decades on the preservation and adaptation of pond-based water elements amid ongoing urbanisation. In August 2025, Nicolas Plain, founder of RISE[4], a non-profit documentary initiative that addresses climate and biodiversity challenges through immersive storytelling, scientific research, and local knowledge, requested permission to use drawings of traditional water systems from the CWS lab for the film 'Peru's Ancestral Amunas Water Systems'. Volume Lo–TEK Water–Field Guide for TEKnology (Watson, 2025) marks a significant continuation and expansion of research on indigenous and traditional ecological knowledge, particularly regarding water-based technologies. Four alumni of the CWS course, Naeema Ali, Amina Chouairi, Boomi Kim, and Ayu Tri Prestasia, were invited to contribute chapters to the volume, presenting work on the Kayalnilam dikes,

Fig. 1
Exhibition *Traditional Water Systems* at the Faculty of Architecture and the Built Environment, 2019. Participating students: Melinda Marján, Anhubuti Chandna, Rapa Surajaras, Boomi Kim, Krit Thienvutichai, Jui Deuskar, Catalina Rey-Hernández and Huadong Zhu. Photograph by Inge Bobbink.





Fig. 2
Exhibition *Indigenous Intelligence: Ancient Knowledge in Contemporary Design* at the Faculty of Architecture and the Built Environment, 2025. Participating students: Nicola Vollmer, Kanako Inai, Houxuan Zhang, Carolina Marquez Luna, Tobias Macchione, Camila Rosado and Xiaolei Ma. Photograph by Inge Bobbink.

ponds, and canals of the Malayalis, the Valli da Pesca fishing ponds of the Venice Lagoon, and the Ngais Pasir terracing system of the Sundanese in Indonesia. The CWS course provided the initial basis from which these research inquiries grew, later taking shape as mature contributions to the publication.

COMPASS

This book offers readers a visually rich and intellectually grounded exploration of the traditional water systems. It presents a combination of original drawings, maps, manipulated photographs, and field-based case studies from countries such as China, India, Indonesia, Spain, England, and the Netherlands. Organized thematically, the chapters guide the reader through comparative insights, design analyses, and narratives that unfold across diverse temporal and geographical contexts.

Alongside the nine richly illustrated essays, Parts 1 and 2 comprise five intermezzi: 'Circularity,' 'Water Landscape Elements and Waterworks,' 'Water as a Source,' 'Channelling Water,' and 'People Practices. ' These concise visual documentations interrupt the sequence of essays and create moments of comparison and reflection. Each intermezzo explores a specific dimension of water systems, foregrounding themes such as the infrastructural elements that regulate water flows, interdependence of water and food production, and diverse ways in which people engage with, shape, and are shaped by water landscapes. By placing elements from different systems side-by-side, these intermezzles reveal new relationships and tell stories that might otherwise remain obscured. For example, the illustration could inspire readers to study whether certain waterworks were developed in parallel on different continents or whether inventors who travelled the seas brought their knowledge across the world. They also inspire fast readers to read essays to learn more about the elements that make up the water systems.

After this introduction, the book continues with the intermezzo 'Circularity' in Part 1, which introduces a propaedeutic concept that underpins the analytical perspective adopted throughout the volume. Through a series of drawings, this intermezzo demonstrates different ways of representing water systems, showing how the drawings can serve as tools for understanding their circular dynamics.

The essays in the second part are written by the alumni of the CWS lab across multiple academic years, united by a shared engagement with themes that emerged from their investigations into traditional water systems. Through comparative analysis and case study discussions, the essays provide original insights into diverse topics: 'Vanishing Waters', 'Grand Projects', 'Feeding Waters', 'Water Heritage', and 'Tracing Wetness'. Each chapter is illustrated using analytical and speculative drawings.

The third part presents the implementation of the CWS research. 'Co-design,' 'Stories from Akalapuzha,' and 'Calling to Map' demonstrate how the material has informed further research, pedagogy, and professional practice. The final and most comprehensive chapter, 'Lessons to Learn: Scaling Traditional Knowledge to Face Increasingly Complex Challenges', examines how the knowledge gained through these investigations was tested and applied in students' graduation projects, delivering a vast range of design tools for today's challenges.

We deliberately published this book as open access so that people around the world could freely reconnect with their ancestors' knowledge. By making these documented water systems accessible to everyone, we hope that they will inspire learning, spark new insights, and help inform solutions to today's water challenges. Readers are invited to navigate the book either sequentially or selectively, engaging with chapters and case studies, according to their interests. Whether consulted as a reference, source of design inspiration, or foundation for further academic or professional inquiry, the book is intended to be read slowly and visually, allowing for a deeper understanding.

By combining these systems through a shared visual language, we aim to make this knowledge accessible to everyone. The practices presented are understood as forms of situated knowledge that are shaped and sustained by communities over generations. They are documented here with recognition of the people, places, and traditions from which they emerge.

We hope that the projects, principles, stories, and illustrations presented in this book will inspire reflection and action across disciplines, encouraging professionals within and beyond landscape architecture and urbanism to reconsider the role of water in design.

NOTES

1. https://circularwaterstories.org
2. The exhibition was on display from October 2022 until August 2023.
3. School of Design, Chung Yuan Christian University, Taiwan.
4. RISE connects the world's most remote communities with global decision-makers to scale the most ingenious climate, biodiversity and social solutions through film, science, and action (https://riseourworldheritage.org)

Circularity

In the circular water story lab research, circularity drawing plays a central role in illustrating the understanding of traditional water systems. It is an analytical and communicative tool that comprehensively encapsulates the key functions, components, and elements of a water system. Circularity drawings were developed to understand the system's relation to its surroundings, to show its components, and how the water system is used, for example, to drain or irrigate fields. Furthermore, the drawing highlights the associated ecological processes and collateral human practices, such as spiritual and religious rituals, which are tightly connected to water. Often, these representations reflect and map indigenous knowledge, preserving insights passed down through the generations.

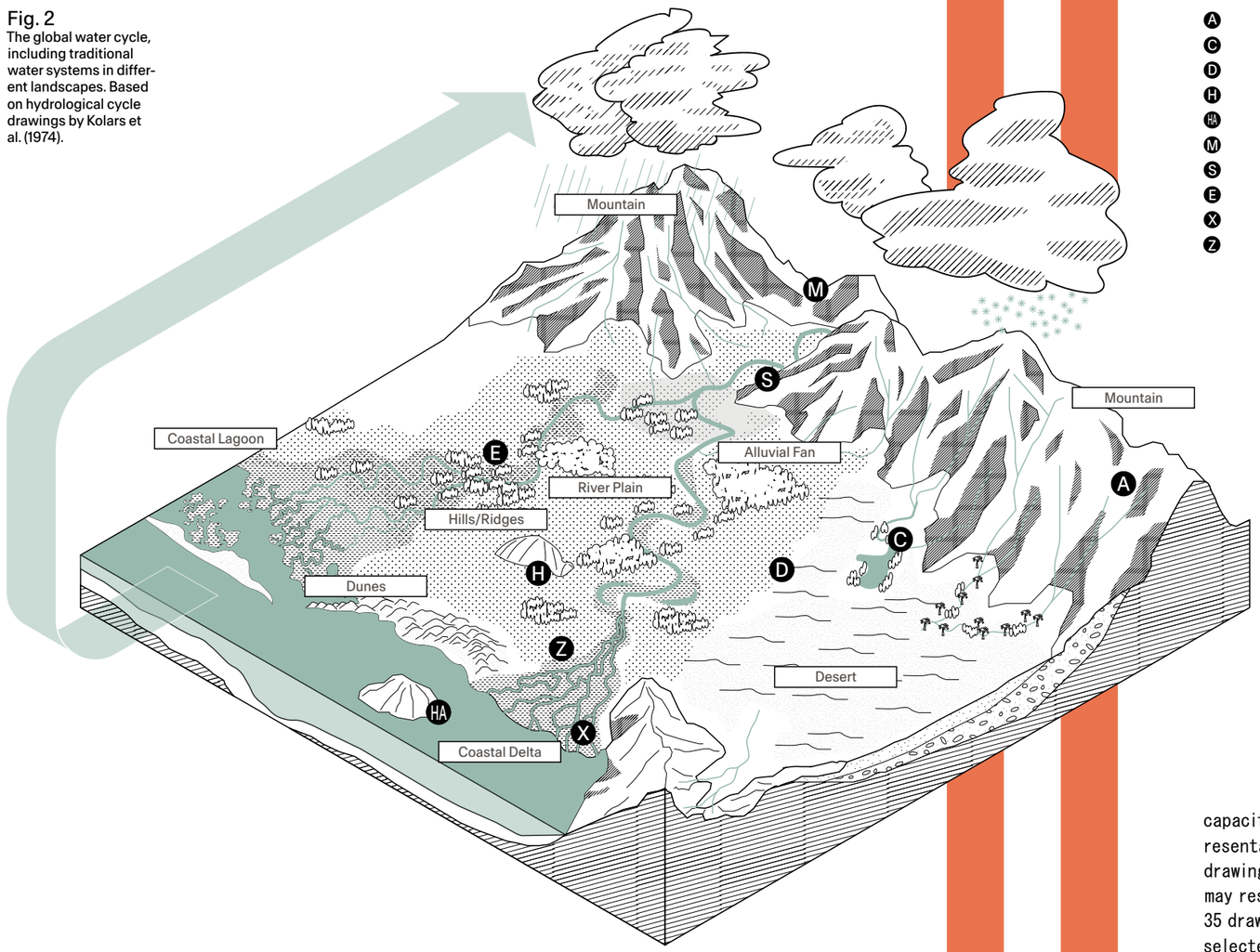
Defining circularity in the context of water systems involves understanding how water is used, reused, and returned to the environment in ways that maintain an ecological balance and minimize waste or harm. The circularity drawing draws on data relating to the climate zone, annual rainfall, soil type, and natural water flow, and maps the human-made dimensions of the water system. Topographical and geographical conditions were represented abstractly to emphasise the site-specific nature of the system. The drawing illustrates the structure, flow direction, and multifunctionality of the water system. Detailed zooms on specific elements, such as sluices, stairs, and wells, clarify their roles within the system and show how humans engage with it.

Fig. 1
Stepping stones at Landgoed Het Lankheet (Haaksbergen, Overijssel), along the Kidney Pools and the Pieter Vereijken Pad. Adapted from a photograph by Inge Bobbink.

Unravelling Water Systems through Circular Drawings

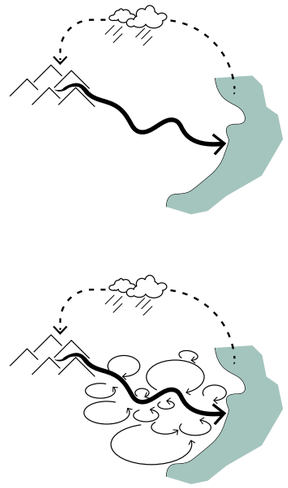
INTERMEZZO

Fig. 2
The global water cycle, including traditional water systems in different landscapes. Based on hydrological cycle drawings by Kolars et al. (1974).



- A Amunas Water System_Peru
- C Chinampas Agriculture and Settlement Patterns_Mexico
- D Delhi Sultanate Waterworks_India
- H Sprengen system of the Hoge Veluwe_The Netherlands
- HA Sea Salt Field in Hainan_China
- M Water Harvesting System in Matera_Italy
- S Consecutive Dams and Mills System_Spain
- E Watermeadow system_England
- X Xinghua Doutian Agrosystem_China
- Z The Industrial Zaanstreek_The Netherlands

Fig. 3
Schemes illustrating the natural circulation of water (top) and the detour loops created to, for example, drain or irrigate land (bottom). By the authors.



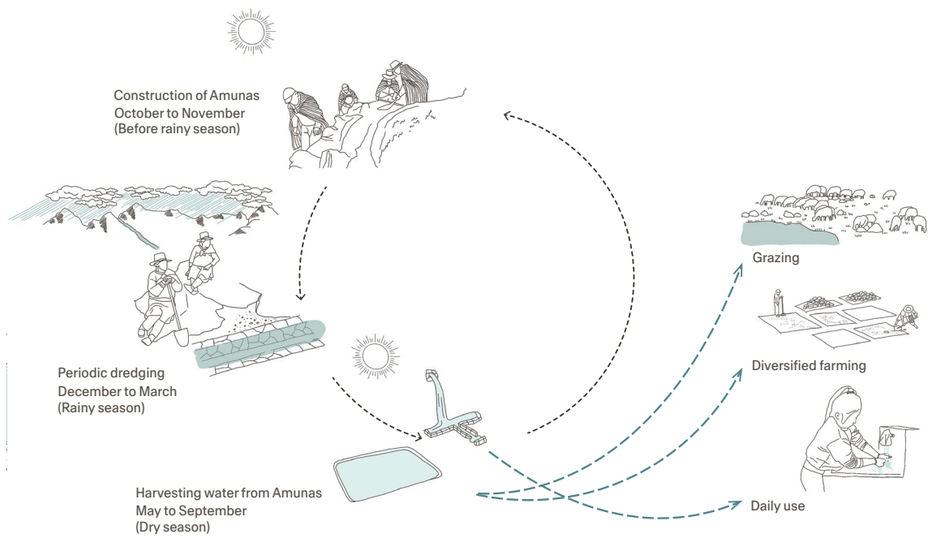
Circularity drawings can take many forms, offering a comprehensive summary of how a water system functions and is used. As such, they serve as tools from which designers can learn. Therefore, a sketch is not merely a visual construct but a means of effectively understanding and communicating complex systems (Corner, 1992). Considerable effort and dialogue are often invested in making drawings as clear and informative as possible. Representing a three-dimensional world on a two-dimensional surface requires more than a single plan or section; such complexity is primarily addressed through multiple scales within the same drawing. As Anssi Paasi notes in his article, Place and Region: Looking through the Prism of Scale, scaling is a dynamic measurement (Paasi, 2004).

Circularity drawings must often be redrawn multiple times to fulfill their communicative and explanatory potential. Their limitations stem from the system's inherent complexity, availability and reliability of information, and capacity for accurate and effective visual representation. Too much information can render the drawing illegible, whereas too little information may result in a loss of meaning. Of the more than 35 drawings produced in the laboratory, 10 were selected and grouped into five typologies that convey different aspects of water circularity. Naturally, other forms of drawing are conceivable. Although this chapter focuses on the results, the authors conducted extensive experiments before examining specific types of drawings. They discovered the narratives they wished to convey through drawing, discussing, adjusting, changing, and expanding the visuals accordingly.

The axonometric Global Water Cycle drawing (Figure 2) brings together various water landscapes and indicates the locations of the projects discussed in this chapter. It invites us to imagine a single drop of water as it journeys through the cycle: rising into the atmosphere, descending onto a mountain, freezing, and, if warmed by the sun, percolating into the ground, emerging as a spring, forming a stream that merges into a river, becoming part of a lake, and eventually returning to the ocean, where the cycle begins anew.

The traditional water systems explored in this study can be understood as detour loops within the global cycle (Figure 3). These systems draw water from the larger cycle, use it, and discharge it back, ideally maintaining its quality or purifying it before re-entering global flow. When engaging with water-related systems, this basic scheme should be a foundational reference for all water users, particularly for humans and designers.

Fig. 4
Circularity drawing of the Amunas System, Sierra de Lima, Peru. Adapted from Liang (2023a).



Diagrammatic Circularity Drawing

These diagrams refer more broadly to regions rather than to specific sites. The flow and, at times, the direction of water and associated materials are organized in a layout resembling an electronic circuit. Human interactions with the system, including water use and related practices, were integrated into the diagram through annotations or small illustrations. A diagrammatic approach is beneficial for identifying and clarifying the key actors involved. The initial setup is rarely definitive; it requires continual review and redrawing to ensure that it accurately reflects the system operation. This type of drawing typically serves as an initial step in understanding the system and is intended more for analytical exploration than for visual appeal. (Figures 4, 5, and 6)

Fig. 5
The Global Diagram-Circularity drawing of the Delhi Sultanate Waterworks, Rajasthan, India. Adapted from Gupta (2020).

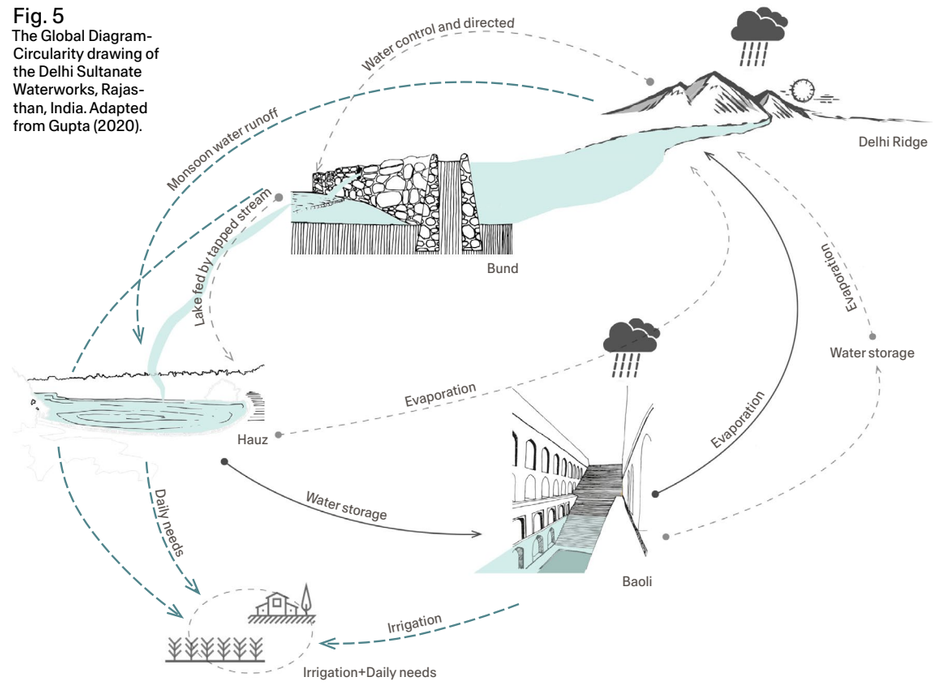


Fig. 6
Circularity drawing of the Chinampas Agrosystem, Xochimilco, Mexico. Adapted from Rey-Hernández (2019).

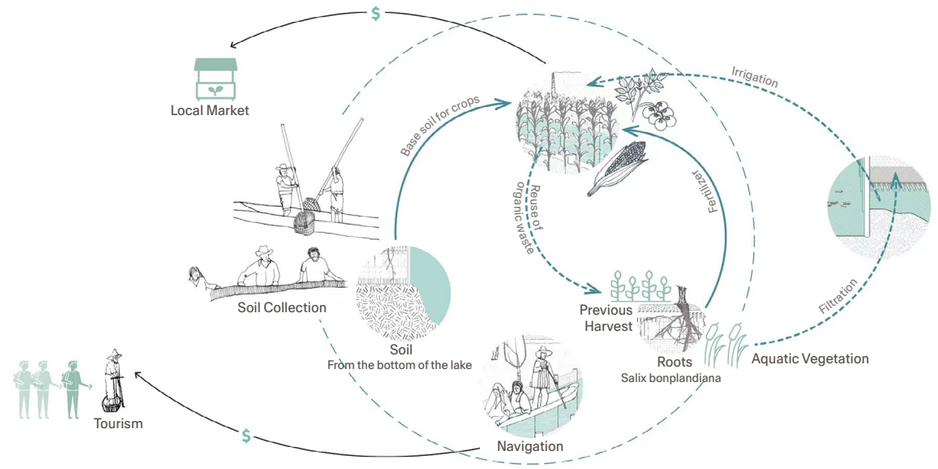
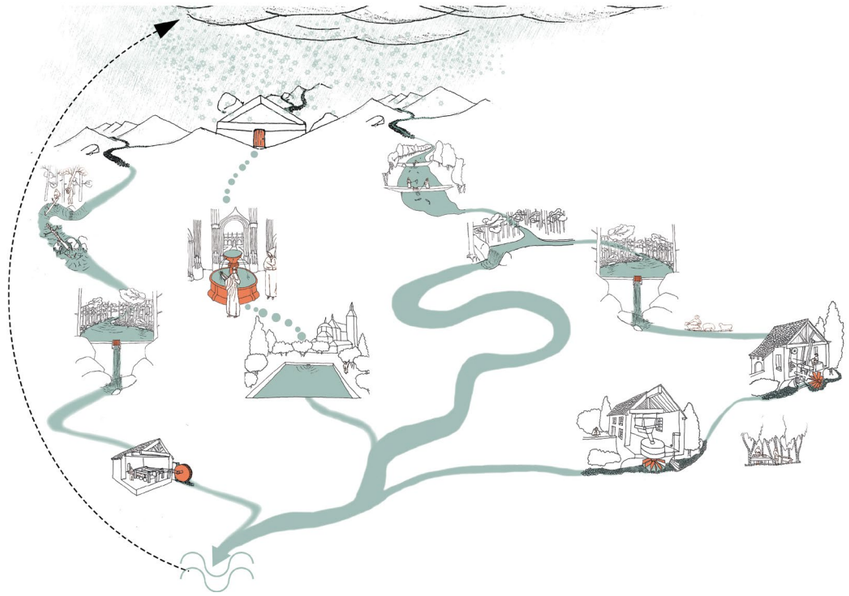


Fig. 7
The stone dam in the Rascafría project. Adapted from Sánchez Jiménez (2023).



Fig. 8
Circularity drawing of the Watermills in Rascafría, former Kingdom of Castile, Spain. Adapted from Sánchez Jiménez (2023).



Linear Circularity Drawing

This drawing traces water flow from upstream to downstream, focusing on the elements that guide its path or harness its kinetic energy. Along its journey, water serves multiple purposes: it transports goods, sustains aquatic life, and generates power through movement. To achieve this, the water is redirected to maintain a consistent height along parts of the system before being allowed to fall at a specific point, thereby activating mechanisms such as water wheels. Humans intentionally create abrupt changes in elevation to manage and exploit water flow. In the monastery

Fig. 9
A Sprengen, a dug water line including steps and a pool, in the Sprengen System project. Adapted from Jiang (2022a).

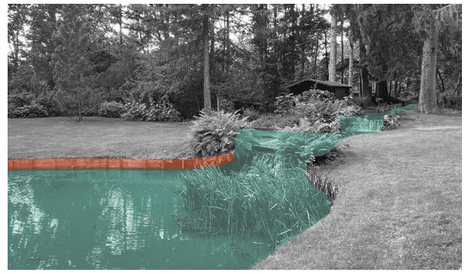
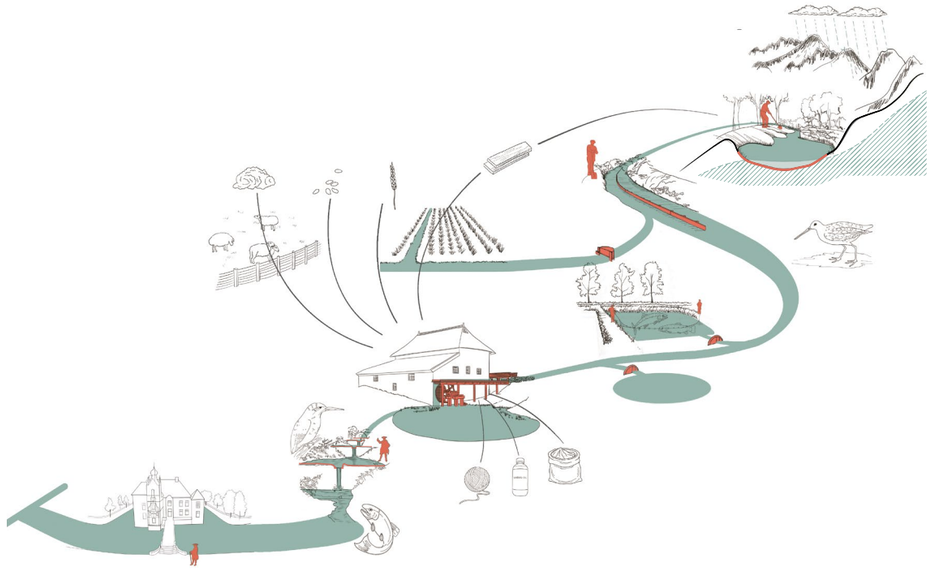


Fig. 10
Circularity drawing of the Watermills Sprengen System, Veluwe, the Netherlands. Adapted from Jiang (2022a).



landscape, the system consists of several converging streams that meet downstream. In contrast, the Sprengen System in the Netherlands channels groundwater to the surface by tapping into the hillsides. In both examples, water is an essential resource enabling land cultivation, and the entire system is typically controlled by a single stakeholder, either the monastery or, in the Dutch case, the estate owner. (Figures 7, 8, 9 and 10)

Fig. 11
Field pattern of Harnham Water Meadows. Adapted from Bazrafkan (2021).

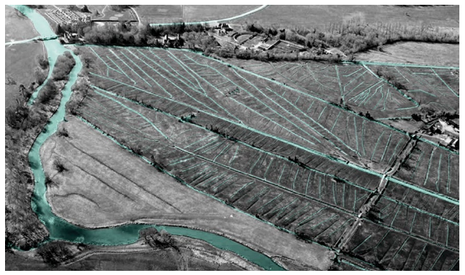
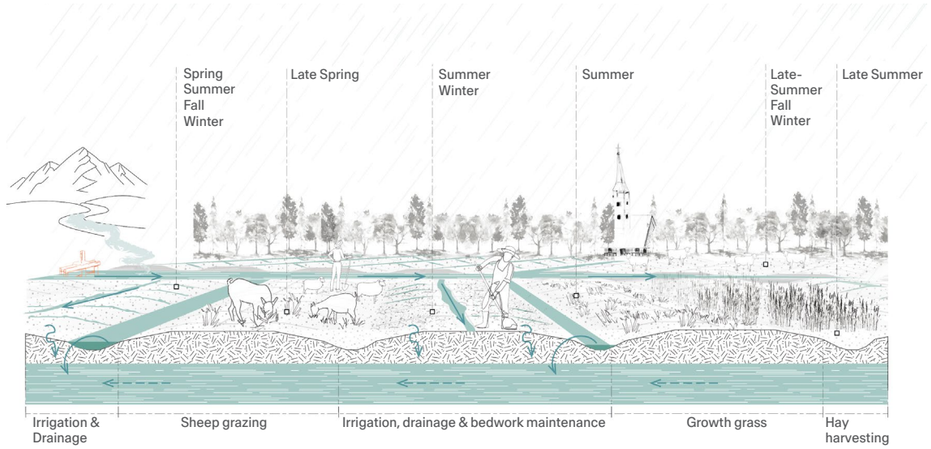


Fig. 12
Circularity drawing of Harnham Water Meadows, England. Adapted from Bazrafkan (2021).



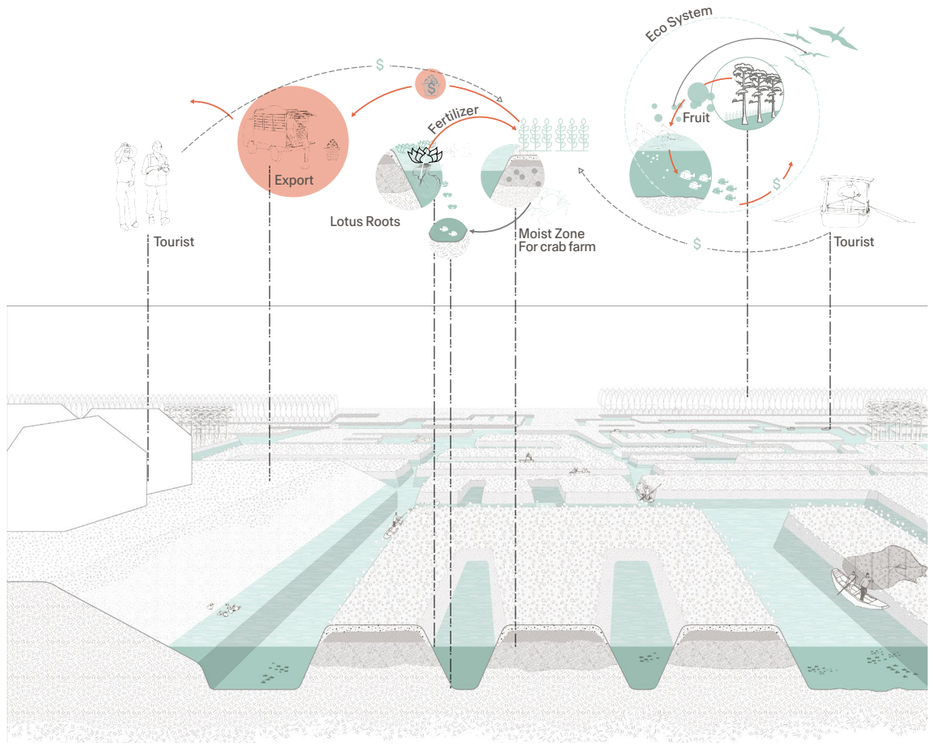
Section-based Circularity Drawing

Water is a vital resource for the flora, fauna, and human communities. These two drawings are based on a sectional view, extended by a perspective drawing that illustrates the activities and products found within cultivated fields. Each drawing presents a zoomed-in cut-out of the system, offering a focused view of how water shapes land use and livelihoods. In England, for example, river meadows are seasonally flushed, enriching soil with nutrients. This section captures the seasonality of agricultural practices through four distinct phases, arranged from left to right.

Fig. 13
Field pattern of Xinghua Duotian. Adapted from Surajaras (2019).



Fig. 14
Circularity drawing of Xinghua Duotian Agrosystem, Jiangsu, China. Adapted from Surajaras (2019).

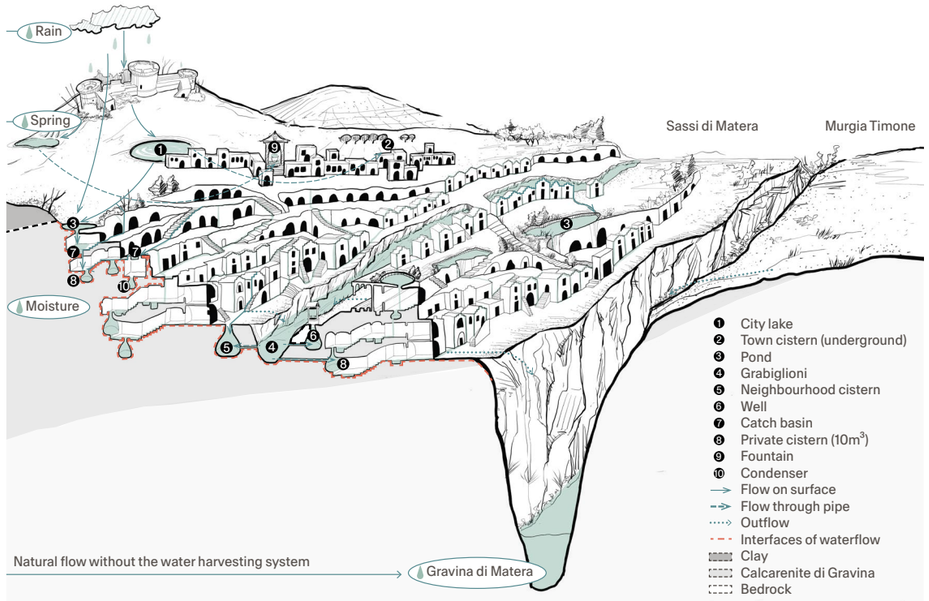


In the Xinghua Doutian Agrosystem, perspective drawing conveys the progression of farming activities over time, represented by the movement of a boat that organizes and enables these tasks. Schematic drawings highlight key aspects of the system, such as production, tourism, and economic dynamics, linked explicitly to the spatial and temporal contexts of the fields. (Figures 11, 12, 13 and 14).

Fig. 15
Village and ravine of the Sassi di Matera. Adapted from a photograph by Sailko (2016).



Fig. 16
Circularity drawing of the Sassi di Matera Water Harvest System, Basilicata, Italy. Adapted from Gao (2023).



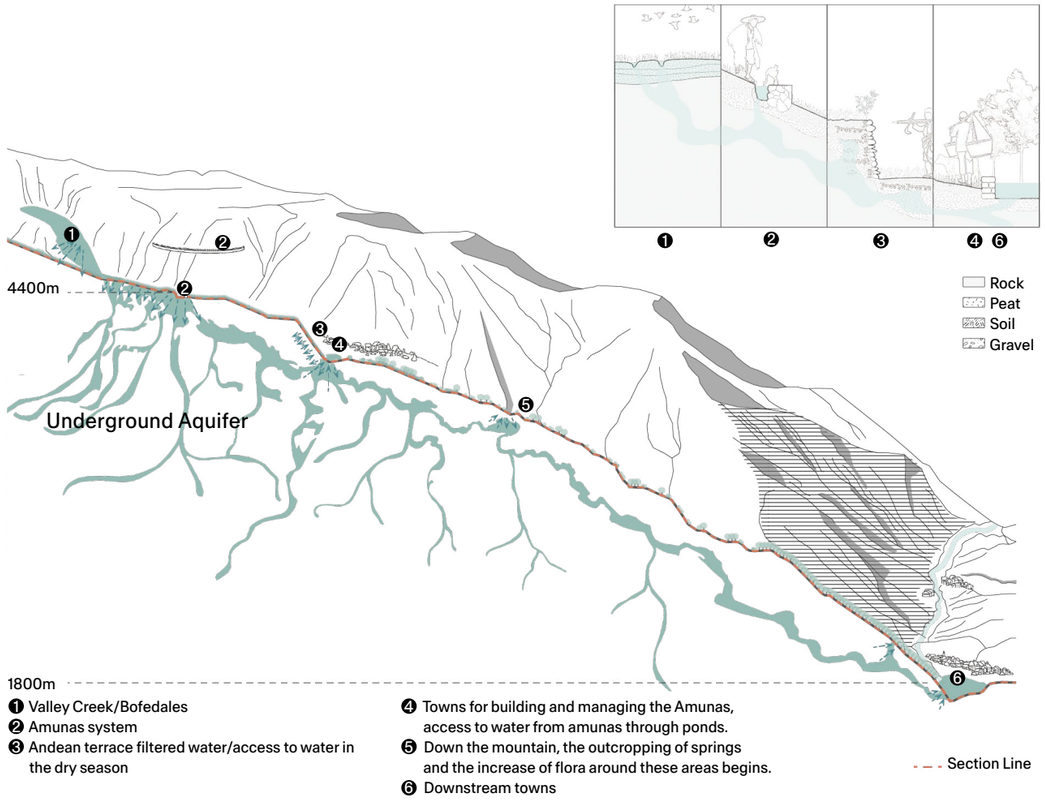
Soil-Based Circularity Drawing

These drawings explore the relationship between surface water and the soil beneath it, which is essential for understanding the functioning of the system. At the scale of the entire landscape, a sectional drawing extended from a perspective view was employed to illustrate the water systems within a given landscape and its specific soil type. The hilly topography and soil characteristics powerfully shaped the system layout in both projects. In Matera, rainwater infiltrates

Fig. 17
Infiltration pond in the Andes. Adapted from Liang (2023a).



Fig. 18
Circularity drawing of the Amunas System, Sierra de Lima, Peru. Adapted from Liang (2023a).



porous limestone and is collected in cisterns and dwellings, all carved directly into the rock. By contrast, the Amunas System channels underground water to the surface. It directs it through canals that follow the contour lines of the terrain, delivering it to the fields or retention ponds. (Figures 15, 16, 17 and 18)

Fig. 19
Worker harvesting salt on a prepared volcanic stone on Hainan Island. Adapted from Yan (2021a).

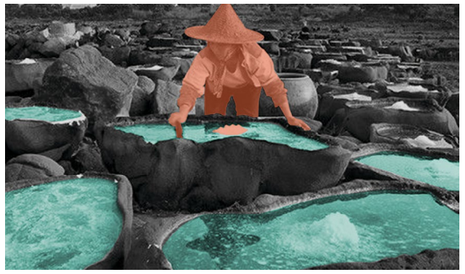
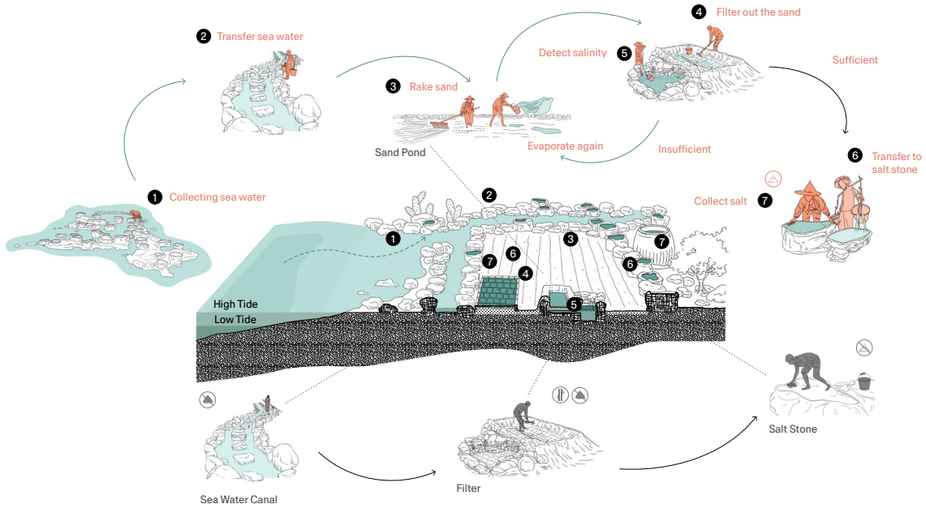


Fig. 20
Circularity drawing of the salt-winning process at the Hainan Island Salt Fields, China. Adapted from Yan (2021a).



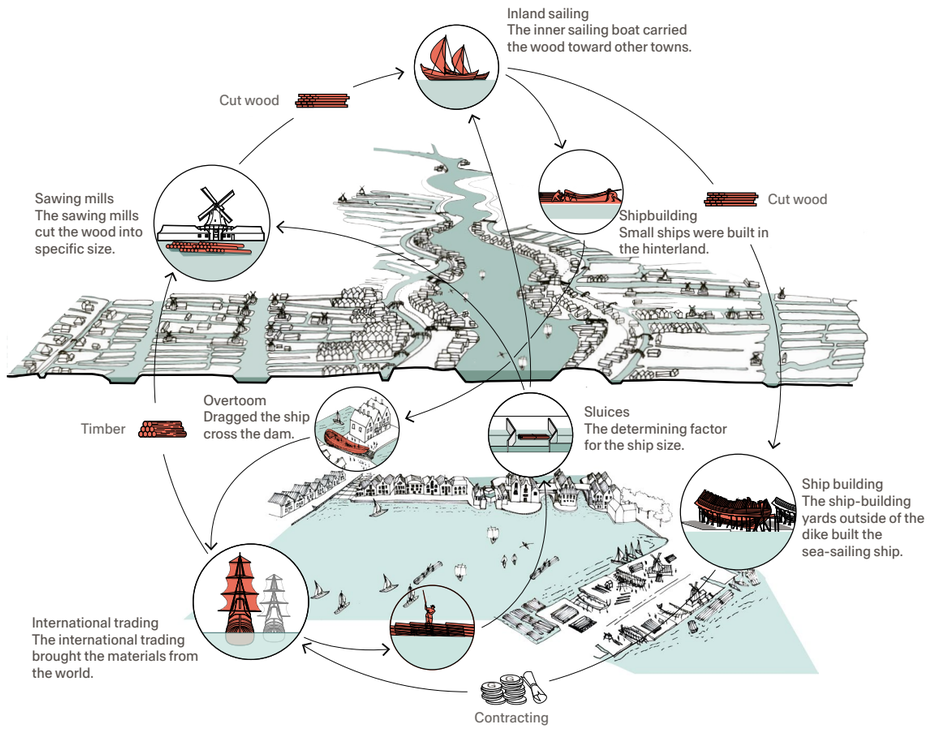
Production-Based Circularity Drawing

These drawings illustrate the circularity of water as a carrier for goods. A system was designed to extract salt from seawater along the coastline of Hainan Province. The volcanic landscape enables this process by separating thin layers of water that are left to evaporate naturally, allowing the salt to crystallize. In the Zaanstreek region, the shipbuilding industry developed owing to an intricate network of ditches and rivers connected to the sea. This fine-grained water system allowed timber to be transported to wind-powered sawmills, where it

Fig. 21
Food transport on the River Zaan during the eighteenth century in the Zaanstreek, the Netherlands. Adapted from a painting by L. Oomheijn (1786).



Fig. 22
Circularity drawing of the shipping industry and its spin-off Polder System, Industrial Zaanstreek, the Netherlands. Adapted from Chen (2023a).



was cut and processed into ships that would eventually sail globally. These drawings emphasise the scale at which this production process unfolds. Each is paired with a sectional view that captures the dynamics of seawater in salt fields and the structure of the water network in Zaanstreek, illustrating how water movement underpins and sustains these systems. (Figures 19, 20, 21 and 22)

Part II

Traditional Water Systems



Fig. 1
Abandoned cason di valle in Valle Olivara, Northern Venice Lagoon. Adapted from a photograph by Amina Chouairi.

Vanishing Waters

Loss, Transformation, and Resurgence of Water Systems

Amina Chouairi[1]

This essay investigates the disappearance, transformation, and partial survival of Traditional Water Systems through four situated case studies: the Valli da Pesca Aquaculture System of the Venice Lagoon in Italy, the Sassi di Matera Water Harvesting System in Italy, the Budj Bim Aboriginal Eel Aquaculture System in Gunditjmara Country, Australia, and the Hiti Pranali Water Stone Spout System of the Kathmandu Valley in Nepal. Traditional Water Systems are understood as complex socio-ecological infrastructures shaped by long-term interactions between humans, non-humans, water, and landscape. By analysing the triggers, effects, and impacts of their disruption, the paper shows how neoliberal economies, urbanisation, infrastructural development, colonisation, land expropriation, environmental change and mismanagement have altered these systems. Their loss is not only material, but also cultural, social and political, affecting local communities, ecological relations, and fundamental rights such as access to land, housing, public space, and water. At the same time, the cases reveal forms of resistance, restoration, and care through which communities continue to protect, reinterpret, or remember these water landscapes. The essay ultimately asks whether such systems should be revived, functionally restored, or preserved as fragile memories of more situated ways of living with water.

1 Dr ir. A. Chouairi, Landscape Architecture and Spatial Planning, Department of Environmental Sciences, Wageningen University & Research, the Netherlands;
amina.chouairi@wur.nl
0000-0003-3218-0782

Many traditional water practices have slowly disappeared, often without being documented, photographed, or drawn in ways that preserve their memories. In other cases, these practices have been disrupted by environmental shifts, transformed into different activities, and partially absorbed into modern infrastructure. A few traditional water systems studied in the Circular Water Stories lab were selected to reflect on why such practices have been lost and why contemporary society often feels disconnected from water.

Some water systems remain and continue to function today. The circumstances that led to their destruction, disappearance, transformation, or restoration were investigated by examining four cases: the Valli da Pesca Aquaculture System, the Sassi di Matera Water Harvest System, the Budj Bim Aboriginal Eel Aquaculture System, and the Hiti Pranali Water Stone Spout System.[1]

Rather than approaching disappearance only as heritage loss, this chapter treats vanishing water systems as analytical sites through which contemporary design research can understand the conditions that sustain, interrupt, or transform situated water practices. A framework for these investigations was proposed based on triggers, effects, and impacts. Key questions guide the analysis: What types of vulnerabilities can be found in specific systems depending on their geographical or social contexts? How do these conditions accelerate the changes and what is done to slow them down? What can future projects involving Traditional Water Systems learn from these examples, especially when restoration is not simply a matter of rebuilding physical structures, but of rethinking the relationships that once allowed them to function?

Traditional Water Systems are ingeniously and carefully designed, with complex water structures resulting from years of interaction between humans, non-humans, and landscapes. At the same time, they are physical infrastructure and social constructs deeply embedded in local and planetary political and cultural contexts. The survival or disappearance of such systems is closely tied to the sociocultural, political, and economic drivers of the culture in which they are developed and managed. If tested for crises and ruptures, these drivers might profoundly influence, transform, and sometimes destroy Traditional Water Systems.

At the origin of such disruptions, specific roles and responsibilities need to be acknowledged: those of the perpetrators and those of the subjugated. These roles are not always fixed or simple, and involve different degrees of agency, exposure, and vulnerability. Two intertwined questions guided the analysis: Who or what has contributed to the system's transformation and/or destruction? Moreover, who or what has suffered from these actions?

In many cases, perpetrators operate through political and economic interests, which are among the most influential forces affecting Traditional Water Systems and producing inequalities in access to water (Swyngedouw, 2004). Often, the most impacted are those whose systems' everyday functioning, stewardship, and care are affected. In human terms, this may include communities with lower social status or income, racialised communities, disabled people, women, older people, and other groups who may experience the consequences of environmental disruption, infrastructural change, or climate vulnerability in uneven ways. In non-human terms, native species and local ecological communities may also be affected when altered environmental conditions favor stronger, non-native, or invasive species. In this sense, the disappearance of Traditional Water Systems should be understood not only as the loss of material infrastructure but also as the disruption of social, ecological, and political relations that sustain them.

Through the Traditional Water Systems of the Valli da Pesca dikes and ponds of the Venice Lagoon (Chouairi, 2020), the Sassi di Matera Water Harvesting reservoirs of Basilicata (Gao, 2023), the Budj Bim Aboriginal Eel Aquaculture System of Gunditjmara Country (Zúñiga, 2020) and the Hiti Pranali Stone Spout System of Kathmandu Valley (M. Zhang, 2023a), the chapter examines processes of erasure and destruction. It analyzes the triggers that cause systems to be destroyed or undergo severe changes in their effects. Their physical, functional, and cultural dimensions and the impact of partial or complete loss on local communities, environments, and water relations. Each case also considers relevant efforts towards preservation, restoration, or renewed care.

Each case foregrounds a different mechanism by which Traditional Water Systems may vanish, transform, or partially survive. Valli da Pesca shows how economic devaluation, governance failure, and reduced maintenance can weaken a productive landscape. The Sassi di Matera reveals the limits of formal restoration when a water system is preserved as heritage, but no longer functions in everyday life. Budj Bim foregrounds the relationship between colonial erasure, land rights and indigenous resurgence. Hiti Pranali shows how rapid urbanisation, groundwater extraction, and the loss of recharge areas can undermine both water access and communal water cultures.

VALLI DA PESCA DIKES AND PONDS OF THE VENICE LAGOON, VENETO, ITALY

The Valli da Pesca of the Venice Lagoon represents a millenary system of dikes and ponds devoted to extensive aquaculture. From a nomadic practice, they were formalised over the last four centuries through the construction of earth embankments, ultimately settling along the margins of the Venice Lagoon. The term 'valle' comes from the Latin word vallum, meaning 'wall,' which refers to fences made of intertwined branches built and placed in shallow waters as enclosures for fish cultivation. Today, they cover over one hundred square kilometres, almost one-fifth of the surface area of the lagoon. They are still in operation, albeit with significantly reduced production yields, and are owned by the central Italian Government, but managed by private companies and individuals through concessions. (Figures 1 and 2), respectively.

Fig. 2
Abandoned lavoriero in Valle Olivara, Northern Venice Lagoon. Adapted from a photograph by Pietro Consolandi.



TRIGGERS, EFFECTS AND IMPACTS

During the last two decades of the twentieth century, Valli da Pesca's productive system was seriously compromised by three main drivers. First, the unexpected impact of neighboring countries' differing administrative policies led to an unregulated increase in fauna, threatening the functioning of the system. The wintering ponds of Valli da Pesca, several metres deep, where the fish would lie on the bottom during the frigid winters of the lagoon, went into crisis in the late 1980s when the European cormorant population increased uncontrollably. The Province of Venice, which is responsible for the environmental management of Valli da Pesca, was directly affected by this phenomenon. Billions of Italian lire were promised to be reimbursed for damages. However, after several confrontations, the idea of protecting the wintering ponds by saving capital (i.e., the fish) on which Valli's activity depended became welcomed. This was the first signal of the technical and managerial origins of a productive crisis that preceded an economic crisis. Second, the deep financial crisis, induced by the neo-liberal market's effects on small-scale, time-consuming aquaculture activities, was compounded by commercial competition from sea breams and sea basses bred in Croatia and Greece through intensive mariculture. Croatian and Greek fish were sold at a price of exactly 40 per cent of Valli da Pesca products, which meant that the production system went into crisis relatively quickly.[2] Third, the administrative and governmental inability to respond to the illustrated emergencies led to the partial abandonment of Venice Lagoon's Valli da Pesca Aquaculture System.

On the one hand, the accumulation of pressures induced the rapid loss of specific functions, while on the other hand, the most profitable activities prevailed, were preserved and intensified, such as hunting activities, which paid off more quickly than aquaculture operations and required less workforce. In addition, the reduced productive capital led to the abandonment and disappearance of the physical portions of the valli's extent, affecting the system's roles in impacting, benefiting, and sustaining. Finally, global technocratic and hyperproductive realities undermined the system's competitiveness and significantly reduced yields.

The gradual disappearance of the Valli da Pesca Aquaculture System affects Venice Lagoon in multiple ways. Performative management activities keeping pieces of the landscape 'cultured and alive'—avoiding invasive species from proliferating, landsliding and erosion, surveying and observing changes while on the territory, etc.—are lost. Despite their abandonment, they remain fenced state properties privately managed, where hunting activities are practiced, keeping the Valli da Pesca away from the people's imagination of the Venice Lagoon, secluded and segregated, inaccessible, and unknown.

The limbo of Valli da Pesca, an almost-but-not-entirely dismissed millenary productive system, epitomises what Tsing (2015) describes as 'capitalist ruins' in her book *The Mushroom at the End of the World*, which she defines as 'spaces of abandonment for asset production.' However, nothing is lost because 'these places can be lively despite announcements of their death; abandoned asset fields sometimes yield new multispecies and multicultural lives. In a global state of precarity, we do not have choices other than looking for life in this ruin.'

EFFORTS

Despite economic difficulties, a few examples demonstrate the resilience of the Valli da Pesca water system. One is the WWF Oasis Valle Averto in the Central Venice Lagoon, which still partially serves its role as an aquaculture site. Since 1989, Valle Averto has been listed as a wetland of international importance and recognised under the Ramsar Convention (Ramsar Sites Information Service, 1998). The area, covering approximately 200 ha, includes large expanses of brackish water, reed beds, wet meadows, hygrophilous wood, and canals (WWF Italia, n.d.-a). However, Valle Averto covers only five square kilometers of an almost hundred-and-ten-square-kilometer extended water system in Valli da Pesca. The recently concluded EU Life Project FORESTALL, which aims to restore and conserve calcareous swamps and alluvial forests, reiterates the importance and specificity of these environments, emphasising the need for active protection measures (WWF Italia, n.d.-b). Examples such as Isola Falconera, Azienda Marina Averto, and Azienda Agricola Santilario sum up the Valle Averto case study, seeking to support and further the history and ingenuity of Venice Lagoon Valli da Pesca.

SASSI DI MATERA WATER HARVESTING SYSTEM, BASILICATA, ITALY

Owing to its warm Mediterranean climate and low annual precipitation, water is scarce in the Basilicata region of Italy, once known as Lucania. Since the Bronze Age (3300–1200 BC), people have excavated soft rocks, the Calcarenite di Gravina, to create cave dwellings and cisterns to store rainwater for domestic use and irrigation. This water harvesting system includes many water features such as wells, catchment basins, ponds, cisterns, condensers, fountains, and nevieres, that is, large rock-carved spaces where snow is stored to cool food. In Matera, approximately 2,210 cisterns were identified within the so-called Sassi, including 2,039 small bell-shaped cisterns, 170 neighborhood cisterns, and two large cisterns, each with a capacity of 1,300 and 5,000 m^3, respectively. (Manfreda et al., 2016) (Figures 3 and 4)

TRIGGERS, EFFECTS AND IMPACTS

However, from the 1920s onward, through its piping system, the Acquedotto del Sele water infrastructure began to deliver water directly to the houses of Matera. A few years later, the grabiglioni drainage canals were covered and turned into vaulted sewers with streets above them. Since the 1950s, the

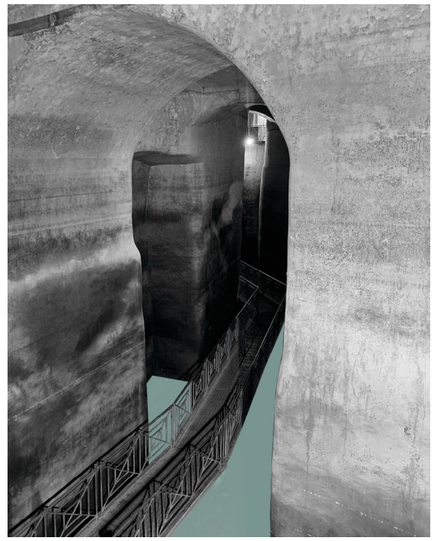


Fig. 3
Inside one of the water cisterns in Sassi di Matera. Adapted from a photograph by Isabella Banfi.

Fig. 4
View over Matera. On the left is Vico Solitario, and on the right is Torrente Gravina. Adapted from a photograph by Pietro Consolandi.



inexorable abandonment and loss of Matera's Traditional Water System began due to the pressures of post-war urbanisation, industrialisation, infrastructural development, and a deteriorating living environment. In 1952, when the town was labelled a 'national shame' because of its poor living conditions, from a hygienist perspective, the historical residents of Sassi were evicted by the Italian Government and relocated to new surrounding neighborhoods outside the rioni 'Sassi'(Bernardo & De Pascale, 2016).Owing to the increasing population, cisterns have been transformed into living spaces. By the end of the 1960s, about 15,000 inhabitants had left the community's historical center and moved uphill to newly built houses (Laureano & Cirella, 2004.)

Consequently, the cave city was emptied. Material expansions—such as the new rural village of La Martella and the urban project of Spine Bianche—see the substantial removal of the water element as a socio-cultural bonding entity.[3] Even if both projects draw formal and spatial inspiration from the antique urban system of Matera, they fail to integrate the water component, sustaining its physical existence.

The Traditional Water System of Sassi has been formally restored, but has yet to be reintegrated into service. Nowadays, modern life in the water system is characterized by gentrification, touristification, and musealisation trends. Caves have been transformed into hotels, restaurants, courtyards, and alleys. Nevertheless, reactivating the water system was deemed infeasible owing to the modern water quality, hygiene, and flow demands. However, although the water-harvesting system is no longer used, many locals have taken commercial initiatives to preserve certain water features, such as public fountains. Even without water, the importance of the system is recognized as a part of Matera's history.

The once-florid culture of living with water in Matera has now been lost. The disappearance of water elements and technologies has changed people's social space and lives. Water spaces were hidden, silenced, and confined. Space for water metamorphosed into space for traffic and commercial activities.

EFFORTS

In 1993, Matera became a UNESCO World Heritage Site because of its unique combination of site-contextual living and water harvesting systems (UNESCO, n.d.-a). Today, Matera welcomes more than 700,000 visitors annually and, thanks to this recent florid transformation, was selected as the European Capital of Culture in 2019 (Fondazione Matera Basilicata 2019, n.d.). However, explicit efforts and projects to promote the formal and functional restoration of Matera's water harvesting system have not advanced. In the past, the Italian Government tried to reconstitute social and cultural bonds among residents and their living dignity through new housing projects but not by restoring Sassi spaces. Today, only enthusiastic private owners are willing to restore and transform former water cisterns into hospitality spaces, while reintroducing the social dimension that once characterised them.

BUDJ BIM EEL AQUACULTURE SYSTEM IN GUNDITJMARA COUNTRY, SOUTHWEST VICTORIA, AUSTRALIA

Traces of the Budj Bim Eel Aquaculture System can be found in the Gunditjmara Aboriginal people's country in southwest Victoria, Australia. Budj Bim, today known as Mount Eccles, is a volcano that erupted thousands of years ago, causing extensive lava flow that transformed the landscape. The lava flow, relentless burning and melting, and the rain excavated creeks and meanders, provided the basis for the aquaculture system developed by the Gunditjmara people. An extensive network of canals, traps, and weirs was once a highly productive aquaculture system constructed to breed, trap, store, and harvest eels. Currently, it is recognised as one of the world's oldest and most extensive aquaculture systems. (Figures 6 and 7), respectively.

TRIGGERS, EFFECTS AND IMPACTS

Large parts of the Budj Bim landscape system have disappeared, not only due to environmental changes over time but also due to modifications to the site during British colonization. The British reached Budj Bim in an 1841 expedition to South West Victoria, when Chief Protector of Aborigines, George Augustus Robinson, reported the existence of an immense piece of ground trenched and banked, resembling the work of civilised man, but which on inspection I found to be the work of the Aboriginal natives, purposefully constructed for catching eels (McNiven, 2017). Between the 1830s and 1860s, several violent conflicts over the possession of the Western District, South West Victoria, followed until British colonists definitively occupied the Gunditjmara Aboriginal people's land and subjugated Indigenous people, either

Fig. 5
A Budj Bim ranger demonstrating the use of a traditional woven basket (modern version) to harvest eels. Adapted from a photograph by Rodney Dekker.



Fig. 6
The landscape of the Budj Bim Aquaculture System. Adapted from a photograph by Rodney Dekker.



through displacement or death. Under these circumstances, the Gunditjmara Aboriginal people were systematically forced not to perform millenary survival practices for decades and, over time, were devastated by the settlers' violence and the uncontrollable spread of diseases. Gunditjmara Aboriginal people 'were eventually pushed onto several church missions in the area, where colonizers undertook a genocidal project of cultural erasure.' (Gattuso, 2020). For almost a century and a half, Aboriginal eel aquaculture, the bereft of those who once breathed life into the system, languished in oblivion. The system's tangible and intangible features withered, lost to the mists of time and the shadow of death. In addition, the relentless and systematic expropriation of Aboriginal lands and the scourge of racial discrimination were violently imposed by British and Australian settlers during colonisation.

EFFORTS

Over the last few decades, careful work has been carried out within the Budj Bim cultural landscape to restore and reconstruct the traces of the Aboriginal eel aquaculture system. After almost disappearing, indigenous associations and corporations completed formal reconstructions and partial functional reactivations in collaboration with research groups and institutions (Rose et al., 2016). Since the early 1980s, various court rulings have acknowledged the validity of Aboriginal claims, and in 2007, the Australian Government officially recognised Gunditjmara land rights. Today, the Gunditjmara people hold a native title, or traditional ownership rights, over almost 1400 square kilometers of ancestral land and jointly manage Budj Bim National Park with the Australian Government. Aboriginal rangers are now focused on 'rehabilitating the damaged wetlands and reinstating traditional fishing practices by teaching young people to catch eels with woven grass baskets' (Gattuso, 2020).

Today, the Budj Bim Cultural Landscape is managed by the Gunditj Mirring Traditional Owners and Winda-Mara Aboriginal Corporation, protecting Gunditjmara-owned properties along the lava flow (Davey, 2019). The traces visible now reflect the cultural practices of many generations, who deeply understood their land and lived in a dynamic relationship with water, materials, nature, and climate. The most recognizable features are structures built from basaltic rocks. This material was used to constrain the water in canals, shallow races, and sinkholes. Stones were also piled across waterways to form weirs and dams. Timber fences were set across rivers and served as traps with woven baskets placed to catch eels (Zúñiga, 2020). In 2019, the Budj Bim Cultural Landscape Site was inscribed on the UNESCO World Heritage List (UNESCO, n.d.-b). The efforts to obtain just credit and recognition of Australian Aboriginal culture and heritage testify that 'Australia has come a long way since G.A. Robinson's recordings of Aboriginal social and technological complexity were sidelined' (McNiven, 2017).

HITI PRANALI WATER STONE SPOUT SYSTEM OF THE KATHMANDU VALLEY, NEPAL

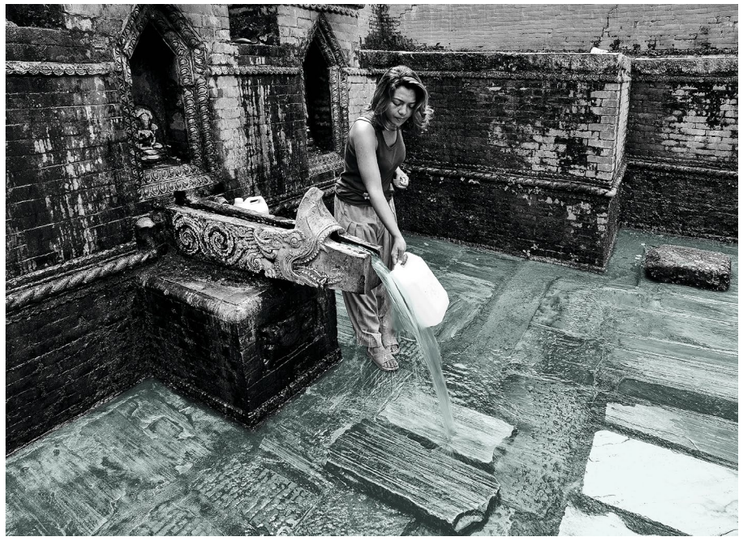
Hiti Pranali is a traditional stone-out water-supply system in the Kathmandu Valley of Nepal. The system's history began during the Licchavi Kingdom (c. 400–750 AD), while many more Hiti were built during the Malla period (c. 1201–1779 AD). Hiti Pranali provides water to people living in the city through canals constructed to follow the topography of the surrounding valley. Mountain water is channelled through these canals to ponds in the city center. Through infiltration, pond water feeds the shallow aquifer and people use channels to discharge water directly into the stone spout. (Figures 7 and 8), respectively.

TRIGGERS, EFFECTS AND IMPACTS

Today, the Kathmandu Valley is in a water crisis, as both water quality and quantity have been and are still affected by anthropogenic activities. Rapid urbanisation and a large influx of rural population into urban areas have increased the pressure on water resources and their availability. The population of the Kathmandu Valley is among the fastest growing in South Asia, increasing nearly fivefold from 1971 to almost 3 million by 2021.

With the advent of piped water supply systems and Kathmandu's uncontrolled, unplanned urbanization over the last few decades, this ancient water supply system is under threat (Shrestha et al., 2022).[4] The construction of modern infrastructure, destruction of the valley's recharge zone, and lowering of the water table due to massive groundwater extraction are the main reasons for the drying up of the traditional water supply system. Much of the public open space within the Kathmandu Valley that serves as rainwater catchment areas has been encroached upon or heavily concreted over, and many ponds have been filled in to make way for building construction.

Fig. 7
Alko Hiti, a 15th-century drinking fountain in Patan, Nepal. Adapted from a photograph by Rajesh Dhungana.



Meanwhile, most underground structures used to lay diversion pipes that filter rainwater have been destroyed by haphazard construction, and building foundations block underground waterways that feed spout taps. To cope with the increasing water scarcity, hotels, construction companies, and private businesses are drilling their own wells, leading to a dramatic drop in the water table. Declining groundwater levels have further exacerbated the drying of traditional water supply systems. In addition to flow rates, water quality is threatened by sewage seepage, septic tanks, industrial spills, and agricultural runoff, all of which are likely to contaminate it. However, with the rapid decline and contamination of groundwater from dug wells and the drying up of the hiti system, people living in poverty in the Kathmandu Valley are increasingly facing water shortages and security problems. The Kathmandu-based NGO Forum for Urban Water and Sanitation (NGOFUWS) reports that low-income communities depend most on spouts because the water is free. When the tap dries up, it directly affects low-income people. The rich have alternatives; the poor do not' (Mathema, 2014).

The disappearance of the Hiti Pranali System threatens the physical and functional aspects of stone waterspouts as well as the wider socio-cultural intangible characteristics associated with living with water in the Kathmandu Valley. Hitis reflects the valley's evolution through various civilisations, and has historically involved community participation, creating a sense of collective responsibility and social cohesion. This communal dimension fosters relationships among residents and promotes knowledge sharing regarding water management practices. Rich religious significance and folklore surround the water system, which serves to educate and instill respect for water sources. Stone spouts are often adorned with symbols and statues of deities, such as Lord Shiva and Bhagiratha, emphasizing the spiritual connection between water and the divine. This imbues the water supply system with religious significance, linking it to rituals and local folklore and reinforcing community ties. These stories perpetuate the cultural significance of water and reinforce its role in daily life and community identity (Joshi, 2022; Poudel, 2022).

EFFORTS

The Nepalese Government is attempting to clean and restore damaged sites. For example, in 2019, the government restored Yanga Hiti, which had fallen into disrepair due to neglect and was clogged with murky water, weeds, and garbage. Locals, youth, and governance bodies worked together for eight months to clean up the Hiti area and restore it to its current condition. The Kathmandu Valley Hiti has been included in the 2022 World Monuments Watch List, a selection of 25 heritage sites of global significance compiled by the World Monuments Fund (World Monuments Fund, 2022). Heritage conservationists say that including Hiti on the Watch List will encourage Nepal to continue its efforts to conserve and rehabilitate the heritage of the Kathmandu Valley. The ongoing efforts to preserve and restore the Hiti Pranali System in response to urban pressure underscore the resilience of cultural practices. The community's recognition of the importance of these traditional water sources demonstrates their commitment to maintaining their heritage and adapting it to contemporary challenges. The stone spouts symbolise a water supply system and the valley's identity, reflecting the relationship between people, nature, and spirituality. This connection plays a critical role in shaping a community's values and priorities concerning resource management.



Fig. 8
Ga Hiti in Thamel, Kathmandu. Adapted from a photograph by Rajesh Dhungana.

BETWEEN LIFE AND DEATH

The four case studies— Valli da Pesca, Sassi di Matera, Budj Bim, and Hiti Pranali—reveal different ways in which Traditional Water Systems disappear, transform, or partially survive.

Their trajectories are shaped by distinct but often overlapping pressures: economic crisis and governance failure in the Valli da Pesca; post-war urbanisation, forced relocation, and musealisation in the Sassi di Matera; colonisation, land occupation, and indigenous dispossession in Budj Bim; and rapid urbanisation, groundwater extraction, and the destruction of recharge areas in the Hiti Pranali. These triggers show that Traditional Water Systems rarely vanish because they are outdated or technically obsolete. Often, they are weakened when the social, ecological, economic, and political relations that sustain them are interrupted.

The effects of these transformations are material and intangible. In Valli da Pesca, the partial loss of the system's features was due to both the economic devaluation of fishing and the consequent loss of competitiveness, as well as a preference for giving even more space to profitable activities such as hunting. At the same time, the lack of skilled labor, reduced to the bone by an uncompetitive market, has also contributed to the loss of the Valli da Pesca landscape. In the Sassi di Matera, while the water infrastructure has been restored to its original form, it has completely lost its functionality and connection to the local community. In the Budj Bim case, the water system has been entirely lost in both its tangible (technologies, elements, works, etc.) and intangible (practices, skills, movements, etc.) forms. In Hiti Pranali, the loss of portions of the physical extent due to recent rapid urbanization has affected the system's sustaining role by reducing its extent. The partial or complete loss of soft skills, beliefs, and managerial knowledge characterised the case studies presented. The impacts on the surrounding communities and environments have increased social inequalities and the perpetuation and legitimisation of subjugative practices.

Across the four cases, the loss of Traditional Water Systems raises questions about access, rights, and responsibility. To date, the contemporary regulation of Valli da Pesca of the Venice Lagoon is part of a heated debate concerning the right to a just, open, and accessible city-lagoon public space. Apart from being located along the conterminazione lagunare

[lagoon perimeter] at the margins of the Venice Lagoon, most Valli da Pesca constitute inaccessible places because of their management regime—concessions where private entities control state property—and the hunting reserves they host, which, by law, must be fenced off. From the 1950s expropriations to the recent gentrification and commercialization operations of Matera's historical center, the disappearance of the cisterns' traditional water system threatened the right to housing and inhabiting the city. Through their care for the Buddhist cultural landscape and Aboriginal water systems, the Gunditjmara people have fought, secured, and reaffirmed their legitimate right to land and indigeneity, or their 'right to be free of fear' (Martinez, 2014). The slow disappearance of the Hiti Pranali in the Kathmandu Valley threatens the right to water security and free and accessible drinking water (Sultana and Loftus, 2020). The increasing privatisation and capitalisation of drinking water severely undermines the survival of the lower-income segments of the Nepalese population, menacing socio-cultural behaviors associated with these open public spaces.

Therefore, restoration cannot be understood only as the reconstruction of physical structures. The cases show that restoring a Traditional Water System also means engaging with the relationships that allow it to function: maintenance, access, stewardship, knowledge transmission, ecological continuity, and collective responsibility. A cistern, pond, dike, canal, spout, or weir can be preserved as a heritage object; however, without the practices and communities that sustain it, its role as a living water system may be lost. Conversely, even partially damaged or fragmented systems may continue to generate forms of care, resistance, and resurgence when communities recognise their value and reclaim their meaning.

Despite the risks and threats they face, active communities have fostered resistance to protecting and reappropriating their cultural water landscapes. The maintenance, preservation, and care of Traditional Water Systems involve the diligent and perseverant conservation of sociocultural equilibria and the defense of tangible and intangible heritage from oblivion, removal, and loss. Therefore, this comparison suggests that the future of Traditional Water Systems lies neither in simple revival nor in passive remembrance. Some systems may be functionally restored, while others may be partially reactivated, protected as cultural landscapes, or remembered as evidence of lost ways of living with water. What matters is to understand, case by case, which relationships can still be repaired, which practices can be sustained, and which forms of knowledge should not disappear. For contemporary water design, these systems offer more than historical examples; they reveal situated forms of intelligence, adaptation, and care. Their disappearance asks designers, planners, and communities not only how to bring water infrastructure back to life, but also how to create the social and ecological conditions that allow it to endure.

NOTES Vanishing Waters

1. The author gratefully acknowledges the research work conducted by Wenting Gao on the Sassi di Matera, Italy; Maria José Zúñiga on Budj Bim, Australia; and Maozhu Zhang on the Hiti Pranali, Nepal, within the framework of the Circular Water Stories lab
2. Zanetti, personal communication, 18 January 2022.
3. *La Martella* was designed by Italian architects Ludovico Quaroni, Luigi Agati, Federico Gorio, Piero Maria Lugli, and Michele Valori (1952–54) while *Spine Bianche* was designed by Carlo Aymonino, Carlo Chiarini, Marcello Girelli, Sergio Lenci, and Mario Ottolenghi (1954–59).
4. A study conducted by the Kathmandu Water Supply Development Board (KVWSMB) in 2019 recorded 573 spouts in the Valley and pointed out that among the previously documented spouts, 94 were lost entirely. Among the 479 available spouts, 224 were functioning at the time of the survey and had a total discharge of 2433,348 litres daily.

Water Landscape Elements and Waterworks

Water landscape elements and waterworks are indispensable infrastructure components in human-developed water systems, reflecting evolving cultural and technological practices in hydraulic engineering. They are constructed structures composed of either natural materials (water landscape elements) or artificial materials (waterworks) designed to regulate and direct the flow of water. The earliest water landscape elements were developed in situ through the direct observation of hydrological patterns. By modifying natural conditions, such as placing additional stones at a constriction in a river channel, water flow can be impeded or redirected. Similarly, mud can be used to retain water in rice fields, while a simple controlled breach allows water to be released. This method is a common agricultural technique in various parts of the world. Beyond these practices, early precursors to more advanced hydraulic structures and waterworks have emerged, incorporating increasingly sophisticated and technical interventions. Such developments were often the work of innovative individuals and engineers, among whom Leonardo da Vinci was one of the most famous, making significant contributions to hydraulic engineering during the 15th and 16th centuries.

The following pages present water landscape elements and waterworks divided into four functional groups – weirs and dams, sluices and locks, wheels and mills, and basins and tanks – from the analysed traditional water systems within the Circular Water Stories lab, presented in chronological order. The documentation highlights variations in size, form, and material, indicating the continued use of traditional materials along with modern innovations. Small drawings illustrate the operational mechanisms and patterns of human interaction. Original names, if available in their respective languages, locations, and climatic regions, are provided, highlighting the site-specific nature of the water landscape element or waterwork.

The examination of traditional water landscape elements and waterworks revealed that local conditions predominantly determine their materials and dimensions. Their aesthetic value is closely linked to their active maintenance, which fosters ongoing engagement by the surrounding community. Depending on their functional and cultural significance, this engagement is often reflected in care taken to ensure visual quality. Because traditional water landscape elements and waterworks are modest in scale, they integrate into the landscape without dominating it, instead providing subtle adjustments to the local environmental conditions. Moreover, at the end of their life cycle, such low-tech structures tend to decompose or be reclaimed by the environment with minimal intervention, leaving little to no lasting disturbance in the landscape, especially when compared to contemporary high-tech infrastructural installations.

The following pages present a selection of landscape elements and waterworks identified in the analysed traditional water systems, arranged chronologically on a timeline. The associated water type, soil type, climate zone according to the Köppen-Geiger climate classification (Kottek et al., 2006), and construction materials reveal how these elements are intrinsically shaped by their specific environmental and geographical conditions. The legend of the Köppen-Geiger classification can be found on page 226/227 on the Project Overview table.

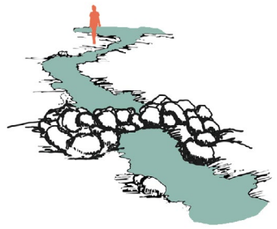
Fig. 1
Manual operation of a sluice regulating water within the saaidamme, traditional flood-irrigation dams used to retain and release water across agricultural fields. Adapted from Vollmer (2025a).

Ingenious Devices to Manage Flows

INTERMEZZO

Weirs and Dams–Blocking Mechanisms

- blocks seasonal river water to raise water level and catch eels
- volcano rocks and peat
- temperate—fully humid—warm summer (Cfb)
- dry stacked basalt rock construction

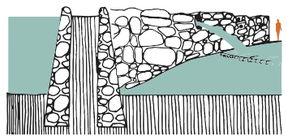


Budj Bim Eel Aquaculture System, Gunditjmara, Australia

Temporary dam—water landscape element

4000 BC ongoing

- controls and directs river water
- quartzite and schist bedrock
- dry climate—semi-arid—hot (BSh)
- stone masonry construction



Delhi Sultanate Waterworks, India

Bund—a dam which can be partly opened—waterwork

13th century

- artificial springs, cascading water for pleasure
- sand soil with clay riches
- temperate – no dry season—warm summer (Cfb)
- terracing according to topography, using concrete and stone

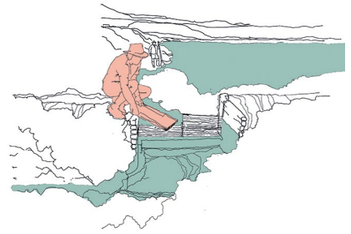


Sprengen System, Veluwe, the Netherlands

Cascade—weirs blocking the water and slowly releasing it—waterwork

17th century onwards

- seasonal river water to flood fields
- stoney and clayish soil
- dry—semi arid/desert (BS, BW)
- wooden flexible construction

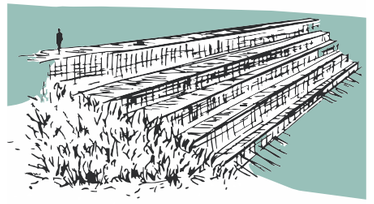


Hantam Saaidamme Flood Irrigating System, Northern Cape, South Africa

Temporal dam—height manual adjustable—waterwork

18th century onwards

- blocks and guides seasonal river water
- alluvial soil
- temperate – dry winter – hot summer (Cwa)
- bamboo and earth construction, now concrete



Ksôkong Tsùn Farming System, Kaohsiung, Taiwan

Thé—1,2 km long dam redirecting water—waterwork

during the 19th century

Weirs and dams are fixed hydraulic structures built across water bodies, most commonly rivers or streams, and occasionally lakes, to create water-level differences and regulate, control, or measure water flow. Although they share the general function of modifying water movement, they differ in scale, purpose, and construction methods.

A weir is typically a small overflow-type barrier designed to control or measure water discharge without storing large volumes of water. Weirs are generally low, and often divert water into irrigation canals or mill races, allowing the flow to pass freely over the crest in a thin, uniform sheet.

Low-technology weirs may be constructed from locally available materials such as mud, stones, earth, branches, wood, or a combination thereof. Such structures can often be dismantled and reconstructed as required, depending on water management needs, as in the Hanu rice terraces in China and meadows in England. Permanent weirs are built from steel, reinforced concrete, or synthetic materials, offering greater durability and reduced maintenance requirements. A dam is a large, elevated impounding structure intended to maintain a sustained difference in water level.

Its primary purposes include water storage, flood control, and generation of hydroelectric power. Unlike weirs, dams generally do not allow uncontrolled overflow across their crests. Instead, water is released through gates, spillways, or turbines in a controlled manner. Dams are often built in mountains to allow water to accumulate in valleys, creating immense basins for water storage. Therefore, they are predominantly constructed from reinforced concrete, earth fill, or rockfill, which provides the strength and durability necessary for long-term water retention and hazard mitigation. These large-scale dams often damage their immediate surroundings; when they fail, they flood large areas. Low-technology dams are rare because their size and storage capacity require materials with high structural integrity to reduce the risk of catastrophic failure.

In contemporary water management, weirs and dams continue to play a critical role not only in traditional functions such as irrigation, water supply, and flood control, but also in climate-adaptive strategies. Weirs are increasingly being employed to manage ecological flows, support sediment transport, and maintain habitat connectivity in rivers. At the same time, dams are integrated into multipurpose water infrastructure networks to balance storage, mitigate floods, and produce renewable energy. Advanced monitoring systems, automated gate controls, and predictive hydrological modelling enhance the operational reliability of both structures, allowing water managers to respond dynamically to extreme events, such as prolonged droughts or intense precipitation. Consequently, weirs and dams have to evolve from static hydraulic barriers into components by integrated water management systems capable of addressing the complex challenges of the twenty-first century. To achieve that we can learn from traditional water systems as well.

Sluices and Locks—Guiding Mechanism

- connecting to levels of surface water
- peat- and clay soil
- temperate—fully humid—warm summer (Cfb)
- wooden construction



Polder System, Industrial Zaanstreek, the Netherlands

Sluice—bringing boats to a different water level—waterwork

16th century onwards

- snow, rain and river water feeds the canal
- limestone, gravelly scree, and clay-marls
- temperate—dry summer—hot summer (Csa)
- bricks and concrete structure, wooden doors

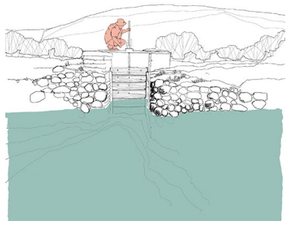


Canal du Midi, Languedoc region, France

Fonseranes Locks—series of locks bringing boats to different water levels—waterworks

17th century onwards

- seasonal river water to flood fields
- stoney and clayish soil
- dry—semi arid/desert (BS, BW)
- stone structure with wooden planks moved by a steel mechanism



Sprengen System, Veluwe, the Netherlands

Cascade—weirs blocking the water and slowly releasing it—waterwork

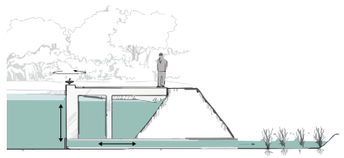
18th century onwards

Sluices are movable hydraulic structures equipped with gates that regulate water flow and separate water bodies at different elevations. They are widely employed in flood control, irrigation intake, drainage regulation, and navigational management. Sluices vary considerably in scale, from small openings just a few centimeters wide to extensive installations spanning hundreds of meters, such as those found in the Delta Works in the Netherlands. The gates themselves can be constructed from a variety of materials, including wood, brick, stone, steel, or concrete, and are operated either manually or through powered mechanisms. Depending on the design, gates may move laterally, downward, or upward to control water release. Sluices can function individually or can be arranged in parallel or in a stepped series to manage water flow, facilitate navigation, or regulate hydraulic gradients.

Closely related to sluices are locks, which consist of two sluice gates enclosing a chamber that enables the controlled equalisation of water levels. By adjusting the water level of the chamber, vessels can ascend or descend between elevations, allowing navigation along waterways with variable heights. In cases where substantial elevation differences exist, multiple locks can be configured sequentially, as seen in the Canal du Midi, forming a lock staircase that ensures the safe and efficient passage of vessels.

In contemporary water management, sluices and locks play dual roles. In addition to their traditional applications in irrigation and navigation, they have become integral to climate-adaptive flood-control strategies. Modern sluice systems are increasingly automated, incorporating sensors, remote monitoring, and predictive water-level modelling to optimise their operation. They are used to mitigate flood risk by controlling the timing and volume of water discharge during extreme precipitation events, and to maintain water supply and ecological stability during droughts or seasonal water shortages. Similarly, locks continue to support commercial and recreational navigation while integrating with broader hydraulic infrastructure, ensuring the coordinated management of rivers, canals, and polders under dynamic environmental and socioeconomic conditions. Because these barriers in the water system are often challenging for amphibious animals to cross, more attention is devoted to designing sluices and locks that are accessible to, for example, fish.

- water from retention ponds to flood fields
- lateritic red clay soil
- temperate—dry winter—hot summer (Cwa)
- concrete and steel

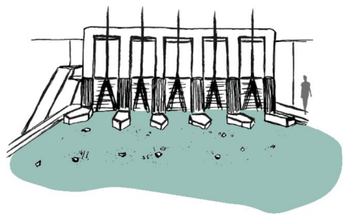


Farm Ponds of Taoyuan Tableland, Taiwan

Weir—connection between retention pond and fields—waterwork

18th century onwards

- seasonal river water, to supply different irrigation canals
- temperate—dry winter—hot summer (Cwa)
- alluvial soil
- concrete structure with wooden planks moved by a steel mechanism



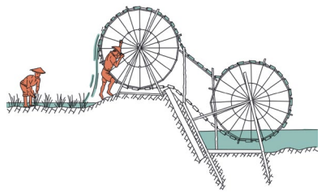
Ksôkong Tsùn Farming System, Kaohsiung, Taiwan

Tsùn-thâu—series of inlets—waterwork

19th century

Wheels and Mills–Lifting Mechanism

- river water lifted (large elevation difference) to irrigate fields
- alluvial floodplain
- temperate—no dry seasons—hot summer (Cfa)
- wood and bamboo construction moved by people or buffalos

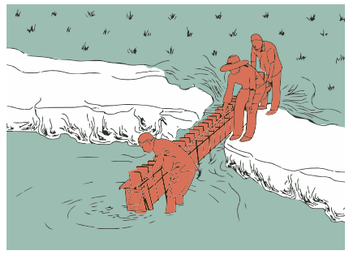


Weiyuan Flood-Adaptive Agricultural System, Jinghan Plain, China

Tong che—the tube cart lifts water up—waterwork

10th century onwards–no wheels are used anymore

- river water lifted (small elevation difference) to irrigate fields
- alluvial floodplain
- temperate—no dry seasons—hot summer (Cfa)
- wooden beam with shutters lifting water (small height) to irrigate fields



Weiyuan Flood-Adaptive Agricultural System, Jinghan Plain, China

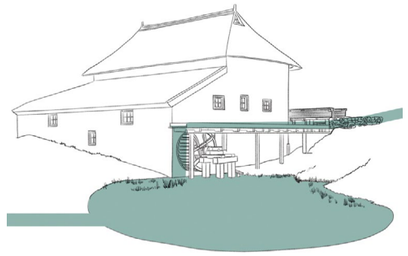
Long gu shui che—valves move lifts water up—waterwork

10th century onwards–not used anymore

Lifting mechanisms such as wheels, mills, and pumping stations are essential components of water management systems, especially in low-lying areas. In many regions, water must be transported upward from one level to a higher level. Among the most significant technologies developed for this purpose were windmills, which played a crucial role in draining low-lying delta areas and making them inhabit. Before the introduction of wind power, water was manually transported in buckets or lifted using simple water wheels. These wheels were initially driven by human or animal labor, typically donkeys, cattle, or horses, making the continuous process labor-intensive and inefficient. The large-scale introduction of the windmill in the thirteenth century marked significant technological advancement, enabling water to be lifted more effectively and on a much larger scale.

Windmills with a vertical axis were first developed in Persia around the 7th-9th centuries CE. Horizontal-axis windmills, closer to the type used in Europe, appeared in the 12th century. The earliest European windmills were documented in France and England in the late 1100s. In the Netherlands, the characteristic polder-draining windmill was introduced in the thirteenth century, and by the fifteenth and sixteenth centuries, it had become the predominant technology for elevating water and reclaiming land from lakes and marshes, becoming part of the country's identity. These mills could lift water

- artificial springs and human made canals
- sand soil with clay riches
- temperate—no dry season—warm summer (Cfb)
- wooden construction

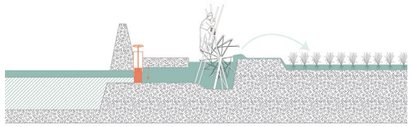


Sprengen System, Veluwe, the Netherlands

Watermill—water flow over the wheel powers all kind of engines—waterwork

16th century onwards

- sea water pushes fresh water up, which is collected and lifted
- marine clay
- temperate—no dry seasons—hot summer (Cfa)
- moveable wooden and bamboo wheels driven by human power



Saga Irrigation System, Kyushu region, Japan

Wheel (combined with inlet)—lifting fresh water to irrigate fields- waterwork

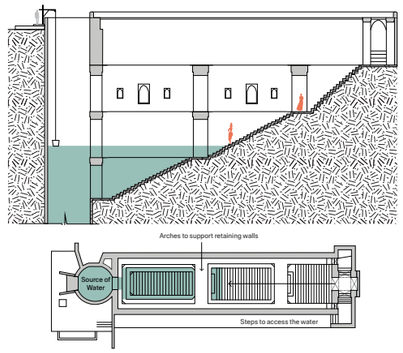
16th century onwards–no wheel is used anymore

approximately 1.5 meters. When a greater elevation was required, multiple mills were arranged in a stepwise configuration, allowing the water to be raised sequentially to the desired level.

From the nineteenth century onward, windmills were gradually replaced by pumping stations powered first by steam engines, then by diesel engines, and eventually by electric pumps. These mechanized systems offer far more consistent and reliable operation, enabling continuous water management independent of weather conditions. Their adoption marked a shift from wind-dependent to engine-driven hydraulic control, enabling greater precision in regulating the water levels in polders and waterways. In contemporary water management practices, emphasis has shifted. Rather than pumping excess water out of the lowlands as quickly as possible, management strategies increasingly focus on retaining water within polders to ensure sufficient water availability during dry periods. This transition reflects a broader shift towards adaptive, climate-resilient water management, aimed at balancing the challenges of both excess and scarcity. Nevertheless, in low-lying countries, such infrastructure remains essential. Unfortunately, modern pumping stations are often regarded primarily as technical devices, with little attention paid to expressing their pivotal role through design within broader water systems.

Basins and Tanks–Harvest and Storage Mechanism

- fluctuating water retention from a well feed by rainwater
- loamy sand to sandy loam
- dry climate—semi-arid—hot (BSh)
- stepped stone representative construction

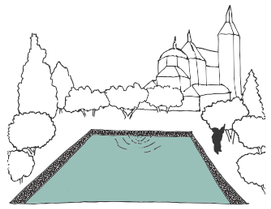


Fort Water System and Stepwells, Jaipur, India

Bavdis, Bawadis, Baolis, Vavs—a retention basin/tank to pray and drinking water supply—waterwork

7th - 19th century

- retaining water to ensure stable water flow for the mills
- stone soil
- temperate—warm summer—mediterranean (Csb)
- carved out of granite stone



Mill System in Rascafria, former Kingdom of Castile, Spain

Alberca—a retention basin/tank—waterwork

14th - 19th century

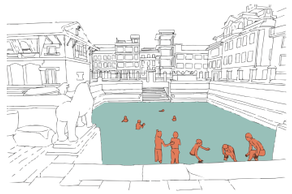
Throughout history, societies have constructed a wide range of structures to retain and store water, drawing from rivers, groundwater, or harvested rainwater, to secure supplies over extended periods. Such practices have been documented for millennia, particularly in arid and semi-arid regions, where water availability is highly variable and long-term storage is essential for survival. The scale and materiality of water storage systems vary considerably, ranging from small household vessels, such as ceramic jars and clay used in Cyprus, Japan, and Brazil, to larger infrastructural elements, including stone-lined cisterns, subterranean reservoirs, and extensive human-made lakes. Nice examples of built structures can be found in the Sassi di Matera, Italy. Rainwater, spring water, moisture, and snow are stored in different buildings carved into the bedrock to keep the water cool.

These storage mechanisms serve multiple purposes: they stabilise water availability across seasons, safeguard against droughts, and support domestic, agricultural, and industrial use.

In addition, soil serves as a water storage medium through infiltration. Access to drinkable groundwater is essential and is often provided through fountains worldwide or stepwells in India. In particular, the fountains provide more than just water; they are well ornamented and arranged in a square, becoming the community' s meeting point, primarily for women. Additionally, the much larger stepping wells in India, often beautifully ornamented, demonstrate a high value for drinking water. Large basins constructed of earth and stone are frequently associated with seasonal agricultural practices. When it rains, water is collected and directed to a lower point in the terrain where it is blocked by a wall,

- seasonal system, collecting rainwater and infiltration of water in the soil
- sandy soil
- dry—dessert—hot/semi-arid (BWh, BSh)
- earth dikes and clay top layer that collect water runoff

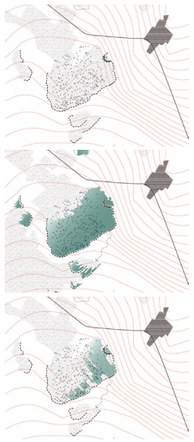
- temperate—dry winter—hot summer (Cwa)
- seasonal collecting of monsoon water
- silty clay, silt, sand, and gravel soil
- religious pond to pray and swim
- stepped stone construction



Hiti Pranali Water Stone Spout System, Kathmandu, Nepal

Pim Bahal Pokhari—a retention basin to pray and enjoy—waterwork

14th century onwards



Khadin Water System, Rajasthan, India

Khadin—earthwork collecting and infiltrating water—water landscape element

15th century onwards

- high tide sea water filling basins
- saline clayey-sand, marine coastal sediments
- temperate—dry summer—hot summer (Csa)
- temporal soil dikes basins



Maritime water system, the Alyki lagoon, Greece

Basins—to gain salt from seawater—water landscape element

1950 onwards, slowly disappearing

allowing it to infiltrate the ground slowly and enabling crops to grow, as seen in Rwanda. Over time, the construction techniques and storage capacities of these systems have evolved in response to demographic pressures, technological innovations, and environmental constraints.

Retention and storage basins have gained increasing relevance in contemporary water management in all climatic zones. Their function has expanded beyond securing the water supply; they now play a crucial role in moderating hydrological extremes. Retention basins help to buffer periods of excessive precipitation by temporarily holding surplus water, thereby reducing flood risks and mitigating shortages during dry spells by releasing stored water when necessary. As climate variability intensifies, such infrastructure is becoming a central component of integrated water management strategies aimed at balancing the conditions of 'too much' and 'too little' water. Unfortunately, the aesthetic quality of these large waterworks is often limited. They are frequently concealed underground or inconspicuously placed at the margins of a site. Such a purely functional approach overlooks their architectural and landscape-architectural potential; for instance, the possibility of designing these structures to serve as meeting places or vantage points within the landscape. Likewise, opportunities to enhance ecological value are often overlooked, particularly along the edges of larger basins, where carefully designed gradients can support diverse thriving habitats.

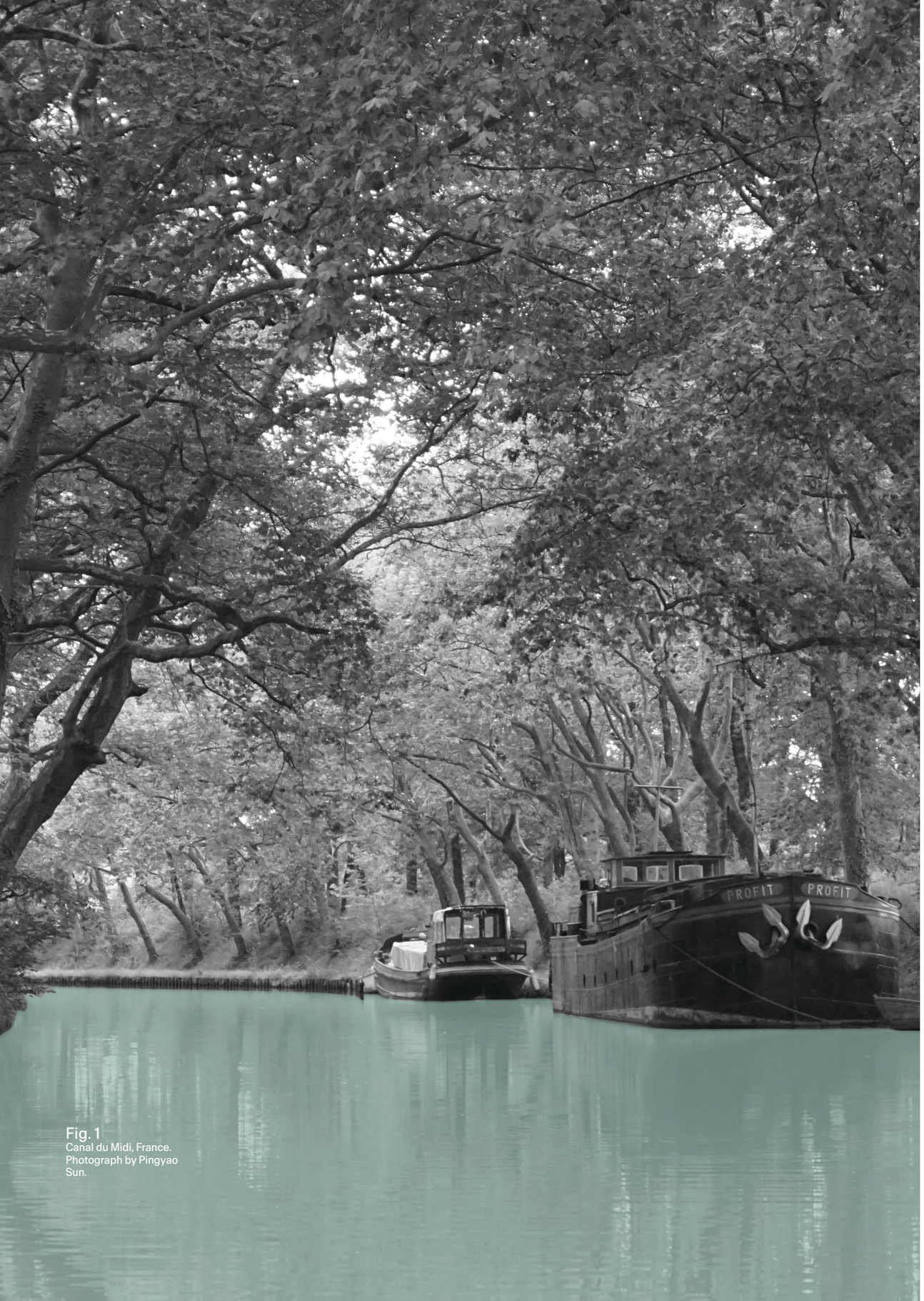


Fig. 1
Canal du Midi, France. Photograph by Pingyao Sun.

Grand Projects

Water as Infrastructure

Pingyao Sun[1], Keng Ching Chen[2] and Nicole Filippoli[3]

Traditional water systems are rooted in local needs and site-specific knowledge. However, certain water infrastructure projects also transcend borders, shaped by transnational and transboundary factors. These grand water projects combine large-scale engineering with local and regional insights. They often serve multiple purposes: supplying water, facilitating trade, supporting freight transport and stimulating cross-border economic activity. In doing so, they reshape vast territories and leave enduring marks on the landscape. This essay explores three such projects studied in the Circular Water Stories (CWS) lab: the Navigli Canal System in Milan, Italy; the Canal du Midi in the Languedoc and Aquitaine region of France; and the Industrial Zaanstreek in the Netherlands. These examples illustrate how water infrastructure of immense scale and ambition responds to geopolitical aspirations, shapes regional identities, and faces challenges of adaptation.

1 Ir. P. Sun, Co-hab Design Consulting (Zhuhai) Co., Ltd. | CAA City Planning & Engineering Consultants Ltd., China;
pysun117@gmail.com
0009-0003-0428-9470

2 Ir. K. Chen, Economic Affairs Department, Yilan County Government, Taiwan (R.O.C.);
3 Ir. N. Filippoli, SAP Studio Architettura & Paesaggio, Italy
0009-0008-6006-8775

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Nevertheless, as global dynamics evolve, the original drivers behind these projects may lose relevance, rendering their infrastructure less functional in new local contexts. A useful theoretical lens for reading grand infrastructural projects is offered by landscape-infrastructure scholarship, which reframes canals and water networks not as neutral, closed engineering artefacts, but as dynamic territorial systems that organise socio-economic life through flows of water, sediment, energy, labour and capital. Pierre Bélanger argues that modern infrastructures have historically normalised standardisation, mono-functionality, and permanence, logics that externalise ecological processes and render their wider biophysical dependencies effectively invisible, producing rigidity and vulnerability as context shifts (Bélanger, 2013). Against this, 'landscape infrastructure' proposes an expanded, cross-scalar operating system in which watersheds, soils, and living systems are understood as essential services that support urban economies, and in which design works through flexibility, interconnection, and the reclamation of ecological flows rather than end-of-pipe control (Bélanger, 2013).

As Bélanger (2009) argues, landscape infrastructure exceeds the provision of utility, functioning as an operative system that mediates ecological processes, economic productivity, and cultural meaning over time. This perspective is particularly apt for transboundary water corridors, whose relevance is periodically re-scripted by changing geopolitical ambitions, technologies, and regimes of mobility, foregrounds their territorial footprint beyond the canal prism, their life-cycle fragility, and their capacity to be reprogrammed as multifunctional socio-ecological infrastructures. Methodologically, it also legitimises the use of drawing and mapping as analytical instruments for revealing submerged relations—between hydraulic works and regionalisation, maintenance and obsolescence, environmental externalities, and cultural attachment—thereby enabling these European systems to be interpreted as landscapes that both materialise power and remain open to adaptive, contemporary rearticulations (Bélanger, 2013).

REFRAMING WATER INFRASTRUCTURE: PERSPECTIVES ON THREE EUROPEAN SYSTEMS

'Water infrastructure' refers broadly to systems for water supply, treatment, storage, management and energy generation, including transport systems such as canals (IGI Global, n.d.). While this term highlights engineering and functional aspects, landscape architecture has long interpreted infrastructure as landscapes, and vice versa (Strang, 1996). Redefined beyond its utilitarian role, the water infrastructure facilitates aesthetic, functional, social, and ecological relationships between natural and human systems (Nijhuis et al., 2015).

From this perspective, we present three cases—Navigli in Italy, Canal du Midi in France, and Industrial Zaanstreek in the Netherlands—each with unique values and a deep influence on regional landscapes. Unlike water projects based solely on local conditions, these infrastructures are notable for their scale; regional governance; and political, environmental, cultural, and financial relevance. However, like other traditional water projects discussed in the CWS lab, they are also susceptible to decline and underuse.

The Navigli System is an ensemble of navigable waterways in Italy, comprising six routes connecting Milan to the Alps, the Swiss waterways, and northwestern Europe. A total of 1,800 kilometres of existing rivers were navigable and extended through parallel canals. This water system ensured a direct connection between the continental hinterland and the sea routes from the east (Navigli Reloading, n.d.-a). Built between the 12th and 19th centuries, it brought prosperity to the medieval cities. Today, most canals are covered and now serve as motorcar lanes, while others are no longer in use.

The Canal du Midi is a significant trading route in southern France. Originally constructed to consolidate the power of King Louis XIV and boost the French economy, it created a permanent waterway that linked the Mediterranean Sea with the Atlantic Ocean (Sun, 2021). Built in the 17th century, this monumental hydraulic infrastructure stretches across half of France and is named after the administrative regions it traverses, Midi-Pyrénées and Languedoc–Roussillon. The canal comprises 328 hydraulic works including staircase locks, aqueducts, siphons, spillways, feeders, dry docks, and tunnels (UNESCO World Heritage Convention, n.d.). It showcases the ingenuity of French civil engineering (French Waterways, n.d.) and remains an important site for recreation and historical preservation. (Figure 1)

Industrial Zaanstreek[1] is a water system located northwest of the Amsterdam Metropolitan Area (AMA) in the Netherlands. The region originally covered approximately 8,300 hectares of polders[2]—land drained by ditches in the late Middle Ages. This water network was later connected to the Schermerboezem, making 27,000 ha of North Holland accessible to water. Zaandam, the region's commercial and cultural center, played a crucial role in establishing Amsterdam as a global trading hub during the Dutch Golden Age[3].

AT THE SOURCE OF THE WATER STORY: POWER, TRADE, AND SOIL

Grand water infrastructure is primarily constructed for navigation, but it often serves multiple purposes such as water supply, drainage, and discharge. To make these complex systems function effectively, humans have long modified the landscape by digging canals, building dikes, and installing engineered waterworks to shape the terrain according to hydraulic needs.

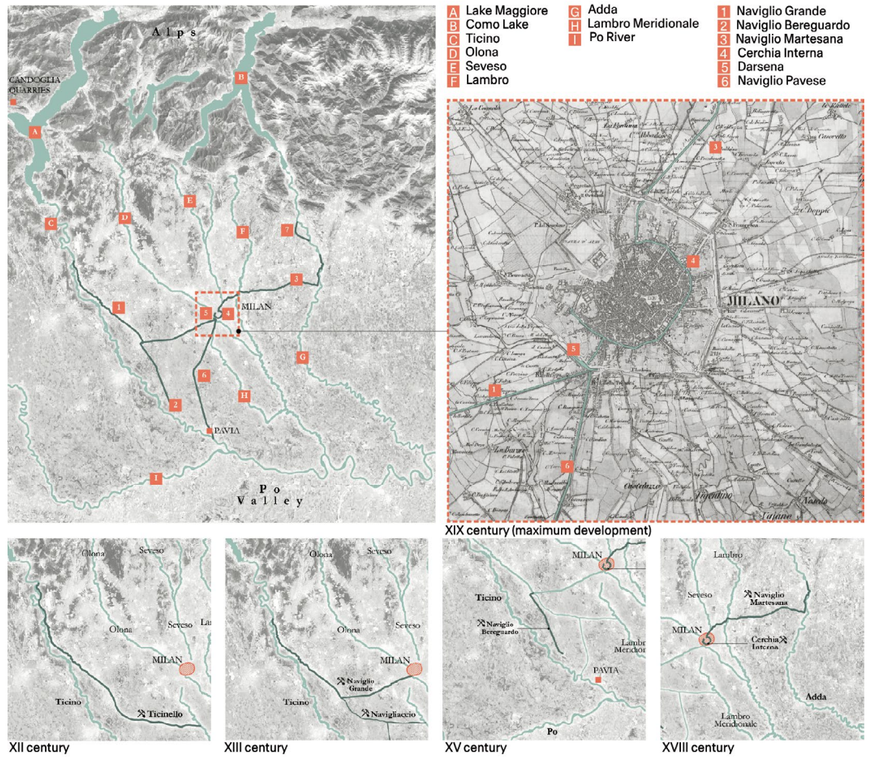


Fig. 2
The development of the Navigli system in the Milan region. Map by the authors, based on Arcanum Maps (n.d.).

Milan's waterways, including the Olona, Seveso, Lambro, Adda, and Ticino rivers—have played a vital role since the city's founding by the Romans in the 3rd century B.C. Initially used for irrigation, these rivers became strategic defensive features in the 12th century, with the construction of the Ticinello Canal in 1152 and a moat encircling the city in 1156, which later evolved into the Cerchia Interna (Monti, 1945). The term Navigli emerged in 1272, during the construction of the Duomo di Milano, when Ticinello was expanded into the 50-kilometre-long Naviglio Grande, used to transport marble for the cathedral (Treccani, n.d.). By the 15th century, additional canals, such as Naviglio Martesana and Naviglio Bereguardo, were excavated, connecting Milan to key trade routes. These connections enhanced Milan's commercial reach to cities such as Pavia and enabled access to Venice and the Mediterranean (Navigli Reloading, n.d.-b). The canals facilitated the movement of goods from the Alps to the sea, transforming Milan into a major commercial hub. Leonardo da Vinci's contributions further enhanced the navigability and water management of the canal system (Navigli Reloading, n.d.-c). (Figure 2)

The story of the Canal du Midi in France follows a different trajectory. Conceived as a royal initiative by King Louis XIV, the project aimed to connect the Atlantic Ocean to the Mediterranean Sea, thereby stimulating trade in southern France. Built between 1665 and 1681, the 242-kilometre canal linked mountainous inland towns to the coast through a series of advanced hydraulic innovations. Notably, the Montagnes Noires region[4] was transformed into a large reservoir to ensure a steady water supply, and a sequence of locks was installed to manage the elevation of the canal. These interventions enabled a stable water flow and reliable navigation capabilities that the region's natural rivers could not provide (Labat et al., 2006). (Figure 3)

In the Dutch lowlands, functional adaptations to water infrastructure have been continuous and transformative. In Zaanstreek, around the 13th century, ditches and canals were excavated to drain wet peat soils, converting them into arable land through a dense and ordered network. With ongoing soil subsidence, it became necessary to regulate the water table, leading to the construction of dikes to protect low-lying land from flooding. This has marked the development of a broader landscape. As peat rivers such as the Zaan and Amstel subsided, they were dammed to prevent water from IJ Bay from flooding the hinterlands.[5] These former rivers have become *boezems*.[6] Dams soon became crucial trading points, enabling goods carried by sea vessels to be transferred to the inland boats. Over time, these water networks have become the region's primary mode of transport. (Van den Berg et al., 2017; Van Sijl & Beukers, 2012) (Figure 4)

Fig. 3
Canal du Midi's water system. Adapted from Sun (2021).

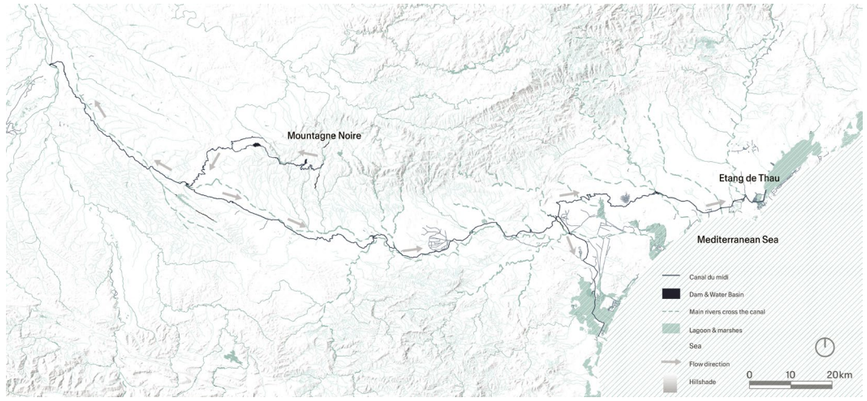
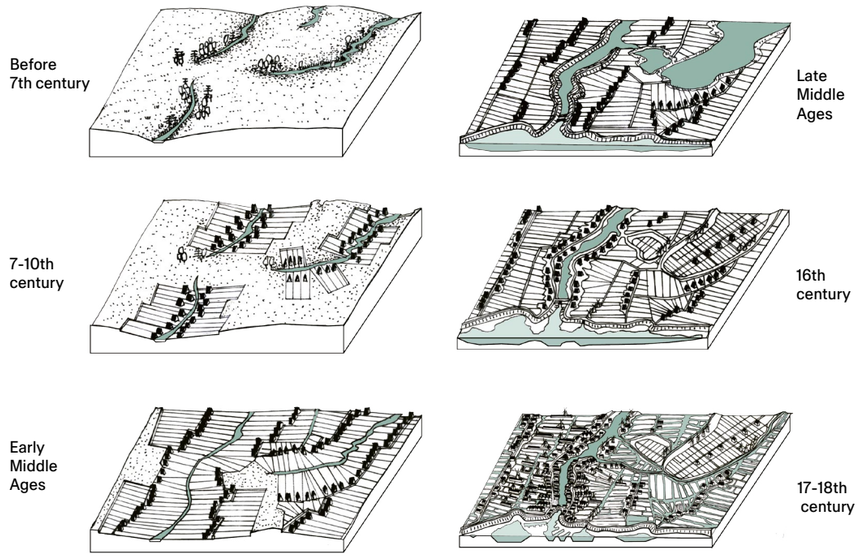


Fig. 4
Land reclamation process in Zaandam: the peatland is constantly subsiding, threatening the hinterland with flooding and storms and leading to the development of dike–dam systems. Adapted from Chen (2023b).



THE SHIP LOCK: A KEY TO TRADING FORTUNE

Among the most essential waterworks, ship locks play a central role in all three examples. It is fundamental to enable water infrastructure to function as an efficient bidirectional transport system. Locks are designed to overcome elevation differences, making waterways navigable in both the directions. Two gates enclose a chamber that can be filled or emptied with water, raising or lowering the vessels to match the water level on the adjacent stretch of the canal.

A total of 35 locks were constructed across the Navigli Canal System. The first, the Viarenna Lock, was built in 1438 to transport massive marble blocks from the Candoglia quarries[7] to Milan for the construction of the cathedral (Houseboat.it, n.d.). This lock had a height difference of three metres. During his stay in Milan in 1482, Leonardo da Vinci studied the lock system and designed several improvements, including two locks that connected Naviglio Martesana to Cerchia dei Navigli, effectively linking the Adda River to the Ticino River. These enhancements, most notably the Incoronata Lock built in 1496, were pivotal for transforming Milan into a key node in the internal waterway network (Fontane di Milano, n.d.; Navigli Reloading, n.d.-c). These innovations enabled efficient transport between the Alpine lakes, Po River, and Mediterranean, establishing Milan as an important inland port. (Figure 5)

In Canal du Midi, the ship locks accommodated considerable elevation changes, amounting to 246 m across their full length (Canal du Midi, 2024; Ministère de l'Intérieur, n.d.).

In Zaanstreek, the ship lock was built into a dike adjacent to the dam, separating the outer water of the IJ from Zaan. Only smaller vessels can pass through this lock to sail from Zaan into the polder. Larger ships remain in the outer waters, requiring cargo to be transferred to smaller boats. Within the polder, the water levels were kept uniform, eliminating the need for locks. As elevation changes were minimal, usually only a few centimeters, the locks constructed here were relatively small but numerous, distributed throughout the low-lying regions of the Netherlands.

Locks are critical waterworks, particularly when canals must traverse uneven terrain. Over time, ship lock design has evolved significantly from timber to steel construction, from rudimentary mechanisms to sophisticated

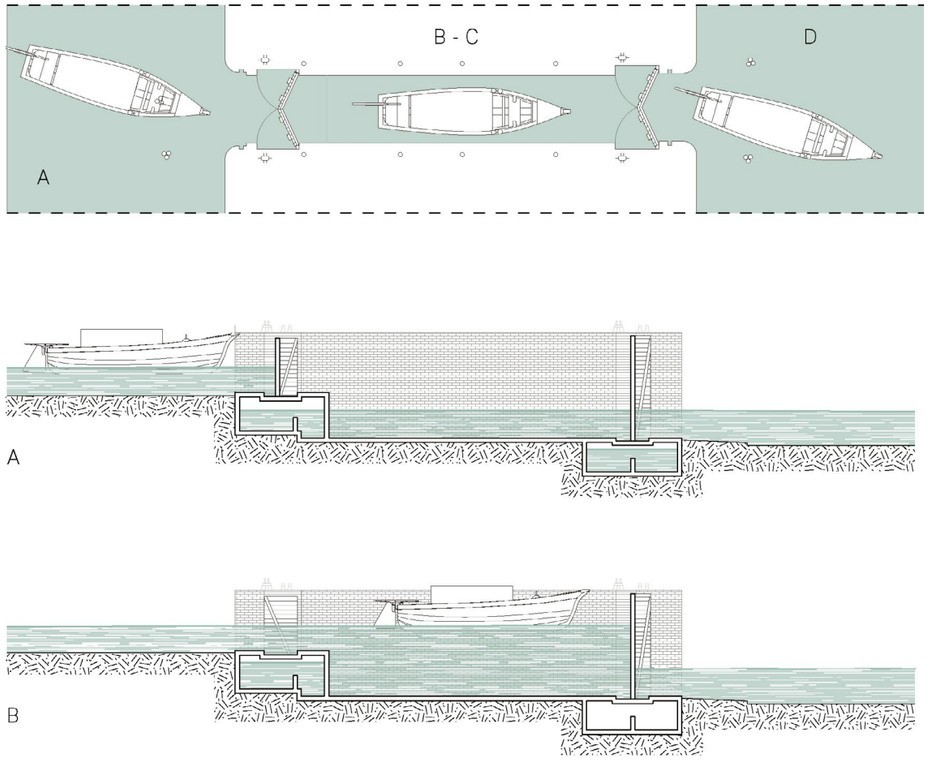


Fig. 5
Section and schematic diagram of the Incoronata Lock. Phases:
(A) Filling of the chamber and opening of the upstream gates;
(B) Entry of the boat into the lock and closing of the upstream gates;
(C) Opening of the valves to drain water and lowering the water level inside the lock;
(D) Opening of the downstream gates and exit of the boat. Adapted from Filippoli (2023).

engineering solutions, and from modest to large-scale capacity. Locks are now being built worldwide. Without them, many lowland regions would be inaccessible; many canals would either become unnavigable or allow travel in only one direction. Their absence also leads to far longer and less efficient shipping routes.

LIVING TRADITIONS: WATER, URBANITY, AND LOCAL CULTURAL IDENTITY

The capacity of humans to adapt to water has played a crucial role in shaping the expansion of settlements. Three distinct urban forms emerged in the cases examined, each profoundly influenced by its water infrastructure. Before roads became central to urban planning and transport, water infrastructure was the backbone of spatial organisation. Beyond their urban extent, the Navigli, Canal du Midi, and Zaanstreek systems shaped regional development by generating specific socio-economic configurations, historical identities, and site-specific festivals and rituals. Ways of living with and alongside water have deeply informed local customs, traditions, and everyday practices. Together, these three cases illustrate a reciprocal relationship between water infrastructure and cultural formation. (Figure 6)

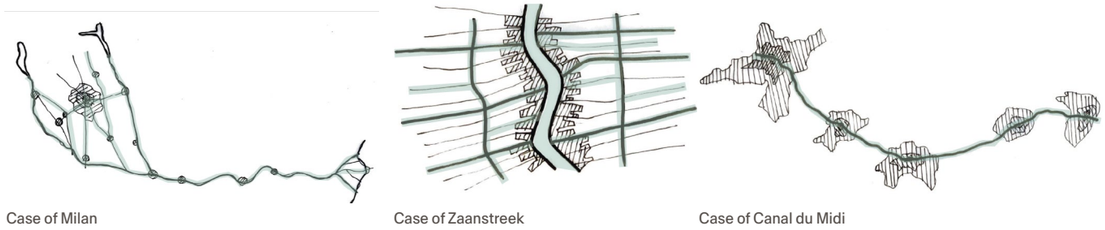


Fig. 6
Three urban fabrics developed in relation to water infrastructure. The water network influences the urban pattern of Zaandam; the Navigli centres on Milan as the system's core; and the Canal du Midi acts as a linear thread along which cities developed. By the authors.

Both Navigli and Canal du Midi are characterized by multi-centric urban development along a central waterway. At that time, these canals were the principal infrastructure for transporting goods and people, and they played a defining role in urban growth. In Italy, the Navigli System facilitated urban expansion from the Alps to the Mediterranean. Similarly, in southern France, numerous villages and towns have developed along the Canal du Midi. New settlements such as Sète emerged, capitalizing on the canal's enhanced trading potential and enabling the export of regional goods to international markets. The town of Castelnaudary grew so closely with the canal that it became known as 'the city of the Canal,' with the Saint-Roch lock basin becoming integral to its identity (Jefferson, 2014). Compared to the more evenly distributed pattern of Canal du Midi, the Navigli system focused on urban development around Milan, a city located equidistant between the Alps and the Mediterranean in the swampy Po Valley. By the late 19th century, owing to the concentric layout of its waterways, Milan was referred to as a water city, akin to Venice and Amsterdam.

In Milan, the Navigli system reflects the city's historic prominence as a centre of art, religion, and commerce. As historical sources suggest, 'Milan became an important river port, which enabled it to receive grain, iron, and especially timber at less expense [...] in short, to make up for the flaw of being a city amid land'(Boatti & Prusicki, 2018). From 1272 onwards, the Navigli waterways were used to transport marble blocks for the construction of

Fig. 7
The Water Jousting Festival in Sète, France. Adapted from a photograph by Felix Koenig.



the Milan Cathedral. This architectural masterpiece remains a symbol of religious authority and artistic excellence. Over time, the canal network expanded and refined into a sophisticated system that facilitated the movement of goods and enabled intercity waterborne connectivity. One notable element was the Cerchia dei Navigli—a 6.5 km-long, 9 m-wide ring of water that encircled Milan's medieval centre (Riaprire i Navigli, n.d.). This infrastructure helped establish Milan as a major inland port, and nurtured a distinctive economic culture rooted in waterborne trade.

The Navigli system has long been remembered as a place of everyday intimacy and vibrant social life, a setting where friendships formed, markets bustled, marriages took place, and leisure activities such as hunting, fishing, games, and informal gatherings unfolded regularly. The navigation itself was remembered with poetic clarity: 'The sailing was as smooth as can be imagined, smooth, along the bank: it seemed like sailing in the middle of meadows' (Boatti & Prusicki, 2018). These recollections highlight how the waterways were woven into daily life, not only for transport and commerce but also as places of gathering and community. (Figure 9)

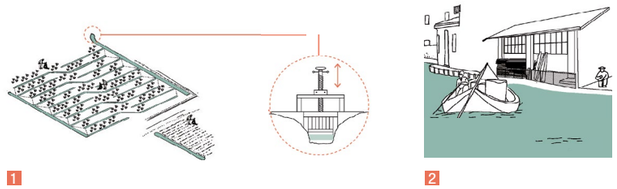
In contrast, the Canal du Midi was an ambitious royal project designed to forge a commercial route between the Atlantic and the Mediterranean in southern France. The region known as le Midi (Lyons, 2022), renowned for its wine, cuisine, and thriving agricultural economy, was historically the first part of France to be annexed by the Romans around 125 B.C., and traces of Roman civilization remain visible to this day (Mukerji, 2009). The construction of the Canal du Midi fused Roman water management knowledge with emerging modern techniques just before the dawn of the Industrial Revolution. Military engineers were trained in Roman structural principles, whereas local peasants retained practical knowledge of Roman hydraulics. Thus, this canal represents not only an engineering feat but also a cultural convergence, a kind of reunification of classical Roman heritage with Enlightenment-era French ingenuity (Visentin & Vallerani, 2017).

Along Canal du Midi, the repeated presence of washhouses, lockhouses, cafés, chapels, and waterside paths has created a vibrant social fabric. These public and semi-public spaces were frequented by local inhabitants, boat crews, and travellers alike, making the canal not just a means of transport but a lived and performative space. Beyond everyday life, water has also inspired celebrations. In the port city of Sète, a long-standing tradition continues with the Water Jousting Festival at the eastern end of Canal du Midi. Two jousters, each standing on a raised platform at the stern of a rowing boat, compete to attempt to knock their opponent into the canal with a shield and wooden lance (Go Languedoc, 2026). This exuberant spectacle, steeped in local identity, remains a cherished and widely attended festival today. (Figure 7)

In contrast, the water pattern in the Zaandam area emerged directly from land reclamation efforts. Ditches were dug perpendicular to the peat river, allowing water to drain and land to be cultivated. Zaan became the main navigable and drainage channel for the area, offering higher edges that served as favorable locations for housing. Factories, often accompanied by windmills used to saw timber or generate mechanical power, were positioned along ditches in open fields. Over time, this activity led to a densely built landscape. The accessibility of the area declined somewhat after the construction of a dam and sluice between Zaan and IJ, but the network continued to function. Later, owing to continued peat subsidence, a dike had to be constructed along the Zaan River. This transformed low-lying land into polders. However, this process disrupted the expansive water network, contributing to the decline of shipbuilding towards the end of the 18th century. The increase in sluices, each needed to manage different water levels between Zaan and the surrounding polders, made shipping slower and more expensive. (Figure 8)

In the 17th century, Zaandam became a living expression of Dutch cultural identity, defined by its relationship with water. The town is known for its shipyards, marine infrastructure, and status as a hub in the global free market, with more than 700 ships sailing annually to the Baltic Sea (Van Braam et al., 1970). This prosperity was made possible by amphibious culture and an acute understanding of how to inhabit and thrive in a water-dominated landscape (Van Dam, 2016). Waterways were everywhere, lined with floating rafts, drifting logs, and skeletal frames of ships under construction.

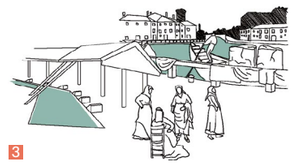
Fig. 9
Production and living by water in Milan. Includes drawings adapted from Filippoli (2023).



1
Marcita
Permanently irrigated terrain, whose grass gets protected by the water temperature in order to grow even in the winter months.

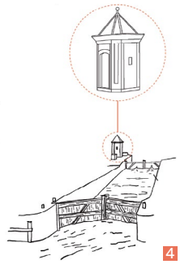
Bocche in fregio
Hydraulic system used for irrigating fields and regulating water diversions from the Navigli.

2
Sciostra
Typical shop in old Milan, acting as a warehouse and selling various products from coal to building materials.

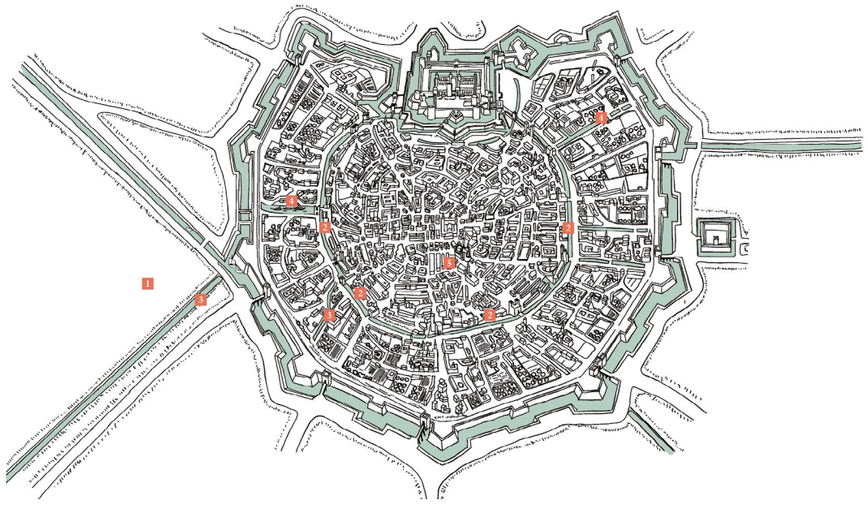


3
Lavatoio
Wash-house used to clean clothes before the advent of public baths. Before the 19th century, personal hygiene was achieved by washing clothes only. In what was known as "brellin" a wooden board, the laundresses used to soap their clothes.

Gabelliere tower
Workplace of the gabelliere, the person who collected the duty tax for goods transported in or out of the city on behalf of the authority.



4
Navigation lock
Hydraulic system that acts as a kind of elevator tor boats. It allows the latter to go up or down the grade created by the different water levels, and it works by harnessing the force of the water.





5
Cascina degli Scalpellini
Construction right adjacent to the Duomo where the marble was processed and modelled by skilled workers under the guidance of architect, designers and artists.

Fig. 8
The water system and urban fabric of the Zaanstreek region. Dam cities developed around dams constructed where peat rivers met larger waterways. In the surrounding villages, settlement expanded along the existing water infrastructure, with development following the linear pattern of river dikes and polder drainage ditches. Together, these hydraulic structures shaped the characteristic spatial layout of the region. Adapted from Chen (2023a).

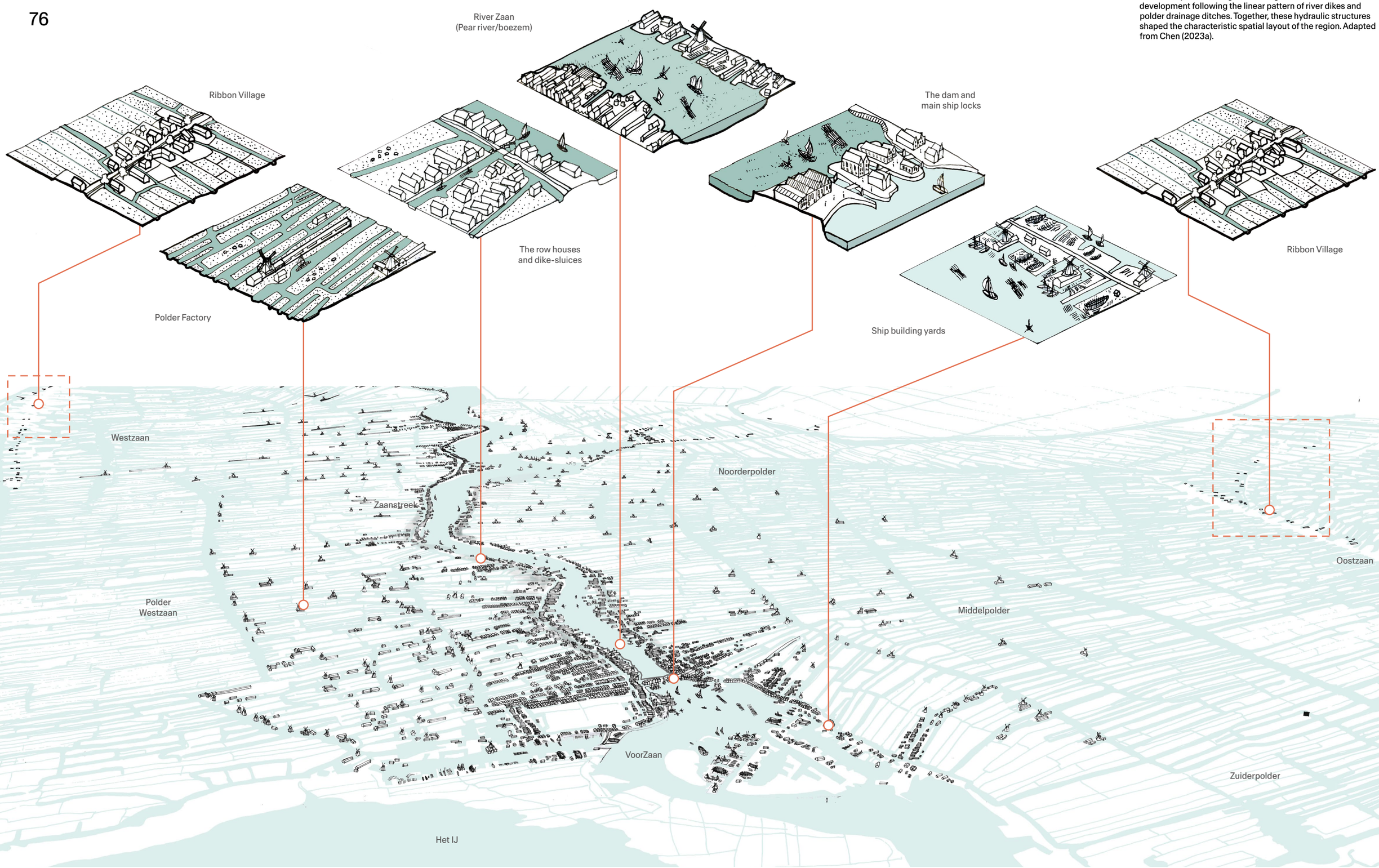


Fig. 10
Living by water in the Zaanstreek. Ships used in international trade (especially timber, on the left-hand side of the engraving) and for regional transport. Adapted from an engraving by Andries de Leth and Hendrik de Leth (1726).



Hundreds of windmills dotted the horizon, driving industrial activities such as timber sawing and grain processing. This landscape, shaped by mercantile ambitions, gradually gave rise to a dynamic industrial and commercial identity. (Figure 10)

In Zaanstreek, a similar close interaction between water and people has shaped the region's culture. Here, every household traditionally possessed a boat, used not only for fishing, but also for local and regional mobility. Over generations, many fishermen have evolved into international traders and deep-sea navigators. The region's thriving economy, anchored in lumber and other waterborne industries (Van Braam et al., 1970), is inseparable from the fluid connectivity enabled by water transport.

The role of water as both a navigational route and a productive resource made these infrastructure magnets for economic and social interaction. The interplay between technical innovation and everyday life has long defined such systems. Traditional water networks became centres of commerce and craftsmanship, shaping the rhythms of village life and instilling each with a distinct character. Water was part of the daily urban experience; launderesses, swimmers, rowers, and fishermen were woven into the fabric of public life. Waterways were also perceived as safer than land routes, less vulnerable to brigand attacks, and thus better suited for fostering relationships and trade. This sense of security, combined with transport efficiency, enabled merchants and traders to flourish, largely unburdened by the temporal or logistical constraints associated with overland travel.

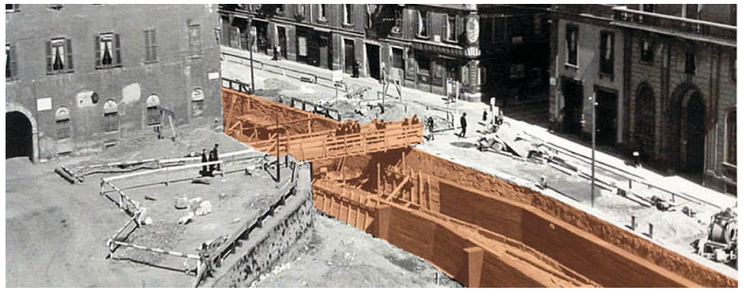
ADAPTATION AND POTENTIALS, FROM TRADING CORRIDORS TO COMPLEX SOCIO-ECOLOGICAL SYSTEMS

With the rise of railways and expansion of air and road transport networks, many historic waterways have lost their economic primacy. Grand infrastructure projects that had driven regional development and global trade began to fade in relevance. Despite their diminished utility, these infrastructures retain cultural and historical significance and today prompt renewed interest in their capacity for transformation.

In Milan, the industrial boom of the 19th and 20th centuries brought rapid urban growth. The surge in population and lack of modern sanitation systems have turned the Navigli canals into open-air drains. Their polluted waters became a civic burden, especially once the railway network replaced the canals as the dominant mode of transport. By the mid-20th century, many of Milan's waterways had been culverted, converted into sewer channels, or entirely covered by roads. (Figure 11)

Canal du Midi underwent a series of modifications to modernize its infrastructure. The Agde lock, which was originally a circular design, was extended to accommodate larger vessels. However, these changes came at cost. These alterations were expensive and perceived as damaging the canal's historical and aesthetic integrity. Critics argued that modernization compromised the heritage value of the locks, prompting renewed discussions about preservation and use. (Figure 12)

Fig. 11
Evolution of the urban fabric of Milan: the water basin known as the Laghetto di San Marco, connecting the surrounding canals (bottom left). The gradual infilling of the basin (top). The modern landscape, now car-oriented, with underground parking replacing the basin (bottom right). Composite image by the authors, based on historical photographs by unknown photographers (before 1930, public domain) and a contemporary photograph by Roberto Arsuffi.



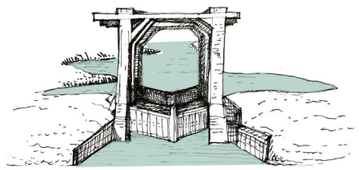


In Zaandam, the challenge arose from the increasing size of the ships. The locks connecting Zaan to the IJ had to be regularly enlarged to accommodate the growing cargo vessels. While the main infrastructure, including sluices, dikes, dams, and pumping stations, was continually upgraded, many smaller polder ditches remained unchanged (Hijdra, 2017). Cleaned every three to five years, these ditches have retained their original form and are now recognized as part of the region's cultural heritage. (Figure 13)

Although these historic waterways have lost their central function in trade and freight transport, they continue to play a valuable role in contemporary life. Their ongoing presence offers opportunities for diverse reinterpretations ranging from agriculture to leisure and tourism. These examples illustrate how water infrastructure, although no longer central to commerce, remains deeply embedded in the evolving life of cities and landscapes.

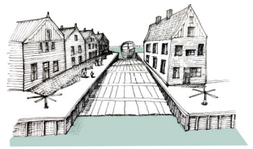
Fig. 12
Evolution of the Round Lock of Agde in the Canal du Midi before (left) and after (right) its enlargement. Composite image by the authors, based on a historical postcard by an unknown author (c. 1900, public domain) and a contemporary photograph by Miguel Espada (2022).





1544

The Grote Sluis (Great Sluice) was built.



1608

The construction of the Overtoom, for dragging large ships cross the dam.



1722

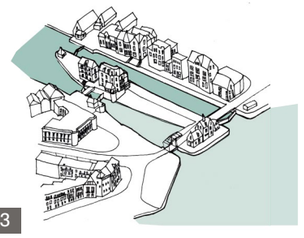
Rebuild the Grote Sluis/Hondsbossche Sluis



28m x 5.1m x 2.6m(depth)

1876

Opening of the North Sea Canal



1903

Wilhelminasluis was constructed



120m x 12m x 3.7m(depth)

Wilhelminasluis renewed/enlarge

2020



156m x 14m x 4.7m(depth)

1500 1600 1700 1800 1900 2000

Fig. 13
The enlargement process of the main lock in Zaandam. Includes drawings adapted from Chen (2023a).

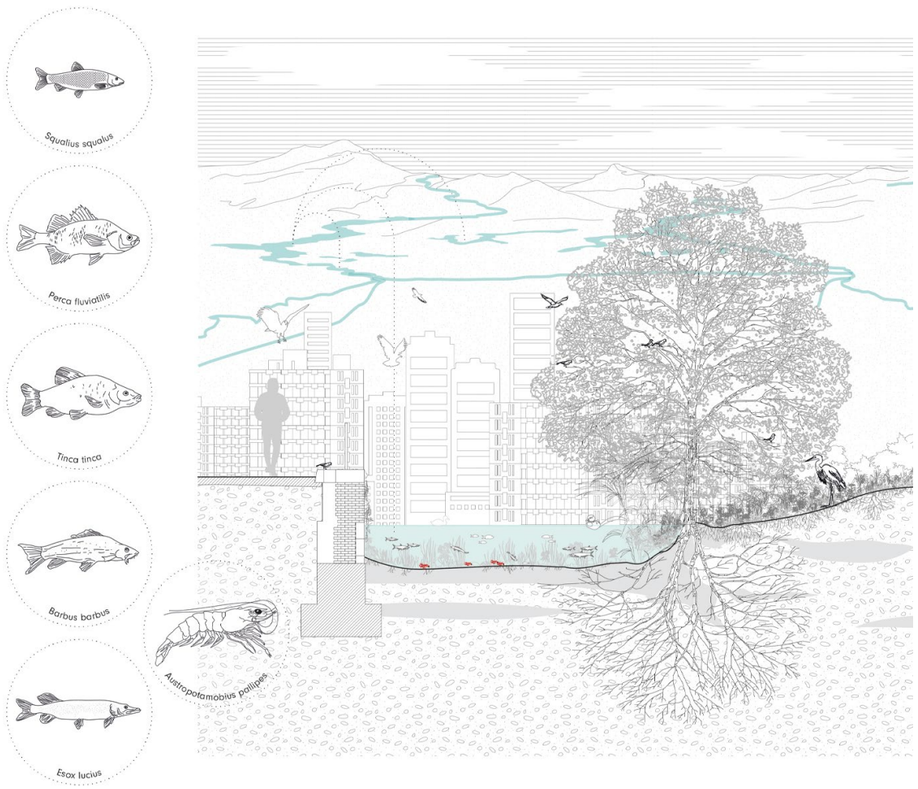
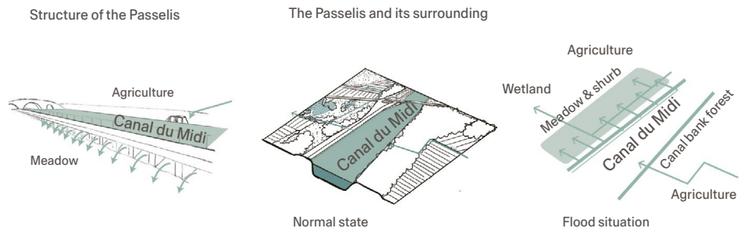


Fig. 14
The naturalisation of canal banks in Milan.
Adapted from Filippoli (2023).

Fig. 15
The *passelis* system along the Canal du Midi.
By the authors.



In Milan, Naviglio Grande and Naviglio Pavese now serve as picturesque backdrops for nightlife and local gatherings. Despite their marginalisation in terms of infrastructure, they have gained renewed attention for their potential for irrigation, tourism, and recreation.

Meanwhile, the Canal du Midi officially ceased transporting freight in 1989. The railway and the two world wars have long since diverted major traffic. In response, the canal was reimagined as a tourism and leisure site. By the 1980s, it had been promoted as a linear park ideal for slow travel, boating holidays, and heritage tourism. Since 1973, the canal has also been used for agricultural irrigation and the provision of drinking water, now serving approximately 185 communes. These adaptations show how a single infrastructure can evolve to serve multiple-layered functions over time.

In Zaandam, the water system has gradually been redefined as a recreational and natural resource. The polder landscape, threaded with canals and ditches, now hosts rowing and leisure boats. These slow-paced activities allow residents and visitors to experience an almost medieval water landscape, which is complete with windmills rising on the horizon. The familiarity and persistence of this waterscape provides a strong sense of place and historical continuity.

While the ecological potential of historical water infrastructures has rarely been considered at the time of their construction, the decline in their transport functions has opened new opportunities. As shipping faded, ecological values began to emerge, as communities rediscovered the role of canals and polders in supporting biodiversity, habitat restoration, and climate resilience. In Milan, natural processes have begun to reshape Navigli Canals into unexpected reservoirs of biodiversity. Their expansive connectivity allows species from alpine lakes and surrounding rivers to

migrate, sometimes in search of refuge from predators or pollution. Naviglio Martesana provides a clear example: In the absence of industrial disturbance or freight traffic, the canal now supports calm waters in which aquatic plants take root. These plants create habitats for a wide range of wildlife, from amphibians and fish, to birds and small mammals. Over time, these canals have attracted migratory species and insects, thereby forming a layered and dynamic ecosystem within the urban fabric. Along Navigli, residents and visitors now enjoy walking and cycling routes that pass through green corridors, teeming with life. This transformation speaks not only to the resilience of natural systems, but also to Milan's evolving vision of sustainability, one in which historical memory and environmental awareness coexist. (Figure 14)

In the case of Canal du Midi, the water system was embedded in a broader network of rivers, canals, and wetlands. These interconnections provide a water supply to the canal while also creating valuable floodplains and riparian habitats. In recent years, ecological thinking has been integrated into new design interventions, particularly in response to the increased flooding linked to climate change. One such innovation is the passelis[8], a spillway system that allows water from high-lying rice fields to flow across flat land into the canal. These areas were intentionally left as floodplains, functioning as dynamic wet zones that support both flora and fauna (Sun et al., 2023). (Figure 15)

In Zaandam, the polder water system supports ecologically valuable peatlands that are now actively managed as conservation landscapes (Sweco, 2023). Polder Westzaan, on the city's western edge, is a prime example: a diverse mix of brackish waters, bird meadows, and insect habitats is gradually reestablishing itself. Through natural succession, sphagnum moss is a key indicator of peatland health and a vital component of long-term CO_2 storage. Because the soil conditions in these landscapes depend heavily on water quality and regulation, historic polder canals have taken on a renewed environmental role as mediators of ecological restoration.

These transformations led to a larger shift in perception. Water, once seen only as a functionalistic infrastructure designed for navigation and drainage, is now being understood as an agent within a larger blue-green infrastructure, creating space for deeper and more complex socio-cultural contamination. The historic waterways of Milan, southern France, and Zaandam have been transformed into hybrid systems that support biodiversity, ecological networks, and human well-being, while revealing how long-standing infrastructure can serve as a laboratory for ecological adaptation. As pressures from urbanization and climate change grow, these living systems offer valuable models for more integrated landscapes. (Figure 16)

INFRASTRUCTURES AS LANDSCAPES AND LANDSCAPES AS INFRASTRUCTURES

When considered beyond their engineering functions, these grand projects reveal new layered meanings. The complementary perspectives on Navigli in Italy, Canal du Midi in France, and Zaanstreek in the Netherlands demonstrate that water infrastructure plays a fundamental role in shaping not only the physical landscape but also the cultural identity of a region. Although no longer central to trade or industry, these systems continue to contribute meaningfully to contemporary society. They enhance the quality of life through leisure and tourism, reveal the multifunctional potential of water, support ecological diversity, and preserve essential historical and cultural narratives.

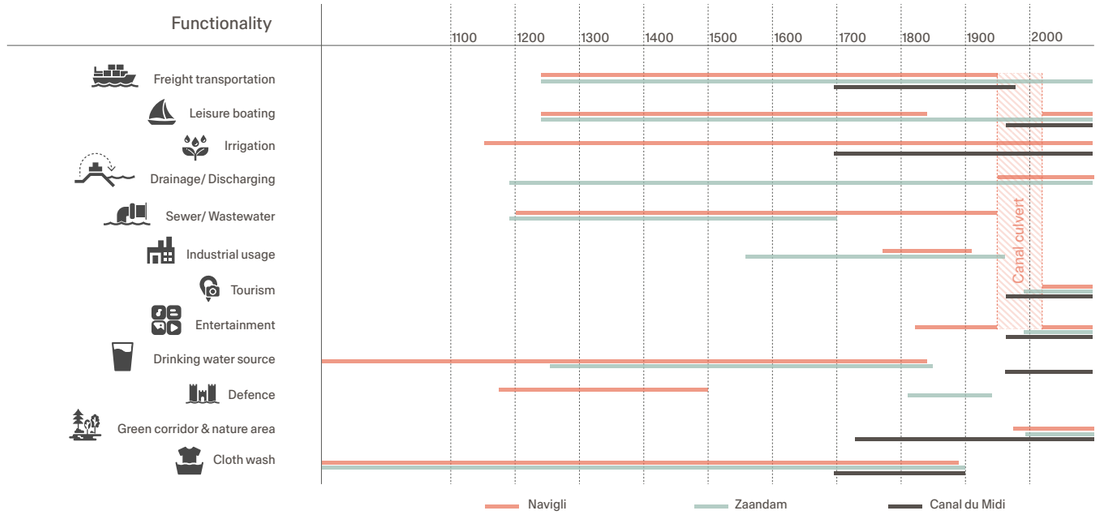


Fig. 16
Comparison of the functions of the three cases over time, showing shifts in the use and meaning of water infrastructures. By the authors.

Reading through political ecology, however, the three systems also reveal how infrastructure connects nature, society, and power. Their construction reorganized landscapes around particular flows of water, labor, materials, and trade, generating prosperity for connected cities and industries, while making local economies dependent on wider political and commercial networks. When railways, larger ports, and global trade routes redirected these flows, physical infrastructure remained, but the livelihoods and economies that had sustained them weakened. Their decline and later transformations, therefore, cannot be understood as purely technical processes: they reflect the changing distributions of investment, access, environmental burden, and political priority. Hence, reassessing the values embedded in these infrastructures allows us to see them as reservoirs of knowledge that hold spatial, ecological, and cultural insights that can inform the future planning and design of large-scale infrastructure and cities.

In this sense, Navigli, Canal du Midi, and Zaanstreek stand as archetypes of what we now call blue-green infrastructure. They demonstrate how infrastructure can be read and designed as landscapes, just as landscapes can function as infrastructure. Bélanger's concept of landscape infrastructure helps explain this reciprocal relationship: their value lies not in individual canals, locks, or ecological features, but in the way water, soils, habitats, settlements, economies, and cultural practices operate together. Further, as cities increasingly explore a shift towards blue-green infrastructure, the transformation and continued adaptation of these grand water projects offer operational precedents for aligning local ecological and socio-economic adaptation with macro-level forces of governance, investment, trade, and mobility.

NOTES Grand Projects

1. The word 'streek' in Dutch means 'region.'
2. Polders are the land which is surrounded by dikes which have an enclosed inner water system.
3. Approximate 1588–1672.
4. The Montagnes Noires is a mountain range in central southern France, known as the 'Black Mountain' in English.
5. The 'IJ' is an inner sea in between Amsterdam and Zaandam in province North Holland, it is conncected to the Zuider Zee and further the North Sea. The IJ has been reclaimed into polders and where the North Sea Canal was also built. (Engel et al., 2017)
6. A network of larger water bodies, mainly canals, that drains water from the polder system towards the sea. Today, most *boezem* systems are also situated below mean sea level (NAP) and need pumps to discharge the water (Hooimeijer, 2015).
7. In the north-west Alpine area, in Piedmont, are located the quarries from which the marble that makes up the Cathedral comes.
8. The passelis, a type of specially designed spillway system.

Water as a Source

Various traditional methods and techniques used by communities worldwide to cultivate land for food production have been sustained for hundreds of years. A profound understanding of how nature works and the mutualistic symbiosis of ecosystems are values that guide people's choices to live. Consideration of nature, seasonal changes, and the soil's carrying capacity led to alterations in topography and water flow to optimize food production and overcome unfavorable conditions.

The elevation, topographic conditions, and water quality of the seven traditional agricultural and aquaculture communities are displayed. Despite these differences, there are some similarities. Land reclamation occurred in the Chinese lake, Xinghua Duotian floodplain, and Kuttanad deltaic region. The land was raised above the water level or drained to create arable land. Traditional construction techniques use local materials and are therefore sustainable. Irrigation systems allow communities to grow various crops, and through intercropping and crop rotation, land profitability is maximised while maintaining soil quality. In the Harnham Water Meadows, the land is flooded at a particular time of the year to improve the soil fertility. Moreover, river water helps prevent diseases and adds to the growing season.

Fig. 1
Chinampa farming in Xochimilco, Mexico. Adapted from a photograph by Catalina Rey-Hernández.

Focusing on Food Production

INTERMEZZO



Fig. 2
Traditional food production practices organised according to water levels and salinity, from freshwater to brackish-water environments. (bottom) Maps of the six traditional water systems. Composite image including photographs and drawings developed within the Circular Water Stories lab.
By the authors.

The hydrological patterns and seasonal succession that influence water quality (freshwater and brackish water) were also well understood by the locals, who shaped the pattern of aquaculture in the Venetian Fishing Lagoon and the cyclical operation of agriculture and aquaculture in Kuttanad Kayalniyad Farming. Kampung Naga and the Linpan System of cultivation represent ecological, self-sufficient settlement units. An integrated river, woodland, and cultivated-land system supports the community's way of life. Despite the different topographies, people in both settlements live close to the water, irrigate small-scale fields with it, use it for daily life, and socialise beside it. While the raised agricultural land and canal systems in China, Xinghua Duotian, and Kuttanad tackle the threat of floods, the terracing system in Kampung Naga reduces the risk of landslides on steep slopes. In these steep landscapes (or sloped landscapes), traditional methods and tools for working in the fields are still used because of the limited access caused by the landform and the strong cohesion of the community. All of these systems are the result of the collective work of the people. These collective works embed agricultural activities into the community's culture (lifestyle) and values (rituals). Shared responsibilities and equal prosperity for the community are factors that have helped these traditional systems survive.



Fig. 1
Birdseye view of Xinghua Duotian agrosystem. Source: China-Xinghua Duotian Agrosystem - GIAHS.

Feeding Waters

Emerging Perspectives on Traditional Agricultural Landscapes

Catalina Rey-Hernández[1], Naeema Ali[2], Rapa Surajara[3], Yuan Yuan[4]

This essay examines four traditional agricultural landscapes: the Chinampas in Mexico, the Kayalnilams in India, the Xinghua Duotian Agrosystem, and the Honghe Hani Rice Terraces in China, to draw lessons for sustainable, climate-resilient food production. With agriculture consuming 70% of global freshwater and food demand projected to rise by over 50% by 2050, these centuries-old agricultural systems demonstrate how working with natural water cycles, local resources, and ecological processes can sustain food security, livelihoods and biodiversity. A comparative framework reveals that their longevity stems not from fixed practices but from a capacity to adapt production, technologies and livelihoods to shifting environmental and socio-economic conditions. Four lessons emerge: circularity in water and nutrient flows, resilience to climate extremes, the interdependence of food, ecology and society, and the advantages of nature-based production over extensive monoculture. However, these systems face mounting pressures from ageing farming populations and urban expansion, which can fragment the relationships sustaining them. The chapter argues that contemporary agro-landscape planning should foster adaptive frameworks rather than rigid master plans, enabling water systems, production capacities, and local livelihoods to evolve together while preserving their ecological foundations.

1 Ir. C. Rey-Hernández, Water Resources Management Group, Department of Environmental Sciences, Wageningen University & Research, the Netherlands; catalina.reyhernandez@wur.nl 0009-0001-9516-1047
2 Ir. N. Ali, Witteveen+Bos, United Arab Emirates 0000-0002-3498-3397
3 Ir. R. Surajaras, OKRA Landscape Architects, the Netherlands
4 Ir. Y. Yuan, Harbin Institute of Technology, China 0009-0001-3516-0472

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Water is at the heart of agriculture, weaving together the threads of our food systems and sustaining our global population. As we strive to feed a growing population, the relationship between water and food production becomes more crucial. Strikingly, agriculture consumes 70 per cent of the global freshwater resources, a figure set to skyrocket, as the demand for food production is projected to increase by over 50 per cent by 2050 (Kumar et al., 2022). To navigate this future, we must deeply understand the role of water in our food systems and provide a more water-efficient and resilient approach.

In this light, we can examine the past for inspiration. Traditional agricultural practices have evolved sustainably and are closely tied to water systems that support water management, supply, flood and drought protection, irrigation, and drainage infrastructures. By examining these traditional practices, we can better understand the global food security challenges and their links to water. Despite their resilience, traditional agrosystems have experienced several changes owing to overarching impacts. Therefore, it is crucial to explore these transformation strategies.

Four representative cases were selected: Chinampas Agrosystem, Xochimilco in Mexico (Figure 2), Kuttanad Kayalnilam Agrosystem (Figure 3), Xinghua Duotian Agrosystem (Figure 4), and Honghe Hani Rice Terraces (Figures 1 and 5). Whether nestled in the high mountain valleys where Chinampas flourish, the below-sea-level expanses of Kuttanad Kayalnilam, the low-lying fields of Xinghua Duotian, or the densely forested alpine terraces of the Honghe Hani Rice fields, inhabitants have mastered their natural surroundings to produce food with minimal resources. These cases have been examined through two lenses: 1) how nature acts as the foundation for the functioning of these systems and 2) the complex interactions between these systems and their surrounding environments.

The goal is to show how these systems have provided not only food for many communities around the world, but also livelihoods and resilience to extreme weather events. Water is an indispensable element in this achievement. Through a detailed analysis of these four cases, we present a comparative review to visualise the collected information and reflect on four core lessons for the future of food production: 1) circular practices in modern food systems; 2) resilient food systems towards climate change and natural disasters; 3) interdependence of food, ecology, and society; and 4) nature-based food production versus extensive food production.

UNDERSTANDING TRADITIONAL AGRICULTURAL LANDSCAPES

Floating Gardens of Wetland Agriculture—Chinampas in the Valley of Mexico

Chinampas is a system of human-made islands for agriculture and land expansion in the Valley of Mexico (Figures 6, 7, and 8), enabling practical agriculture and sustainable water management since approximately 200 BC. Tenochca civilization (also known as Mexica or Aztec) built Tenochtitlán, the capital of their empire, in the middle of the shallow waters of what is now Lake Texcoco, strategically protecting the city from external threats (Alcántara, 2007). To expand their capital, they developed the Chinampas Agrosystem to enlarge their territory, where the water was sufficiently shallow to reclaim land for settlement and agriculture (Gibson and Campos, 1978). Currently, the Chinampas have partly survived in the southern part of the Valley of Mexico, in the areas of Xochimilco and Tlahuac, which have







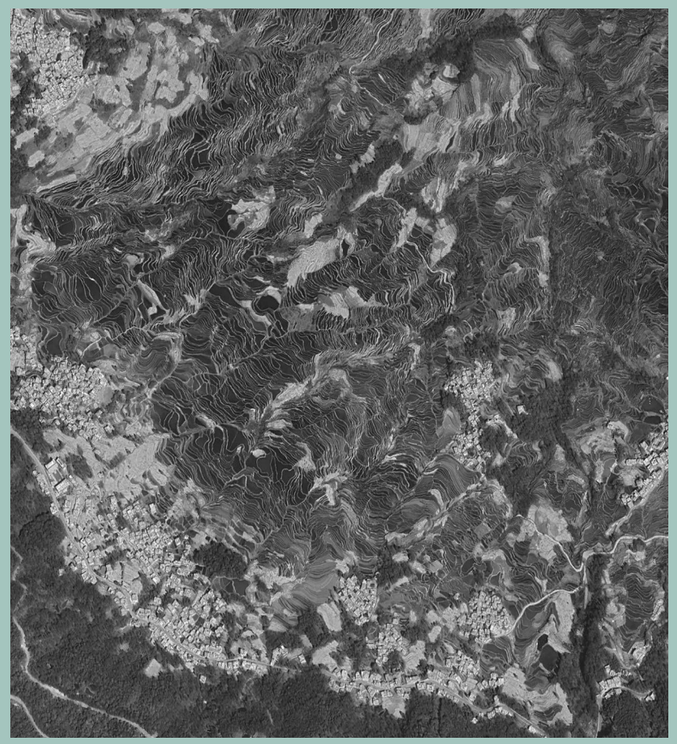


Fig. 2
(top left) Satellite view of the Chinampas Agrosystem. Adapted from Google (2020-a).

Fig. 3
(top right) Satellite view of the Kuttanad Kayalnilam Agrosystem. Adapted from Google (2020-b).

Fig. 4
(bottom left) Satellite view of the Xinghua Duotian Agrosystem. Adapted from Google (2020-c).

Fig. 5
(bottom right) Satellite view of the Honghe Hani Rice Agrosystem. Adapted from Google (2020-d).

become extensive islands of traditional urban agriculture for vegetables and ornamental flowers in the middle of densely populated Mexico City (Rey-Hernández & Bobbink, 2022).

Nature as a starting point

The Chinampas were initially developed in a high-mountain lacustrine valley with a wetland ecosystem of now-extinct interconnected lakes. Owing to the confined nature of the water system, mineralized sediments from the mountains accumulated at the bottom of the lakes, creating incredibly fertile soil (Scarborough, 2003). However, without a natural outlet for water, this area is prone to periodic flooding (Parque Ecológico Lago Texcoco, 2009). The inundations led the Tenochcas to modify their territory to 'reclaim land' and create safe grounds for the expansion of their city and agricultural areas (Surajaras & Rey-Hernández, 2021).

The Chinampas were built using existing resources to create cultivable land above the water's surface. To create these 'floating islands,' Tenochcas built reed rafts and enclosed them in rectangular wattle enclosures. The raft was then layered with mud, lake sediments, and topsoil composed of grass, leaves, and husks. Once the 'island' was stable enough, they stabilised the Chinampas by planting trees such as Salix bonplandiana in the raft's corners to secure it to the lakebed. (Rojas-Rabiela, 1993)

Relationship with the Environment

The Chinampa's 'floating gardens' have been built and used in close relationship to its landscape and environment, using the site conditions and natural resources to achieve maximum food production and profitability with minimum materials and infrastructure by taking advantage of the natural wetlands, which provide the ideal conditions for efficient crops without using external energy sources. At the same time, the materials used in the construction and maintenance of China come from the surrounding areas, enabling sustainable resource use and, combined with cyclical crop harvests, creating a circular food-production process. Furthermore, the system is deeply intertwined with its lacustrine landscape using natural irrigation and water filtration to maintain constant humidity throughout its structure and return it to the biological cycle. (Rojas-Rabiela, 1993)

Fig. 6
Canoers in a boat at the entrance to a chinampa. Adapted from a photograph by Catalina Rey-Hernández.



Fig. 7
(left) Fenced chinampa with Salix bonplandiana trees securing it to the lakebed. Adapted from a photograph by Catalina Rey-Hernández.

Fig. 8
(right) Chinampa worker on a boat in the Xochimilco Canal. Adapted from a photograph by Catalina Rey-Hernández.



Harvesting under the Sea-level—Kayalnilams in Kuttanad, Kerala

In southern India, adjoining the Vembanad backwaters, the longest lake in India, is a cluster of emerald-green islands fringed by coconut trees, called Kuttanad. Beyond this picturesque beauty, this area of Kerala unfolds an agricultural legacy that has been growing rice two metres below sea level for more than a century (Sreeja et al., 2015). They do this by constructing 'Kayalnilams,' where 'Kayal' means backwaters and 'Nilam' means land, implying that they are reclaimed from the backwaters (Chandran & Purkayastha, 2018).

Kerala's inhabitants developed techniques for constructing and operating Kayalnilams in the late 1800s (Figures 9, 10, and 11). They constructed dikes at least two metres above sea level, which acted as barriers separating water inside and outside the system. With a set of canals, inlets, and motor-powered outlets, the water levels within Kayalnilam are controlled to optimize agriculture. Kayalnilams grow food under various natural conditions, such as waterlogging, flooding, and sea salt intrusion, contributing to the dynamic site conditions of backwaters and the five rivers that flow through the system (Swaminathan, 2007).

Nature as a Starting Point

The reclamation process started by setting the boundaries of the identified shallow areas in the Vembanad backwaters. Then, an array of coconut poles is hammered deep enough into the lakebed in two rows, enveloping the area. The poles were fenced with bamboo mats on either side to form a skeleton for the dyke. Subsequently, the dyke channels were filled to the desired height with sand, twigs, and sedges mixed with high-quality clay dug from the bottom of the lake. The entire construction process uses organic, locally sourced materials, and the dykes and canals are sufficiently porous to create an excellent habitat for aquatic species.[1]

Relationship with the Environment

In this system, paddy farming works well with seasonal flooding and salt intrusion from the Arabian Sea but can be supplemented by fish farming and duck rearing for a few months. During summer, river water levels drop below sea level, and saltwater flows inland (Sreejith, 2013). The increased salinity







Fig. 9
(top) Aerial view of flooded Kayalnilams. Adapted from a photograph by Prasanth.

Fig. 10
(middle) Women agricultural labourers harvesting paddy by hand. Adapted from a photograph by Redz Photography.

Fig. 11
(bottom) Kuttanad Kayalnilam when the paddy crop is ready for harvest. Adapted from a photograph by Redz Photography.

renders the soil unsuitable for paddy farming, so the fields are deliberately flooded to harvest fish that migrate from the sea. Even the life cycles of local fish vary, adapting to this salt cycle; during certain growth phases, some fish and prawn species become intolerant of saltwater. At the same time, for the rest of their lifespan, they need a salty environment that naturally occurs during salt intrusion periods (Ali, 2020).

Additionally, paddy roots provide shelter for these species, and aerating movements of the fish improve soil fertility. Hence, aquaculture becomes the primary source of livelihood when rice is not cultivated and continues through the peak monsoon season, when the fields make room for excess water in the system, making the Kayalnilams resilient to flooding. Post-monsoon, when the water level recedes, this is a freshwater system that shifts back to growing rice. During this period, the soil was also enriched by sediments carried by upstream rivers into these low-lying areas during the monsoon season.

Instead of fighting salt and water, which are seen as threats in coastal areas, the rotation between agriculture and aquaculture aligns well with the natural water cycle and local ecology of the area. Thus, Kayalnilams are components of ecological infrastructure with multifunctional values that grow food, provide coastal protection, and serve as breeding and nesting habitats for fish and birds.

However, in the late 1900s, the industrial revolution began to reshape indigenous Kayalnilams. The construction of salt dams and expansion of industrial salt production have disrupted the traditional balance between agriculture and aquaculture. As a result, these landscapes have become less ecologically diverse, with reduced habitat availability for fish and birds. While salt production brings economic benefits, it also alters the natural water cycle, limiting the multifunctionality that once sustained both local livelihoods and biodiversity.

Rising above the Surface—Xinghua Duotian Agrosystem

On the eastern side of China, Jiangsu Province lies in a vast open landscape featuring thousands of floating islands. These islands vary in shape, size, and color, creating a unique pattern that extends to the horizon. This waterscape is known as the Xinghua Duotian Agrosystem, a traditional water-land utilization technique developed over a thousand years ago to combat frequent flooding in the low-lying Lixiahe Plain. By constructing wooden structures to support fields and raising mud into small stacks, early agriculturalists transformed waterlogged areas into cultivable lands. This innovative approach has been in practice since the Tang Dynasty (AD 618–907), highlighting the ingenuity of early Chinese agricultural practices (Science and Technology Daily, 2022). (Figures 12 and 13).

This water-land management technique consists of a raised-field agricultural pattern, distinctive from other raised fields because of its thousand-year history and sustainable cultivation approach. The Xinghua Duotian was the region's primary food production source in the past, and it has gradually evolved into a combination of agriculture, forestry, and aquaculture. (Bai et al., 2014)

Nature as a Starting Point

The Duotian Agrosystem was initially established because of the area's natural condition: low-lying land surrounded by higher ground. This flat plain is significantly influenced by its surrounding riverine landscape, the Huai,

Fig. 13
Overview of the Xinghua Duotian Agrosystem. Adapted from a photograph courtesy of GIAHS—Xinghua Duotian Agrosystem, China (2020).



Yellow, and Yangtze rivers. People have suffered frequent floods. Tracing back 4200 years, the area was originally a lagoon fed by sedimentation from rivers, transforming it into a freshwater wetland landscape with numerous lakes. During this period, the Xinghua population grew due to its strategic location as a commercial hub (Bai et al., 2014). This led to massive food demand and challenged the Xinghua ancestors, who began using the area's fertile conditions, digging soil from rivers, and creating earthen platforms suitable for farming.

The raised fields were initially composed of a layer of piled wood as a base, followed by wetland soil, fertile soil from the rivers, lotus roots, and finally, a vegetation layer on top. They floated on the surface of the water, rising during flooding and falling when the water was released. After 1949, the frequency of floods decreased significantly because of dam construction. This made it possible to lower the field height. The soil was then used to widen and narrow the waterways. Thus, more land has been gained and used for various purposes and for urban development.

Relationship with the Environment

Currently, the area is mainly used to grow vegetables, with Longxiang taro, Xinghua chive, and Xinghua oilseed rape as the three most important farm products (Surajaras & Rey-Hernández, 2021) Other vegetation types are rotated according to season, changing the colors and textures of the fields throughout the year. Farmers plant crops under trees, breed fish and shrimp, and raise ducks and geese in the water to increase income and maximise land utilisation. Thus, the entire system provides food for the local population and exemplifies highly efficient agriculture within a unique wetland landscape.

Cultivating through Slopes—Honghe Hani Rice Terraces

Hani Rice Terraces have existed since 720 A.D. They are located in Yuanyang County, Yunnan Province, China, where terraced farming is central to the material production and national culture of the Hani people (Figure 14). For 1300 years, the Hani people have developed farming techniques, such as terrace management and ecological cultivation, in long-term farming. However, in the second half of the 20th century, with the transformation of Chinese society and the development of a market economy, the country blindly pursued food production and cut down forests to reclaim land without considering water sources. In 2012, scientists introduced the 'Rice-Fish-Duck Symbiosis System' production mode in the terraced fields to improve efficiency. Just one year later, the Hani Rice Terraces were declared 'World Agricultural Cultural Heritage' by the United Nations. (Hua & Zhou, 2015)

Nature as a Starting Point

After the Hani ancestors migrated to the Ailao Mountains and settled, they chose to live on sunny gentle hillsides. Later, they opened canals and ditches for drinking water and irrigation, and built terraced fields. The water source for the Hani people is rainfall and groundwater. Water is stored in forests on mountaintops. By utilising the topography when excavating canals, the Hani people developed the 'flowing water ditching method' to transport water from the mountain's summit into the village. In other words, the mountain's height was first visually gauged, followed by the terrain's direction. When excavating canals, a small amount of water is added to determine whether it can flow through existing ditches to the intended location. In this manner, the Hani gradually constructed canals and ditches from the mountain summit to the village. The Hani people developed the 'wood carving water-dividing method' simultaneously to guarantee equitable water use for residents upstream and downstream. This method involves determining the amount of water each terrace needs based on its area, then placing a horizontal beam at the terrace-ditch intersection and carving a specific width into it to restrict the amount of water entering the terrace.

The terraced fields were excavated and built from low to high, with the field width and length planned to fit the dimensions of the slope. After exposure to the sun and rain, the platform's natural settlement forms a stable foundation for building terrace ridges and irrigation systems. After this step-by-step process, the hillslope is reclaimed upward. Terraced fields of different lengths, widths, and layers were formed according to topography.

Relationship with the Environment

Regarding food production, the Hani people have shaped the ground to suit the local terrain and climate, recognising that forests on hills are essential for water storage and preventing landslides. Moreover, they deliver wood to build houses in the villages. The Yuanyang Terraced Fields store water for food production and daily use year-round.

Currently, the Hani Terraces only grow one crop rotation per year—red rice—and the land is left empty after the autumn harvest until the following year's planting. Farmers begin plowing and sowing the fields in April, and the rice fields grow lushly throughout the summer. In mid-September, water was drained from the fields to harvest the rice. The rice harvest was completed in November and the terraces were refilled with water to await the farming cycle of the new year.

Fig. 14
Subsistent farming in Yunnan Province. Adapted from a photograph by Jialiang Gao (2008).



TRADITIONAL AGRICULTURAL LANDSCAPES SIDE BY SIDE

Based on the knowledge collected from the four cases and analysis of the water systems (Figures 15, 16, 17, and 18), a framework was developed to compare the cases. This comparison aims to discuss the values embedded in these traditional agricultural landscapes that are relevant to today's food production challenges. By placing the cases side by side, it becomes possible to understand how different combinations of water, landforms, productive activities, labor, and maintenance have enabled them to remain viable over time. Preliminary conclusions were drawn from the comparison framework. (Figure 19)

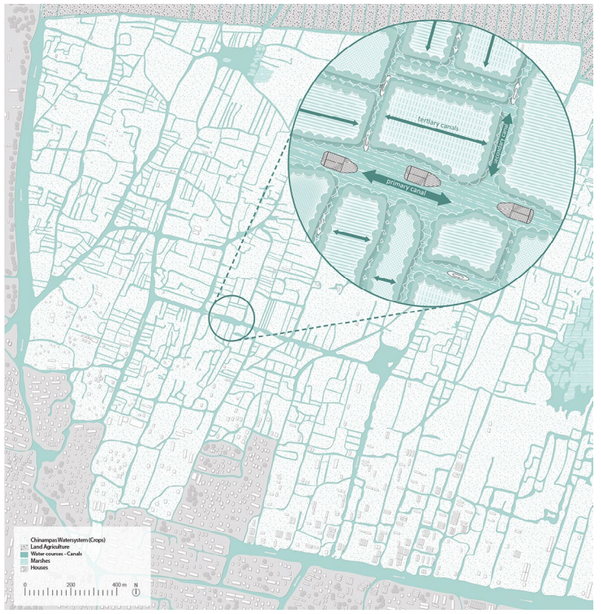
First, although the four cases are situated in very different weather conditions and landscapes, they all work with existing environmental processes to optimize food production using locally available resources. The Kayalnilams, Chinampas, and Xinghua Duotian cases are based on comparable landscape types and water conditions: wetlands with fresh-to-brackish water quality. These conditions support a greater variety of crops; however, because of the dynamic nature of wetlands, they also require continuous human intervention to maintain fields, waterways, and water levels. The Honghe Hani terraces, situated on the slopes of a mountainous region, are irrigated with freshwater and primarily produce rice. Human-made ponds require minimal maintenance, because they rely on gravity-fed irrigation systems. Therefore, their productivity is dependent on the continued relationships among forests, settlements, water channels, and terraces.

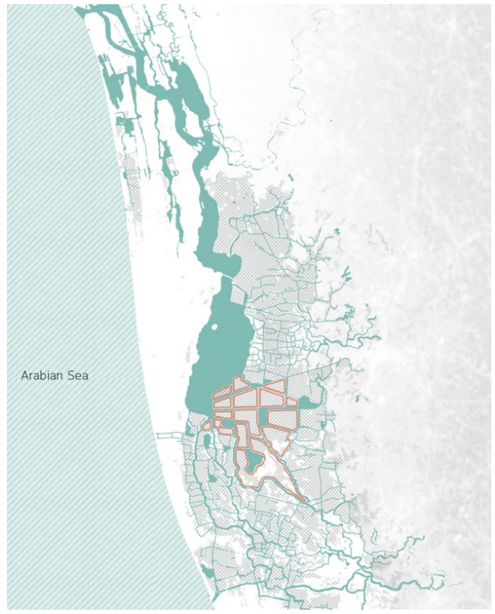
At the same time, all four systems extend beyond agriculture by combining food production with activities such as fish and duck breeding, horticulture, tourism, and Chinese cattle farming. This multifunctionality allows water, nutrients, labor, and productive space to be used across several interconnected activities. Therefore, the systems demonstrate different forms of circularity in water supply, irrigation, nutrient cycling, and self-sufficient local food production. Through these relationships, they support their livelihoods, biodiversity, and continued access to locally produced food.

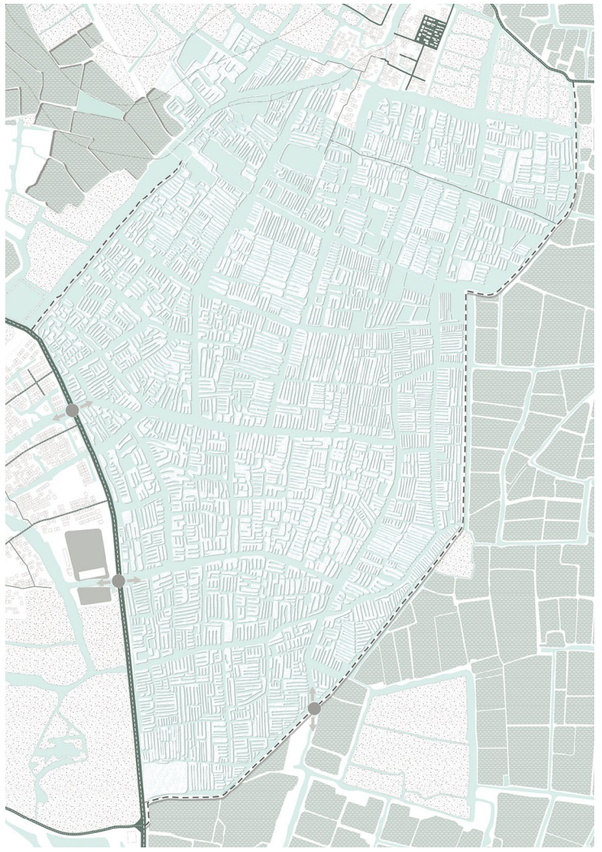
The comparison also shows that their continuity depends on adaptation rather than preservation of historical agricultural practices. Crops, water control methods, field dimensions, technologies, and livelihood-related activities have evolved in response to changing environmental and socioeconomic conditions. The capacity to reorganise production around local water cycles and ecological processes has endured. The four cases, therefore, represent neither fixed traditions nor models to be copied directly but living agricultural landscapes whose survival depends on their ability to change without losing the underlying relationships that sustain them.

LESSONS FOR MODERN AGRO-LANDSCAPES

Building on the previous analysis and comparison, this section considers how these food production systems have sustained communities, supported livelihoods, and responded to climate shocks and extremes. Their longevity should not be viewed as evidence that they have remained unchanged or are inherently sustainable. Rather, it reflects their capacity to adapt while maintaining the relationships among water management, food production, ecological processes, labor, and local knowledge. Four lessons were drawn that show the indispensable role of water in addressing today's challenges to food production: circularity; resilience; the interdependence of food, ecology, and society; and nature-based food production.







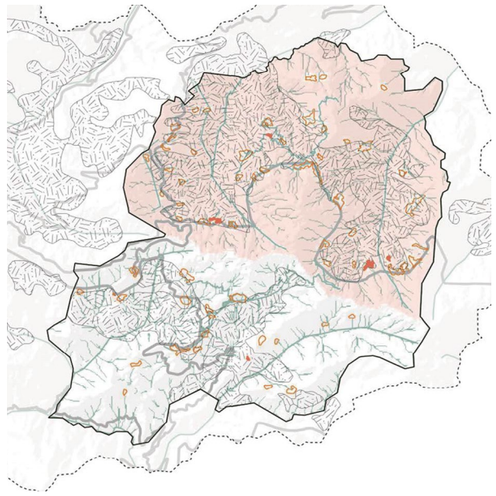


Fig. 15
(top left) Catchment area of the Chinampas Farming System. Adapted from Bobbink and Rey-Hernández (2022).

Fig. 16
(top right) Catchment area of the Kuttanad Kayalnilam Agrosystem. Adapted from Ali (2020).

Fig. 17
(bottom left) Catchment area of the Xinghua Duotian Agrosystem. Adapted from Surajaras (2019).

Fig. 18
(bottom right) Catchment area of the Honghe Hani Rice Agrosystem. Adapted from Yuan (2022).

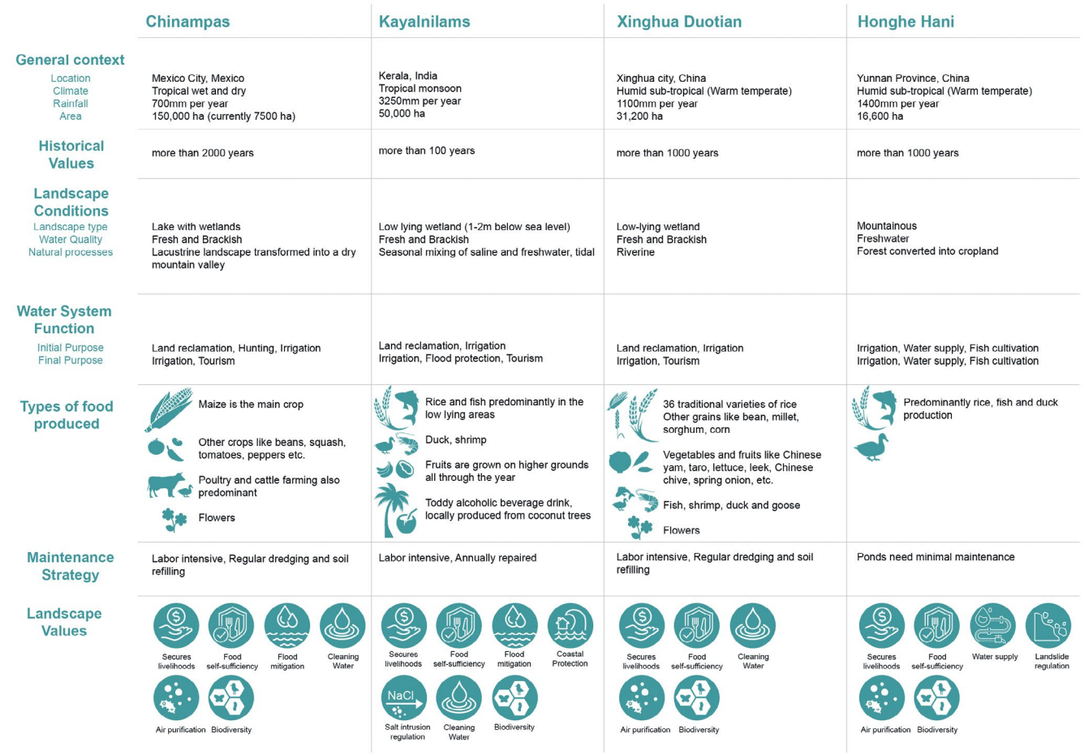


Fig. 19
Comparative overview of the agrosystems, including their contexts, conditions and key characteristics. By the authors.

CIRCULAR PRACTICES IN MODERN FOOD SYSTEMS

Farmers in these four agrosystems have embraced traditional agricultural techniques and knowledge passed down through generations, although the extent to which these practices remain active varies across cases. They have developed ingenious ways of living with nature, protecting local biodiversity, securing livelihoods, and generating income from landscapes. The economy in these areas is closely connected to the ecosystem services for food production. Farmers continue traditional agricultural techniques (re)using local resources and, at the same time, the construction of these water systems facilitates natural water irrigation.

The crops produced and harvested in these systems allow inhabitants easy access to food from their surroundings. Self-sufficiency is an adaptation strategy that bolsters food security against climate change, closes nutrient cycles, and reduces dependence on global markets. Additionally, the circular use of water in these examples helps to restore the ecological quality of water, naturally cleaning it as part of its cycle.

Furthermore, there is a mutualistic symbiotic relationship among agriculture, non-human species, and other productive activities such as fish, shrimp, and duck breeding, where different crops provide protection and shelter to these species, which enhances land fertility and creates suitable environments for the crops to thrive. At the same time, the rotation between crop cultivation and aquaculture, for example, is intertwined with the life cycle of different endemic species, such as fish and shrimp. By combining these productive activities with others, such as tourism and, in some cases, horticulture, farmers have shifted their focus from food production alone to the production and maintenance of heritage landscapes. (Figures 20, 21, 22 and 23)

RESILIENT FOOD SYSTEMS TOWARDS CLIMATE CHANGE AND NATURAL DISASTERS

Beyond adaptation and mitigation, which are usually considered the pillars of global climate discourse, these systems are resilient to the impacts of climate change because of their ability to quickly recover from extreme events such as floods, while also preventing hazards such as landslides and foreshore erosion.

Amid climate change, these agrosystems have diversified their productive activities, creating conditions for local economic development and providing goods and services to urban areas. By rotating between agriculture, aquaculture, horticulture, and associated productive activities, the analysed systems can grow food while adapting to daily tides and seasonal flooding and avoiding land erosion, which is generally seen as a threat to life associated with climate change.

Furthermore, these water systems exhibit remarkable resilience as they have been designed to accommodate changing site conditions. Consequently, they transform themselves according to season, flowering time, migration, and breeding pattern. In this way, local inhabitants also adjust their livelihoods accordingly: when seasonal conditions change, farmers shift among different productive activities, making intelligent use of local resources and improving field efficiency.

INTERDEPENDENCE OF FOOD, ECOLOGY AND SOCIETY

In terms of the societal aspect of these systems, an important insight is the close eco-social relationship and symbiosis among humans, water management, and agriculture. As they are not automated, food landscapes require constant maintenance and care from the inhabitants of each place, fostering an embedded sense of place and a close relationship between humans and their environment.

Furthermore, when locally administered, maintained, and managed, these agrosystems become more democratic and climate-just because of the involvement of their inhabitants in decision-making processes regarding food production and distribution.

Regarding health and well-being, the analysed systems have a direct impact on people's diet; in the current global scenario, for every undernourished person, there are two obese or overweight people. These agrosystems show us how to rely on a balanced diet. By relying on the local food supply, inhabitants derive their nutrition from their surroundings. Simultaneously, people are naturally physically active, as they must work and manage the systems on their own.

NATURE-BASED FOOD PRODUCTION VERSUS EXTENSIVE FOOD PRODUCTION

As discussed in the chapter, these systems were created based on the natural conditions of the landscapes in which they were developed. Therefore, these systems have a special respect for the natural processes inherent in the landscape, allowing them to (partially) survive for thousands of years. The discussed circularity and resilience characteristics of these food production systems can be important lessons towards the current scenario of agriculture, where extensive areas of monoculture or greenhouses are not responsive

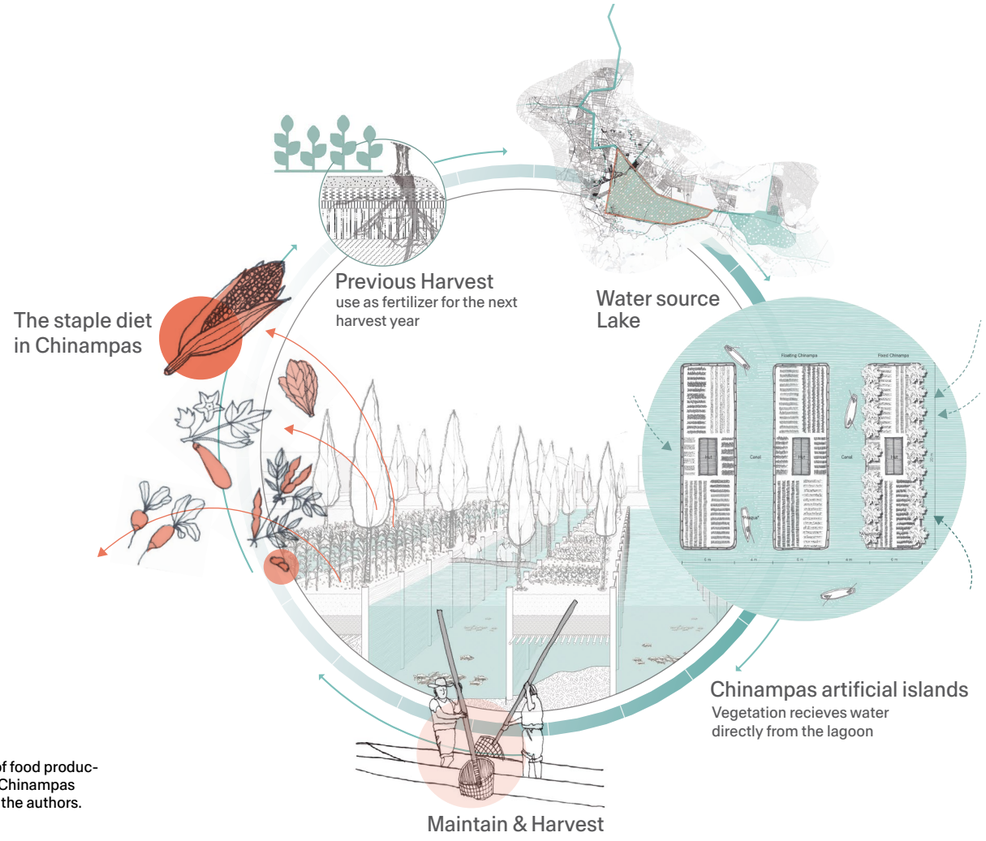


Fig. 20
The cycle of food production at the Chinampas islands. By the authors.

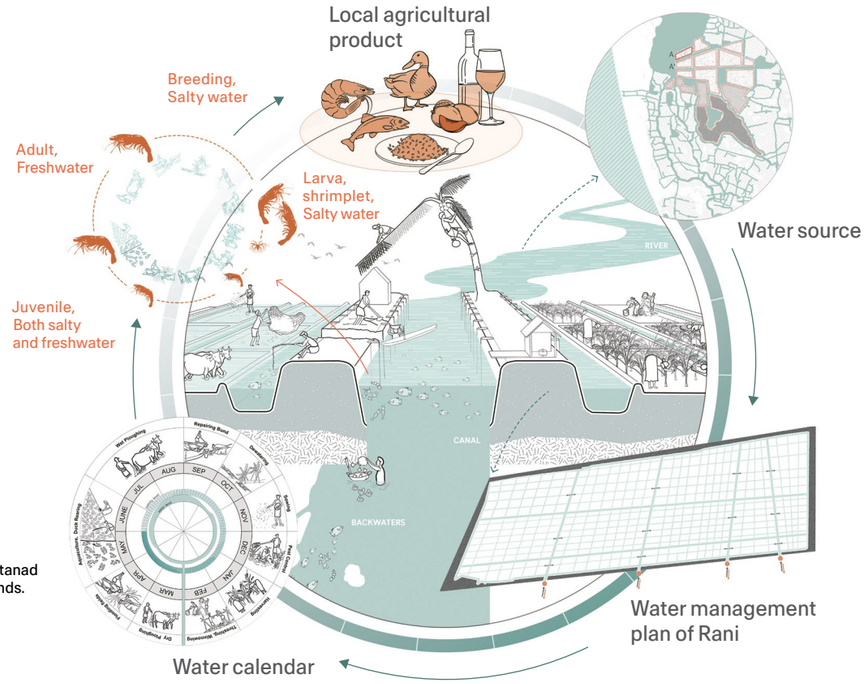


Fig. 21
The cycle of food production at Kuttanad Kayalnilam lowlands. By the authors.

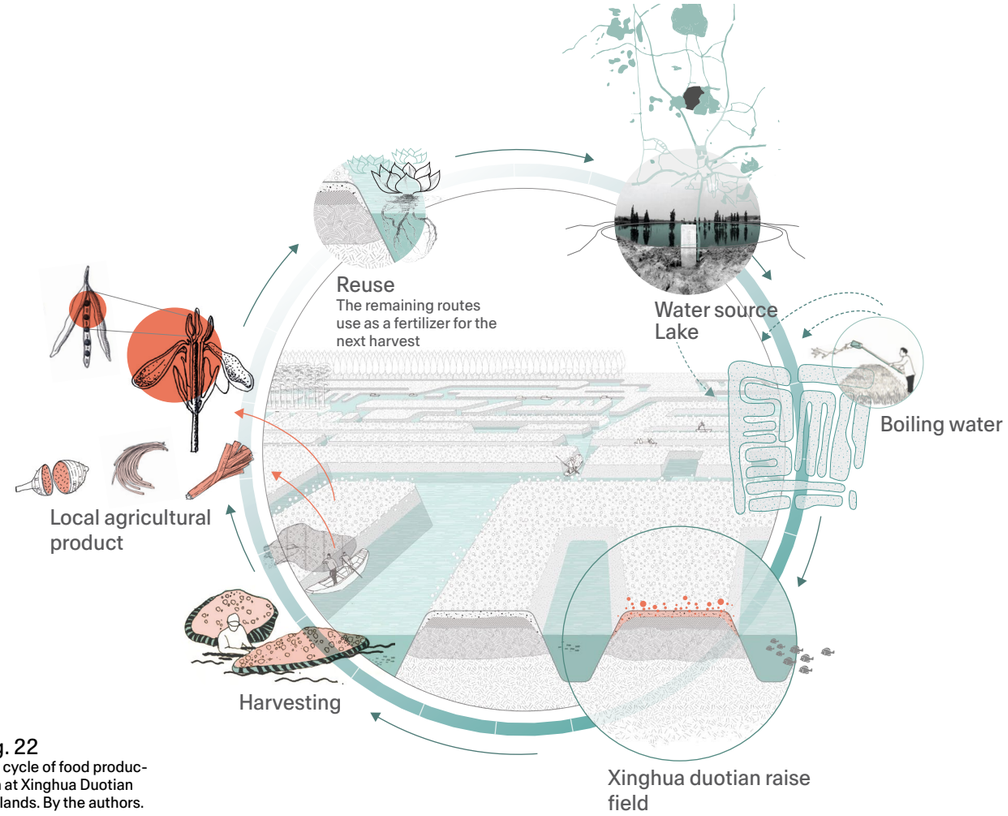


Fig. 22
The cycle of food production at Xinghua Duotian lowlands. By the authors.

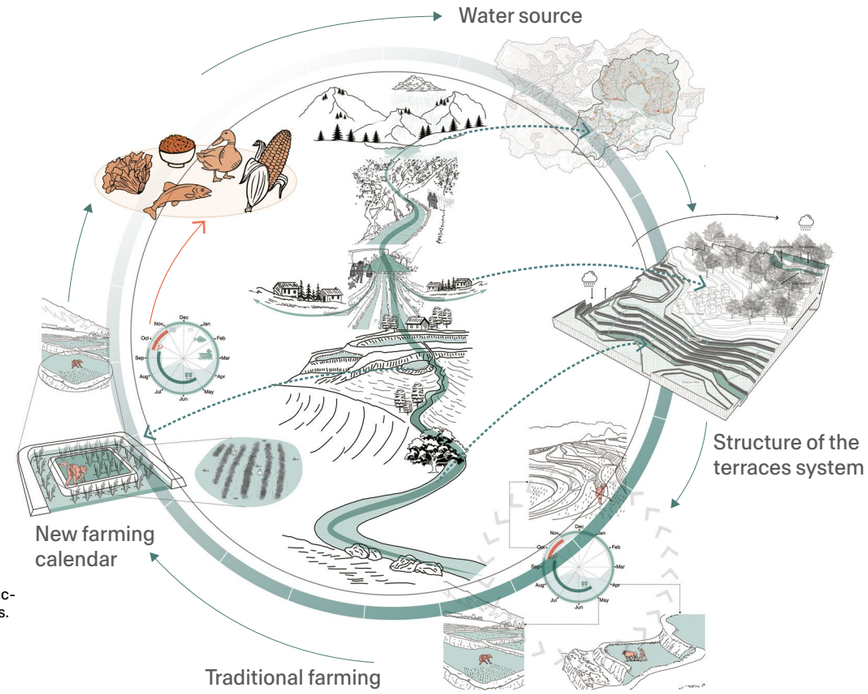


Fig. 23
The cycle of food production in the Hani Terraces. By the authors.

to the natural context, overuse sensitive resources, such as water, and contribute to the acceleration of climate change through carbon emissions, water scarcity, and excessive pollutants.

CONTINUITY THROUGH ADAPTATION

The traditional agricultural systems discussed in this section demonstrate the central role of water in sustaining food production. By circulating water and nutrients within the landscape, they support irrigation, food security, and multiple livelihood activities during different seasons. Even with changing seasons, local food production is not affected, but is instead adapted. This language of adaptation translates into a unique relationship between ecology and communities, whereby people adapt to the rhythm of the seasons, changing their livelihoods to work both within and beyond agriculture, and to earn money from other ecosystem services, keeping the ecosystem and the local socioeconomic system healthy and alive. All decisions and interventions, ranging from the individual to society level, align with nature, giving rise to nature-based food production systems. With nature and the water cycle as the starting points, these systems have also shown remarkable resilience to climate change and natural disasters, proving that flourishing communities adapt by working with, not against, the natural world.

The central question in analyzing the cases was not only how they functioned, but also why they remained viable. A comparative framework showed that the degree and form of adaptation differ across the Chinese, Kayalnilams, Xinghua Duotian Agrosystem, and Hani terraces. Therefore, their longevity cannot be attributed to any single quality, such as circularity or multifunctionality. What has sustained them is their capacity to adjust production, technologies, and livelihoods to changing environmental and socioeconomic conditions.

Some of these conditions are under pressure, and we identified two main threats common to all four cases. First, although to different degrees, many farmers who have mastered the required agricultural techniques are relatively old, while younger generations tend to leave their hometowns to seek better work opportunities in cities. This weakens both the knowledge transfer and the human power needed to maintain fields, canals, dikes, terraces, and other waterworks. This has resulted in abandoned or collapsed fields that have affected local food production. Second, urban expansion and infrastructure development have converted agricultural land into roads, housing, factories, and other uses, thereby significantly reducing the extent and continuity of several systems. These pressures do more than remove farmland; they fragment the relationships among water management, food production, biodiversity, and local livelihoods on which the systems depend.

However, these landscapes did not survive by resisting all the changes. They have incorporated new technologies, diversified productive activities, and, in some cases, drawn on aquaculture, tourism, heritage recognition, and ecological conservation to remain viable. Such adaptations can support continuity, but can also weaken food production or local control when driven primarily by external markets and development priorities. Therefore, the challenge is not to preserve these systems as static heritage but to enable them to continue changing without losing the ecological functions, knowledge, and livelihood relationships that sustain them. In contemporary agro-landscape planning, the key lesson is to foster adaptive frameworks rather than fixed master plans, allowing water systems, production capacities, and livelihoods to evolve together.

NOTES Feeding Waters

1. Rupeshkumar, personal communication, January 2023.

Channelling Water

Over hundreds of years, various methods and techniques for collecting water have been developed based on the possibilities offered by surrounding landscapes. The most common practice is channelling water from a source, well, or river to a place where a community settles to provide access to drinking water, irrigate fields for food production, and support other uses.

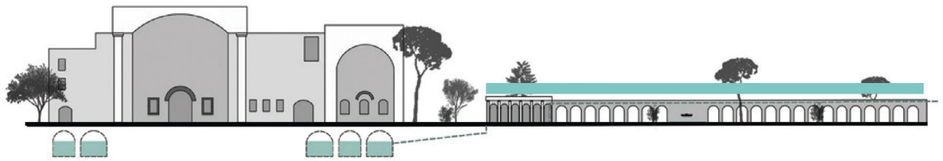
The images distinguished three categories of water supply channels: water lines above ground, water lines in shallow aquifers, and water lines deep below the surface. Although the analyzed projects in the Circular Water Stories lab are located worldwide, we discovered that similar techniques are used in similar landscapes or topographical conditions. Several additional water systems can be added.

Flows Above, On and Below the Surface

INTERMEZZO

Fig. 1
Chrob ou Chouf Fountain, Marrakech region, Morocco. Adapted from a photograph by Riad Dar Zampa & Inspiration Morocco.

Water Lines Above the Ground



The first category includes projects that utilise aqueducts, basins, and channels, such as the Roman Aqueducts in Italy and Nahargarh Water System in Jaipur, India. By transporting water from the hills to the city, water is conveyed high above the ground along the most efficient route by utilising the correct gradient to stabilise the gravity-based flow of the water. Aqueducts that make this possible are impressive in size and structure. Many of these have heritage value. Not only does the system bring water to communities, it also uses water to irrigate agricultural areas along the way.



Fig. 2
Roman aqueducts, Lazio, Italy. Adapted from Di Nicola (2020a).

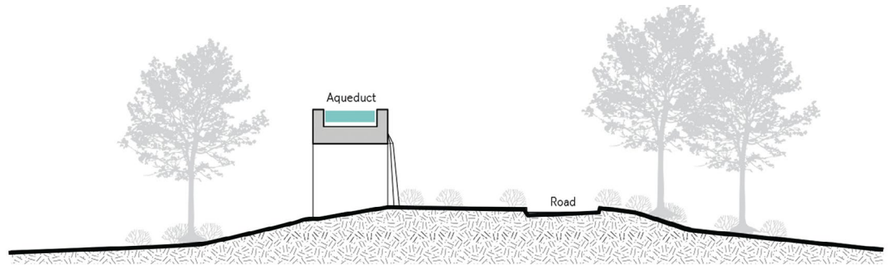
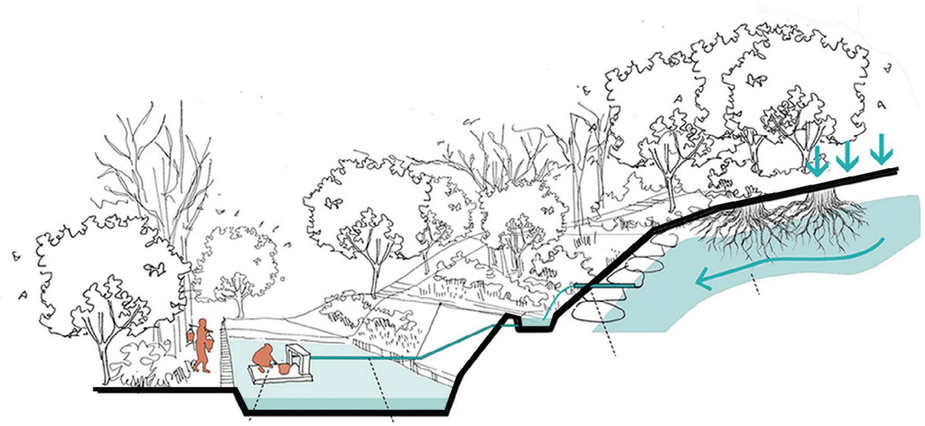




Fig. 3
Forts, public wells and stepwells, Jaipur, India. Adapted from Chandna (2019).



Water Lines in Shallow Aquifers



The second category we distinguished shows systems that channel water for daily consumption from the shallow aquifer close to the settlements. In Kampung Naga in Indonesia, a hill with a small forest untouched by human activities provides a clean water source from which people can extract water by creating an opening on the hillside. The tree roots filter the water and make it possible to drink. On a larger scale, in Nepal's Hiti Pranali system, water is collected in a human-made pond, letting water infiltrate the aquifer: a carefully designed building structure and a horizontal fountain sprouts water for domestic use. Apart from the natural cleaning by the soil, a filtration system behind the spout wall is implemented.





(Fig. 4)
Kampung Naga System, Indonesia.
Adapted from Prestasia and Kim (2019).

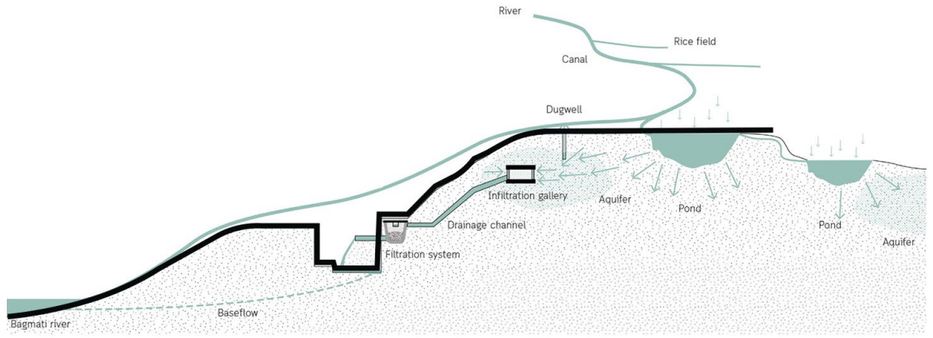
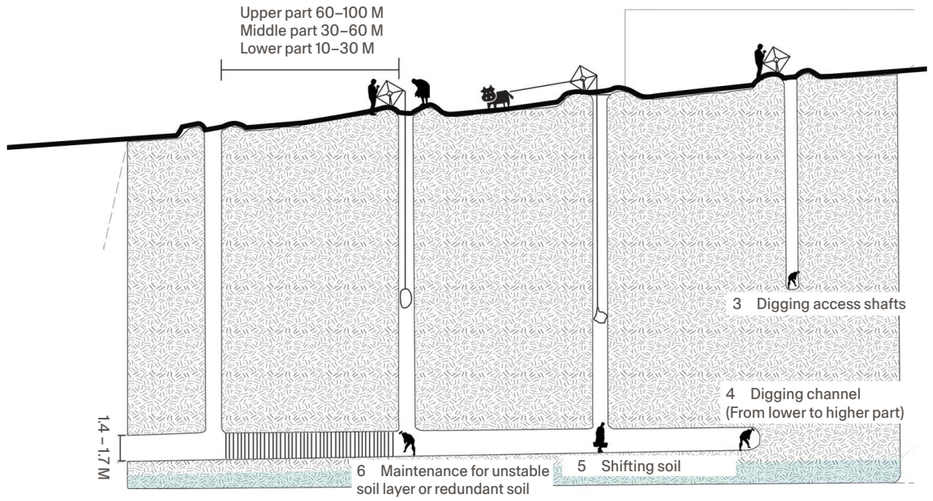




Fig. 5
Hiti Pranali water stone spout system, Kathmandu, Nepal. Adapted from Zhang (2023a).



Water Lines Deep Below the Surface



The third category shows similarities between the Qanat System in Morocco and the Turpan Karez Qanat System in China, where deep air shafts enabled the digging of tunnels in the soil to guide and transport water from the aquifer uphill towards the settlements at the foot of the hills. The tunnels reach the groundwater, which is subsequently guided by the tunnel system. Clay soil enables this construction. Limited exposure to sunlight protects water from evaporation.



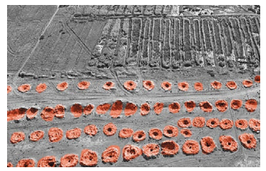
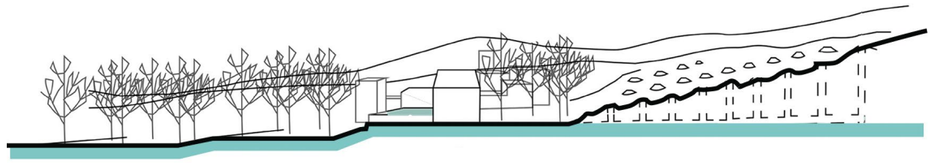


Fig. 6
Turpan Karez qanat system, Xinjiang, China. Adapted from He (2021).



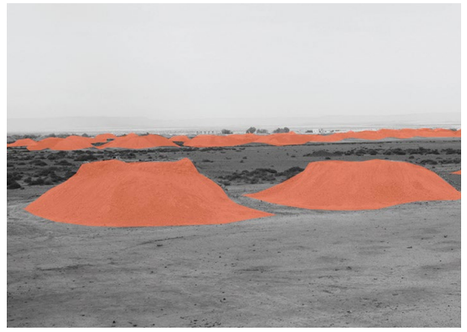




Fig. 7
Qanat system, Marrakech region, Morocco. Adapted from Marjan (2019).



Fig. 1
Jaigarh Fort, Jaipur, India. Adapted from a photograph by Anubhuti Chandna.

Water Heritage

Valuing the Tangible and Intangible

Gloria Rivero-Lamela[1], Ran Yan[2], Farnoosh Bazrafkan[3], Anubhuti Chandna[4]

From a contemporary perspective, this essay examines a series of qualities and heritage values identified in traditional water systems. It approaches these systems from a cultural landscape perspective, recognising that their heritage values extend beyond individual structures to the broader relationships, practices and knowledge they embody. This framework enables a more comprehensive understanding of these interconnected tangible and intangible values. Four projects are discussed: the Watermills of Sierra de Cádiz, Andalucía, Spain; the Salt Fields in Hainan, China; the Water Meadows in Harnham, England; and the Fort Water System and Stepwells of Jaipur, India. We deliberately do not focus on water management, as the potential for learning from the past to address contemporary climate change challenges is discussed more extensively in other essays.

1 Dr ir. G. Rivero-Lamela, Departamento de Ideación Gráfica Arquitectónica, Escuela Técnica Superior de Arquitectura de Madrid, Universidad Politécnica de Madrid, Spain; gloria.rivero@upm.es
0000-0002-8683-0704

2 Ir. R. Yan, Buro Sant en Co landschapsarchitectuur, the Netherlands
0009-0006-3775-641X

3 Ir. F. Bazrafkan, Echo Urban Design, the Netherlands

4 Ir. A. Chandna, Architect and Urban Designer Stuttgart, Germany

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The Charter on the Built Vernacular Heritage (ICOMOS, 1999), a valuable and concise document that addresses the concepts and problems of fragile and vulnerable heritage, emphasises the insoluble relationship between construction and the cultural landscape. The expression 'Outstanding Universal Value' is repeated in the definitions of cultural and natural heritage. Nevertheless, until 2005, it was not described as a key concept in the Operational Guidelines for Implementing the World Heritage Convention. Paragraph 49 clarifies that 'Outstanding Universal Value means cultural and/or natural significance, which is so exceptional as to transcend national boundaries and be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community (UNESCO World Heritage Centre, n.d.-a). To be considered as having Outstanding Universal Value, at least one of the ten criteria established by the committee must be met (UNESCO World Heritage Centre, n.d.-b). The following can be:

- 'an outstanding example of a type of building, architectural or technological ensemble, or landscape that illustrates (a) significant stage(s) in human history'.

- 'an outstanding example of a traditional human settlement, land use, or sea use, which is representative of a culture (or cultures) or human interaction with the environment, especially when it has become vulnerable to irreversible changes'.

Researchers and academics in landscape architecture or architecture can map these values to extract their wisdom and preserve their heritage, preferably in physical form. If physical preservation is impossible or not visible for various reasons, drawings help document their value for future generations, allowing us to benefit from our ancestors' knowledge.

HERITAGE VALUES

Recognising that something has value means that the qualities that define it are of interest or importance to a person or group—appreciating and valuing an asset, whatever its nature, is a collective act that concerns and affects society. It comes from the synergy of all the agents involved: academics, users, inhabitants, and ultimately, public institutions and/or administrations. Research is carried out by constructing the state of the art, and the same applies to valorisation. Therefore, it seems relevant to examine the most outstanding and pertinent reflections on this subject from the academic world and review precedents to better understand and delve deeper into the nature of these architectures and systems, as well as their qualifications. The theoretical basis and knowledge of these traditional water systems will validate the validity proposed here.

Since the beginning of the 20th century, many architects and landscape architects have investigated and recognised the value of waterworks. Qualities such as functionality, integration into the landscape, adaptability, sustainability, and identity have been attributed to traditional and vernacular architecture throughout the 20th and 21st centuries by intellectuals and scholars (Vellinga, 2013).

The placement of a traditional water system is determined by the anonymous author's selection process after recognising, understanding, and adapting the site. According to Amos Rapoport, 'vernacular environments […] is the result of 'selectionism,' an evolutionary process whereby environments gradually become congruent with activity systems, lifestyles, meanings, etc (Rapoport, 2000). Bernard Rudofsky already detected this as a lesson from vernacular architecture: 'Instead of trying to 'conquer' nature, as we do, they welcome the vagaries of climate and the challenge of topography' (Rudofsky, 1964).

Implicitly, the landscape value of waterworks and hydraulic systems is assumed because contemplating them implies recognising the territories in which they are inserted, as they generate dispersed focal points of attraction that favor their transit and understanding. These qualities are recognised in traditional water systems. As with every water system and its architectural elements, the choice of location, the transformation of the land, and the functional organisation of the building's parts are pivotal aspects of construction and require adjustment over time to optimize production. Traditional water systems fulfil their functions only if the land is considered a part of them.

In this sense, the site was chosen and read carefully, forming the starting point to explore the possibilities of a human-made water system. The functionality that determines the shape of water systems and their waterworks also defines their size and relationship to relief, thereby ensuring their integration and low-disruptive presence in the environment. Regarding adaptation to the environment, the shape of these systems and architecture vary depending on the place's physical conditions, adjusting to the topographic, climatic, and biological specificities of the soil where they are located. Furthermore, these systems have changed over time. This is because people lived close by or even 'in' the system and changed the system daily. The productive nature of these systems and their architecture imply that their forms express the specific functions for which they are created. Local and proximity materials were used to construct these systems because they are available resources. Using environmental elements, optimised construction, and time.

To illustrate these reflections and discuss these heritage values, four traditional water systems from different corners of the world are discussed: the Watermills of Sierra de Cádiz, Andalucía, Spain, which were created to gain energy from the streams for grain milling and now ruins; the Salt Fields on the Yanpu Peninsula in Hainan, China, a system that harvests salt from the sea that starts to crumble; the Water Meadows in Harnham, England, in which streams are seasonally directed to irrigate the fields and fertilise the ground, which was renovated a few years ago; and the Fort Water System and Stepwells of Jaipur, India, a system that harvested, distributed, and conserved water, which today is only partial at use but starts to gain recognition. In the last few years, the government and local stakeholders have intervened to preserve and restore them.

The analysis of these systems speaks of strategic decisions based on deep knowledge of the landscape, techniques, and processes for optimising results, both in productive terms and with respect to the environment. In that sense, the water systems in this article are discussed explicitly as informative systems that speak to people's history, their relationships with the territory, and the broader context, such as using local, non-polluting, and recycled/recyclable materials; employing low-tech approaches; or respecting specific climatic and geographic conditions. The projects show diverse heritage values inherent in traditional water systems, which we discuss in terms of site-specific integration, sustainability, infrastructure, network, and identity. Today, the Fort Water System and Stepwells in Jaipur are recognised as heritage sites, primarily for tourism. Nevertheless, they are part of the experience of Jaipur as a UNESCO World Heritage City.

The selected projects have not (yet) been included on the World Heritage List. However, some acknowledge different kinds of statuses, showing that they are already considered valuable to society. The Watermills of the Sierra de Cádiz are ruined in the landscape and are not acknowledged as interesting study objects by archaeologists, architects, and landscape architects. Today, only a small group of villagers continues to produce salt using this traditional method. Rather than a means of making a living, it has become more of a performative practice aimed at attracting tourism, as salt production alone can no longer provide sufficient income for villagers. The Harnham Water Meadow belongs to a trust whose primary objective is to protect and preserve this delicate and unique environment for generations to come. Volunteers operate seasonal landscapes. Before discussing the heritage values of the projects, they are introduced.

WATERMILLS OF SIERRA DE CÁDIZ, ANDALUCÍA, SPAIN

The Sierra de Cádiz Watermill System is in a hilly area with many streams (Figure 2) and steep topography. The medieval origins of these devices are situated within pre-industrial architecture and confer historical value. The system used a series of slopes to generate the water pressure needed to drive the horizontal wheels of the mills during medieval times. In contrast, runoff from the slopes fed the ponds near the mills (Figure 3). Mills were positioned on meanders, forks, or points of confluence. In addition to positioning mills along watercourses, the system required proximity to

Fig. 2
Map of the physical and territorial environment of the Sierra de Cádiz: topography, hydrography and municipalities. Water mills are located along the riverbanks of the Sierra de Cádiz. Adapted from Rivero-Lamela (2019).

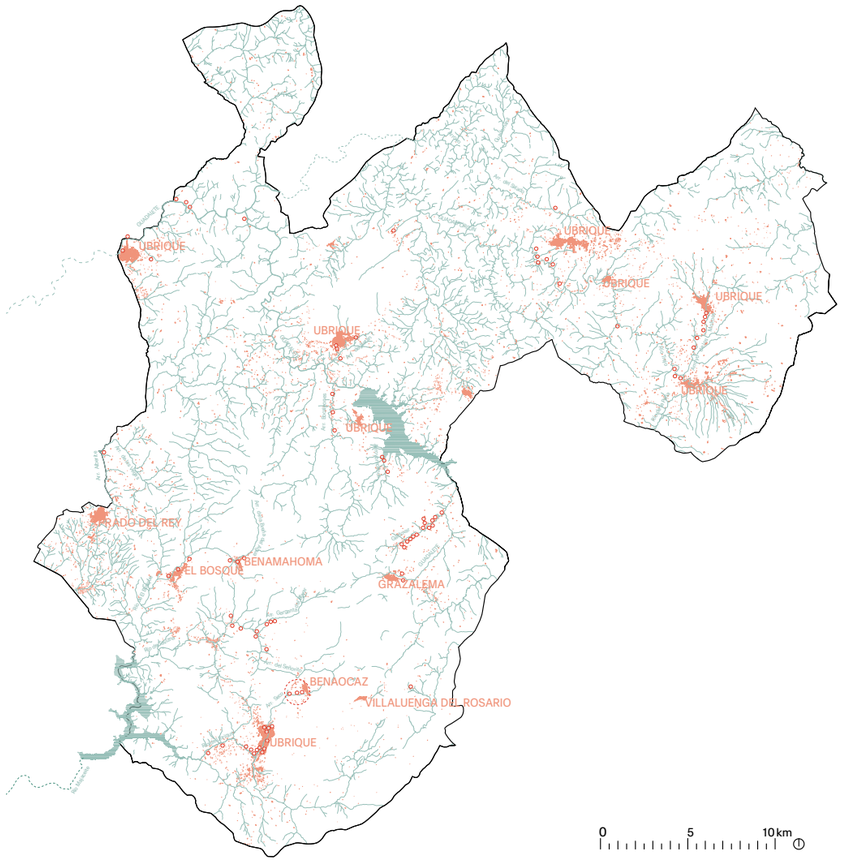


Fig. 3
Water mill 'Segundo' on the Arroyo Seco, Benaocaz (Sierra de Cádiz). Adapted from Rivero-Lamela (2019).



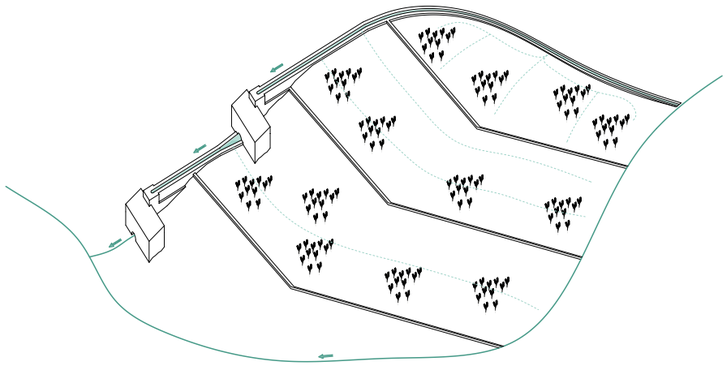
agricultural land and communication networks as well as a balanced spacing between mills. Given the scale of the territory and the considerable distance between the mills, the system hardly impaired the view of the landscape.

Each mill was built specifically on the slope of the riverbank. Although all mills had horizontal wheels and tower penstocks (a wide vertical pipe through which water flows, also known as the 'Aruba penstock'), they modified their formal system to use compact, regular prisms on banks with smooth topography or several irregular volumes on the more rugged terrain. Moreover, their hydraulic infrastructures, the retaining pond, the long irrigation channels, and the channels that linked the mills differed according to the landscape (a wheel and a bucket, where there was less demand or a greater concentration of mills, or two wheels and two buckets for better production to supply higher demand) without changing their function or internal operation and mechanisms, but with varying basic external infrastructures to obtain the most significant productivity. (Figure 4)

Regarding operation and functionality, in the case of water mills, the complex topography of the Sierra de Cádiz places these mills in their own natural space, which requires a functional understanding of the topography to conveniently adapt to the immediate area. The result is a simple architecture that is well suited to its function and is obtained economically and effectively. There were no contradictions between the forms and functions of these buildings. Grinding grains to produce flour immediately affects the form of mills. (Figure 5)

Their construction, most of which had two floors, consisted of a mixed structure with load-bearing walls of irregular stone masonry built with sand and lime mortar, 60-80 cm thick, and plastered with lime and wooden beams. The limestone used was the primary rock in the Sierra de Cádiz. Because of the region's heavy rains, roofs need to be sloped. The structure is made of wood, reeds found in the area, and Arab tiles. The use of Arabic tiles is an example the Islamic past, dating to the Nasrid period between the

Fig. 4
Two mills use the same water pressure to generate energy while supplying the irrigation system. Adapted from Rivero-Lamela (2019).



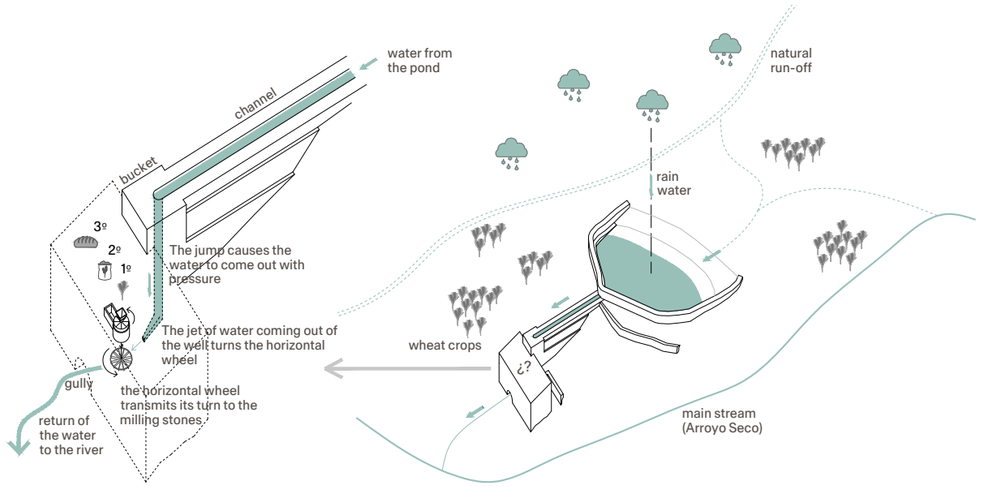


Fig. 5
Functional diagram of the mill, drawn according to the ruins found. Adapted from Rivero-Lamela (2019).

13th and 15th centuries. All these materials are used to build infrastructure that adequately addresses the different levels of the slopes where they are located, channelling or storing water, and terracing their immediate surroundings. Despite the differentiating nuances, the constructive and structural characteristics of mills in all regions are generally expected.

SALT FIELDS IN HAINAN, CHINA

The Sea Salt Fields are located along the bayshore on Hainan Island (Figure 6). In addition to harvesting salt, salt fields serve as buffers between villages and the sea. During high-tide periods, these stone salt fields significantly reduced the impact of waves on the bank and served as breakwaters to protect villages. Salt fields form a unique cultural landscape along the shores of the volcanic island. The stones at the beach were rearranged into fields surrounded by low walls to allow seawater to remain longer in the intertidal zone, making the edges of the salt fields suitable habitats for mangroves and other intertidal organisms. (Figure 7)

The form of the salt field is related to tidal movements. The ancestors of the salt village constructed a system based on the intertidal zones and height differences. Therefore, seawater can naturally flow into pools (fields) during high tide periods. The final process of the salt harvesting system uses sculptured volcanic stones. Salt can be harvested by exposing a thin layer of salty brine on top of a stone-shaped flat bowl to intense sunlight.

Fig. 6
A unique cultural landscape formed by salt fields. Adapted from Yan (2021a).

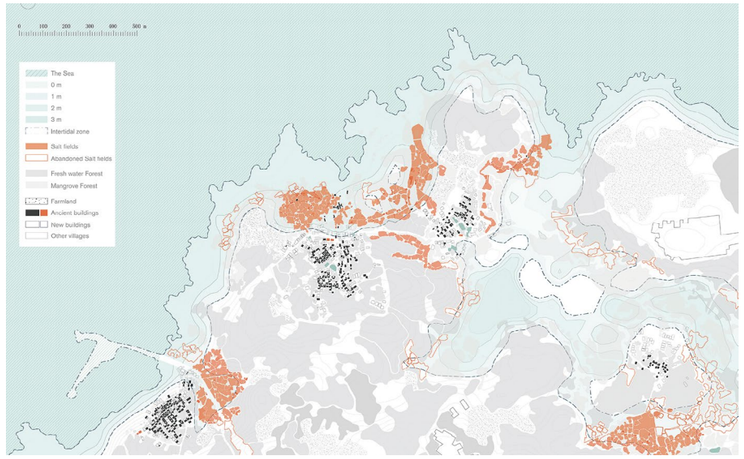


Fig. 7
Mangroves protect the salt fields formed by volcanic rocks by dissipating wave energy. Adapted from Yan (2021a).

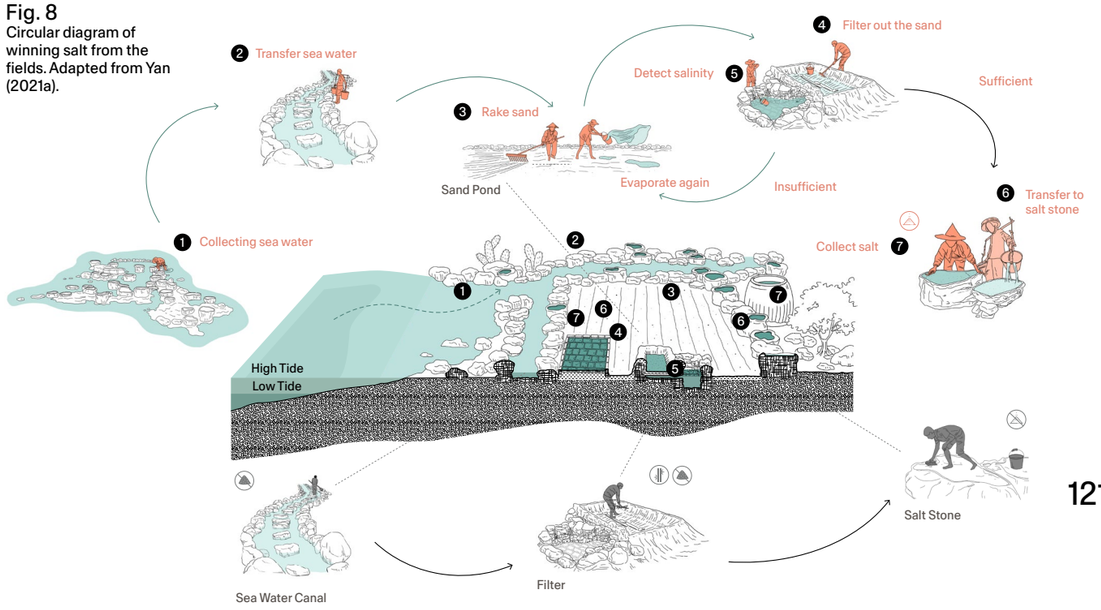


Ancient villagers and the sea acted in the same space at different times—the users of this spectacular landscape changed throughout the day, a month, and even a year. Salt farmers harvest salt from salt mud during low-tide periods, and fish can breed in the same pools when weather or tidal conditions are unsuitable for salt production. This flexibility makes it possible for more stories to happen at the same time and creates more biographies of the landscape.

The high temperature and wide intertidal zone of Danzhou make salt winning possible. With the guidance of volcanic stone ditches, salt-field structures enable the refinement of seawater into usable salts. In ancient times, this mode of production was a means of survival for the villagers in this area of Hainan. (Figure 8)

Volcanic stones (from ancient geographical movements) and sand from local beaches are the primary construction materials for salt fields. Moreover, with the help of stone structures, mangrove forests grow more stably along the edges of fields. These small forests also serve as a buffer zone in front of the artificial structure facing the sea, reducing the damage from solid waves to salt field structures.

Fig. 8
Circular diagram of winning salt from the fields. Adapted from Yan (2021a).



WATER MEADOWS IN HARNHAM, ENGLAND

Water meadows are irrigation systems built in the chalk river valleys of Wessex, southwest England. The positioning of these water meadows in the lower riverbeds made it possible to use the slightly alkaline water and the river sedimentation as a natural fertiliser (Figure 9). In the case of Harnham water meadows, water from the Nadder and Avon rivers was used to create seasonal flooding. This enriched the soil, increased hay production, and contributed to the more extensive English agricultural 'Sheep-Corn system' (Cook et al., 2003).

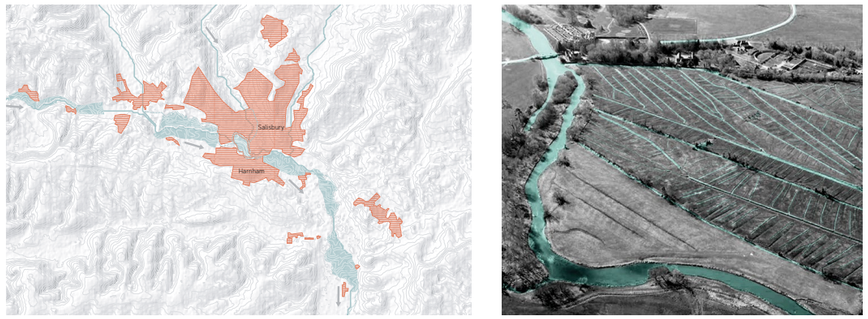


Fig. 9
(left) Tributaries within the River Avon catchment converge around Harnham and Salisbury. Adapted from Bazrafkan (2021).

Fig. 10
(right) Example of a 'bedwork' system by the River Avon (near Salisbury). Adapted from Bazrafkan (2021).

Water meadows are altered in such a way as to control the flow of water for a pasture-productive system. The' catchwork system' was one of the earliest systems used in medieval times. These 'field gutters' were formed by parallel channels that followed the contour lines of the hill slopes. Thus, water flowed from a higher level into the valley. The 17th-century 'bedwork system,' as used in the Harnham water meadows, was a more complex system of carriers, ridges and drains. They were characterised by curved ridges perpendicular to the primary water channel, also known as the herringbone layout, to distribute water on relatively flat river valleys (Figure 10). This latter system required more expertise and expense, so unlike the 'catchworks' created by hill farmers, 'bedworks' were often a product of wealthy landowners and large estates (Bird et al., 2017).

Controlled flooding of the Harnham water meadows relied on minor height differences and waterworks (made of local materials) that could be adjusted to provide adequate water flow. Two mills at Salisbury and Harnham were integrated into the water system, thereby increasing the water level upstream through impoundment. The water was then directed through the meadows in the so-called 'supply channels, with small wooden hatches (sluice gates) and small aqueducts. The water could then trickle down the constructed ridges, enriching the soil (Cook et al., 2008). Eventually, the surplus water was rediverted from the grasslands to the drainage ditches and channels back into the Avon River. (Figure 11)

Drowning of the meadows occurred in a cyclical maintenance system (Figure 12). During the flooding seasons (winter/early spring/summer), the meadows were irrigated for 3-7 days and drained again for a couple of days. In mid-March, when the grass reached a height of 150 mm, grasslands were used to graze sheep. Towards the end of May, the sheep were removed, allowing the grass to grow into hay. Dairy cattle graze from June until the end of September, causing problems for the meadow surface and water banks. This led to the requirement for bed work maintenance at the end of the fall (Figure 13). These farming steps were taken to irrigate the grassland, bringing nutrients and oxygen into the soil so that (typically) two cuts of hay a year could be taken, making water meadows a productive pasture system. During flooding seasons, water meadows appear to be naturally flooded, whereas during dry seasons, the waterworks and ridges show evidence of an advanced human-made agricultural infrastructure.



Fig. 11
(right) Plan of the water system. Based on the 1787 enclosure map by Tim Tatton-Brown. Adapted from Bazrafkan (2021).

Fig. 12
(left) The person responsible for managing the water meadows was known as the 'drowner'. Adapted from Bazrafkan (2021).

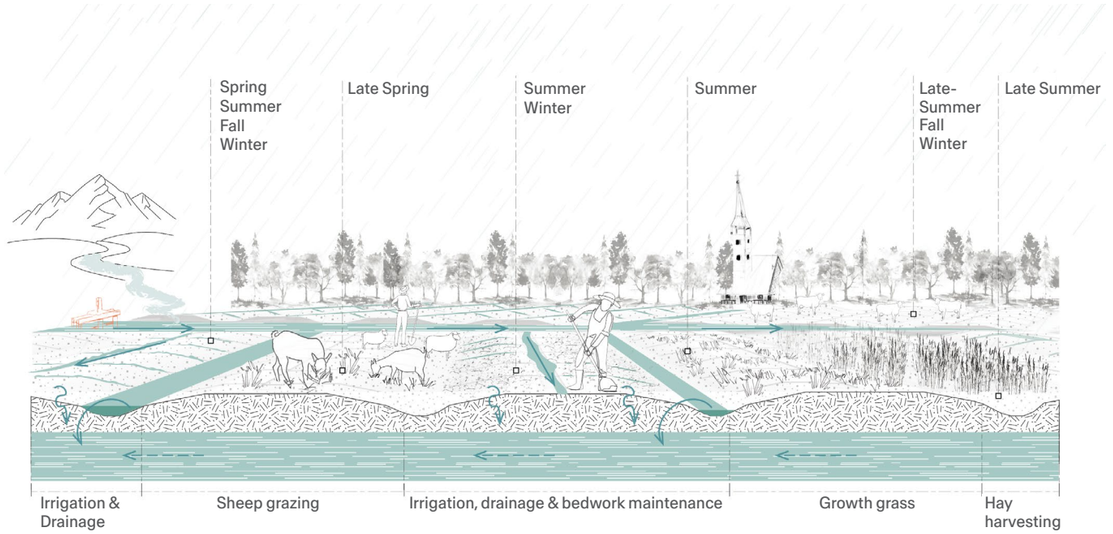


Fig. 13
Circularity drawing of the seasonal farming steps. Adapted from Bazrafkan (2021).

FORT WATER SYSTEM AND STEPWELLS OF JAIPUR, INDIA

Jaipur is a city located in eastern Rajasthan, India. As part of a hot and dry climate zone, it experiences frequent water shortages. Thus, the local inhabitants mastered the use of limited water resources and designed structures that helped them use and conserve water efficiently. Some of these practices are still used in villages across the regions. The main principle behind these indigenous practices is 'rainwater harvesting, ' which is deeply rooted in the social fabric. These practices are eco-friendly and contextual, and base their logic on following natural processes, encouraging community participation, and allowing for a more equitable distribution of benefits. Two systems were

discussed in the analysis of traditional water systems. Today, they are part of the city's urban realm: aqueducts of forts and stepwells. Although the two systems operate on different scales and principles, they together form a holistic water-harvesting system for the city.

JAIGARH FORT WATER SYSTEM

Situated on the north hill of the city, 2000 ft high on the spurs of the Aravali range, the fort was built for defense, but the most exciting feature lies in the water catchment system. The system consisted of water channels totalling 3.5 km (Figure 14), designed to follow the topography, running along the hills before entering the fort walls through a common channel. The hillock is outlined with water ducts approximately a kilometre long, forming three elliptical loops. Between the loops, the water passes through an aqueduct raised on five bastions and 39 arches, which carries water from one hill to another to avoid sudden dips between hills. Small cisterns were installed at the junctions to facilitate the flow.

Along this route, the channels change their direction at sharp angles to promote the sedimentation of debris and runoff. The water falls into a rectangular opening on the floor that carries it into the fort through a subterranean channel. The first catchment area allowed debris to settle. Once filled, the water was directed towards the next reservoir through a channel inclined upward to 25 °. By opening a sluice gate, clean water flowed through underground channels to the central tank of the fort. Once water crosses the second gate of the fort, the channel leads to a water cistern with two sluiced openings. First, the water is directed to a large underground tank (Figure 15) holding 60,00,000 gallons of water. The tank ceiling rested on 80 arched pillars. The second opening leads to a bathing tank with a flight of steps down to the water. Adjoining the open tank towards the south is the third covered underground tank with nine holes on its ceiling to draw water for domestic and drinking purposes. This tank was intended only for clean water.



Fig. 14
Detailed catchment network of the Jaigarh water system (plan), conceptual diagram of the system, and a photograph of the water channel entering the fort. Adapted from Chandna (2019).

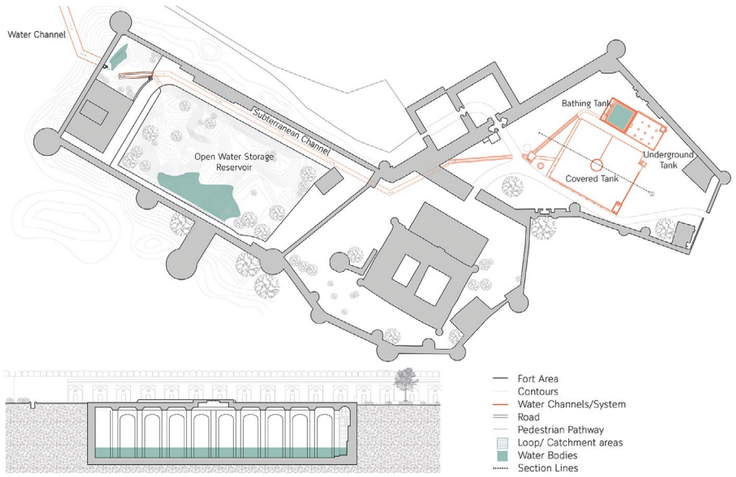


Fig. 15
Water network within Jaigarh Fort (plan at bottom left and photograph at right), and section of the underground tank. Adapted from Chandna (2019).

Underground tanks are advantageous because they minimise evaporation, prevent pollution, and provide natural water cooling. However, some channels and viaducts have deteriorated over the years owing to a lack of maintenance, resulting in ineffective system performance. However, some water is still collected and caters to the needs of tourists and inhabitants of the fort.

NAHARGARH FORT WATER SYSTEM

Located some distance from Jaigarh Fort and overlooking the city, Nahargarh Fort functioned as a residential royal fort, with a maze of courtyards and chambers for nine queens. Apart from providing basic facilities, the fort has a self-sufficient, elaborate water system with catchment areas extending approximately 6 km from the fort.

The main idea behind the networked system is to collect, control, purify, and store as much water as possible. Similar to the Jaigarh fort, this system forms five catchment loops that spread organically across the hill, connected through tiny channels and aqueducts (Figure 16) to bring water to the fort. The catchment beds were designed with gradient and undulating surfaces in mind. The runoff from these beds was collected and directed through a long drain that entered the fort, where it bifurcated at a distribution point with a cistern to switch the flow. (Figure 17)

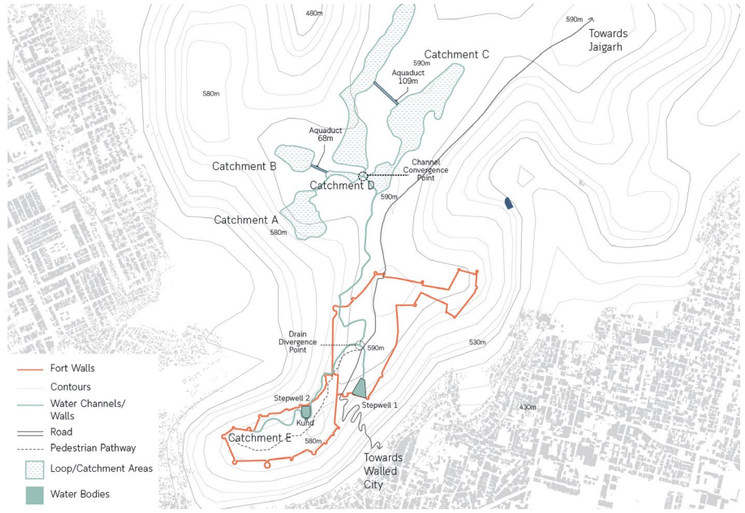


Fig. 16
Network of water catchments and the distribution system within Nahargarh Fort. Adapted from Chandna (2019).

Unlike Jaigarh, the Nahargarh fort has two large stepwells (baolis) and a tank (kund) (Figure 18). The water from the distribution point flows in two directions towards the Stepwells. While ordinary people and animals used Stepwell 1 for bathing and recreation, Stepwell 2 was used for the royal family. Catchment area E, which lies within the fort, collects runoff from the fort area and directs it to the kund. The kund and stepwell 2 were interconnected to ensure maximum storage and adequate water distribution for various purposes.



Fig. 17
Water channels and aqueducts carry water to the Nahargarh fort. Adapted from Chandna (2019).

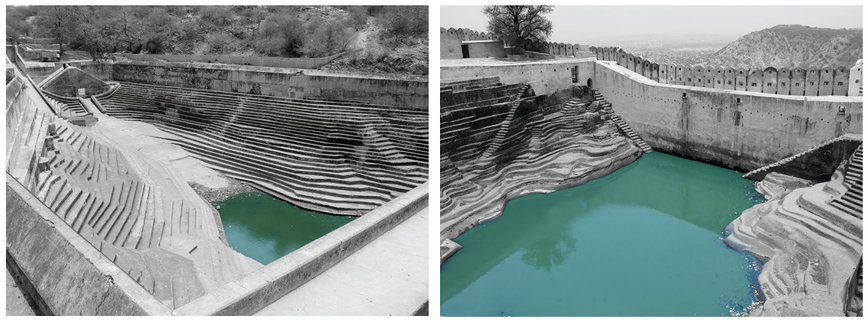
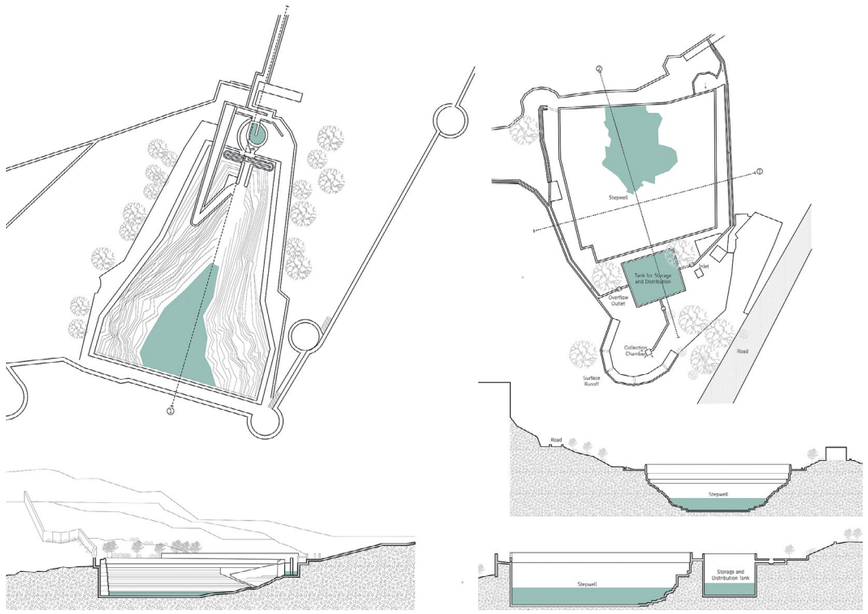


Fig. 18
Stepwells 1 and 2 at Nahargarh Fort. Adapted from Chandna (2019).



Water holds profound significance in Hindu cosmology, where it is regarded as the boundary between heaven and earth. For centuries, stepwells and stepped ponds, known by regional names such as *bavdis*, *bawadis*, *baolis*, and *vavs* (Figure 18) have formed enduring, circular water systems that have sustained communities by harvesting, storing, and providing access to water across generations. Integrated into everyday life, these structures are serving as important places for social interaction, cultural and religious practices, and, today, tourism. Built mainly between the 7th and mid-19th centuries, these structures usually range from three to nine stories deep, forming a passage into the terrain and helping escape the heat, thus becoming community spaces and being invested with religious meanings. Fed either by rainwater harvesting or by natural springs, these stepwells were mainly used for bathing and washing. However, some were built to cater to specific buildings or complexes, such as temples and gardens; some were used by commoners residing within the settlement, while others were part of highway infrastructure, where travellers/commuters and pilgrims would stop, park their animals, take shelter in the covered arches, and rest. Usually commissioned by royal and wealthy patrons, scholars estimate that by the 19th century, thousands of stepwells of varying grandeurs had been built across the country.

The structure of a stepwell usually combines two elements: a vertical shaft/well, protected from direct sunlight by a full or partial roof from which water can be drawn, and the surrounding steps, along with passageways and chambers as spaces for people. The well is lined with stones, which allow the water inside to freely fluctuate with the surrounding water table.

Approximately 50 stepwells in Jaipur have been identified, but only a few have been mapped and are partially conserved. Their concentrations can be observed around the town of Amber (Figure 19). To meet people's needs, the city had a well-functioning water system that included stepwells built within the settlement and along transportation routes. Thus, during the monsoon season, the descent to the water table is shorter, and the well fills and reaches higher levels while recharging the water table. Water is always available through the water table even during dry periods.

However, these structures gradually declined during British rule, as the authorities feared unsanitary conditions at these drinking and bathing spots and replaced them with centralised water pipes and pumps. Most of

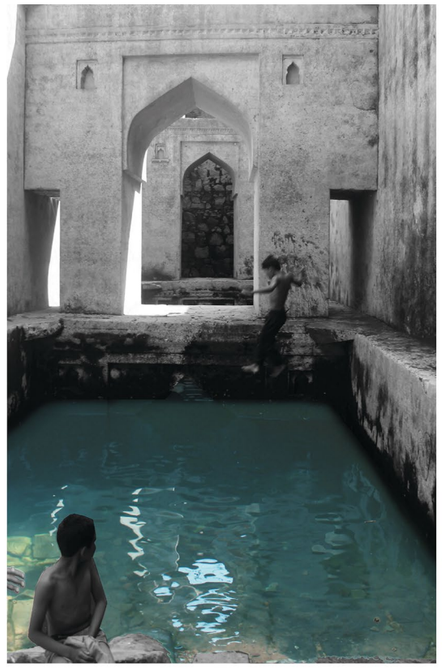


Fig. 19
Panna Meena Kund, Amber. Adapted from Chandna (2019).

them have either dried up due to overuse or inadequate recharge from rain or contain polluted water due to lack of maintenance and government neglect.

The architecture of these bawadis varies according to the material scale, layout, shape, location, and when they were built. They have been found in rectangular, circular, or even L-shaped buildings constructed from stone masonry, rubble, or brick, and can have as many as four entrances. No two stepwells are identical, whether utilitarian or straightforward, complex or ornamented, depending on who commissioned them. Jaipur can be categorised into five typologies (Figure 20) based on access, water source, architectural style, additional spaces, and location.

Fig. 20
Typologies of stepwells. Adapted from Chandna (2019).


Cheela Bawadi


Atreya bawadi


Sarai bawadi


Bengali Bab ki bawadi


Pashuram Dwar ki bawadi

RECOGNISING HERITAGE VALUES

Illustrations of traditional water systems reveal heritage values to the extent that they are recognised collectively by society, academics, and researchers. These four values can be identified across all projects: site-specificity and integration, sustainability, their role in infrastructure and networks, and identity.

SITE-SPECIFIC AND INTEGRATION VALUES

All projects are site-specific and positioned precisely to optimise the results with minimum possible construction resources. The systems are integrated into the landscape, and the position and size of different traditional water systems are determined by the site's water resources and the function of each system. They usually adhere to the terrain on which they are built, and the terrain and relief are part of the systems that determine their possibilities. In addition, these systems were built using local materials. This causes them to merge and integrate into the environment without abrupt interruptions to the natural continuum.

The Watermills, the greatest possible topographic jump, were sought so that the water would acquire maximum pressure and thus move the horizontal wheel faster, which in turn would transmit the rotation to the stones that ground the grains.

Salt Fields extract salt from the seawater. A combination of volcanic soil, hot climate, and tidal conditions was sought to ensure that the sun could efficiently collect and naturally evaporate seawater, leaving behind crystallised salt. The strategic site-specific placement of these fields maximises salt production with minimal intervention, demonstrating a deep understanding of natural processes. Salt Fields are seamlessly integrated into the intertidal zone, and their layout and size are shaped by the site's water availability and the functional needs of salt production. They follow the terrain's natural contours, utilising tidal flows, evaporation basins, and stones that align with the coastal relief. Built with locally sourced volcanic stones, these salt fields blend harmoniously into their surroundings, maintaining a continuous connection with the natural environment without disrupting its balance.

Water Meadows are human-made irrigation systems built in river valleys to manage the water flow in relatively flat plains. The system uses height difference and a simple architecture: supply channels and ditches, hatches (small sluices), aqueducts, and soil ridges. This allows water to infiltrate, channel into, and divert from the grasslands. This process enriches soil, thereby increasing hay production. Grassland waterworks and constructed ridges form a layout that can be recognised during the dry season. Because of their strategic positioning, they appear to be inundated by adjacent rivers during flood seasons, and infrastructure is built to mitigate flooding.

The steps in the Stepwells of the Nahargarh Fort project shape the hills' topography. This structure harvests thousands of gallons of water annually. The complexity and engineering of this structure are so well established that, in the event of water overflow, the system automatically diverts water towards the city's tanks and wells below, ensuring that every drop is conserved. Similarly, at Jaigarh Fort, the overflow was redirected to Sagar Lake, behind the fort. Additionally, the channels and aqueducts of both forts use natural slopes to direct rainwater into storage tanks, without pumps or machinery.

Heritage values, site-specificity, and landscape integration testify to particular ways of inhabiting and transforming landscapes. They embody generations of accumulated knowledge about local topography, hydrology, materials, and ecological processes, revealing how communities have learned to work with the opportunities and constraints of their landscapes, leaving behind tangible expressions of environmental intelligence.

SUSTAINABLE VALUES

Using natural resources, such as soil and stone, and constructing works with traditional materials and techniques from the landscape, the location itself, and non-contamination, these systems are environmentally friendly and often circular.

Watermills participated in and intervened in local water resources to provide energy. The study at the riverbank level allowed us to understand the operation of mills on rivers and streams as open recirculation. Each mill or set of mills does not form a cyclical system and, therefore, a closed system that starts at a geometric point and ends at that point. Instead, these mills are connected at a precise moment to create an artificial but harmless circuit that captures the water and directs it towards the mill mechanisms along a route that ends in the same riverbed of origin, downstream, at another point different from the initial one. Therefore, it is a surface water recirculation system that requires the natural channel itself to complete the technical processes of water use, exploitation, and return. It has been proven that this circular use of water enables different adaptations that make the generic scheme a more complex system; transformations derived from the primary objective of supplying the hydraulic force necessary to carry out the milling of flour, which allows, in turn, to store water in ponds, hydraulic channelling for the irrigation of nearby agricultural lands, or the use of the system by pairs of mills. These actions can be combined to acknowledge the connectivity and collective use of infrastructure, communication, or water in the water recirculation system.

Meanwhile, the production of Salt Fields is sustainable because there is much salt in the sea. Local people harvest edible salt directly from the sea by evaporating seawater with sunlight, fully embodying the rational use of natural resources. New Danzhou immigrants could earn a living by collecting salt-utilised scattered volcanic rocks along the coast to construct dwellings and build monuments, thereby memorialising the birth of new labor within familial units. These stone facilities became symbols of the local salt-harvesting culture.

The sustainable success of Water Meadows is multifaceted. First, positioning the meadows in the Chalkland River valleys provided reliable year-round flow and good subsoil drainage. Second, irrigation systems are regulated through seasonality. This means that land use was based on, and adapted to, water availability. Lastly, they gained popularity despite the expenses to construct and maintain them because of the meadows' regional significance and contribution to the 'sheep and corn economy chain.

In addition to harvesting rainwater, which is a sustainable practice in the region's arid/semi-arid zones, the construction process was also sustainable and circular. The construction of stepwells and forts, like many other structures in the area, uses locally available materials that are durable and suited to an arid climate.

In the case of stepwells, the primary materials were red and yellow sandstone, which were locally quarried and resistant to weathering. Limestone and lime mortar served as binding materials. Another detail was to use Araish plaster (lime-based plaster) on the walls. It is known for its smooth, polished, and water-resistant finish, resembling marble, and offers a reflective surface that keeps interiors cool. This technique is an eco-friendly and sustainable construction method, and some artisans still use it for restoration projects.

Red and pink sandstones are extensively used in the case of forts. Jaipur is known as 'Pink City because of its extensive use of pink sandstone, lime mortar, and plaster. The Jaigarh Fort also housed its foundry, the largest in Asia, for cannon production.

Sustainability as a heritage value should not be understood in terms of its contemporary meaning, which has emerged in response to present and future environmental challenges. Instead, these systems were developed to meet long-term needs for efficiency, productivity, and resource security. In doing so, they embody practical wisdom accumulated through observation, experimentation, and adaptation. Embedded in enduring practices and resource management strategies, this wisdom remains relevant, inspiring more adaptive, circular, and responsible approaches to landscape transformation and governance.

INFRASTRUCTURE AND NETWORK VALUES

Traditional water systems are often embedded within broader infrastructure. Physical structures, such as roads, organise territories, and facilitate trade; many of these systems also form part of agricultural and ecological networks.

Watermills have created many paths or take advantage of existing ones to facilitate the exchange of products and connections between mills in dispersed settlements and villages. Although dates are unknown, analysis of the historical roads through the planimetric surveys of 1873-1874 reveals many roads whose names allude to mills. Therefore, if their creation was not initiated by mills, they were relevant in their use and transit. Similar to communication infrastructure, these lines have shaped mountainous territory.

Salt Fields are more than just a production system; they are the foundation of the salt village's identity and collective memory. From the earliest days of settlement, salt production has been the core of village life, shaping the village's landscape and cultural traditions. Ancestral halls were built beside these salt fields, and structures such as stone towers emerged over time, marking the community's historical relationship with salt production. Apart from their economic and cultural significance, salt fields also play a crucial ecological role. Their unique structure creates favorable conditions for mangrove growth, stabilising the coastline and intertidal zone. For a coastal village, this natural buffer is essential to protect against erosion and to maintain the delicate balance of the marine ecosystem. The fields persist through the villagers' daily use and maintenance, crystallising generations of labor and tradition into a living cultural heritage that sustains the village's existence.

The Water Meadows were part of the more prominent English agricultural 'Sheep-Corn system' in which sheep would graze the pasture of the meadows during the day and be moved to arable land during the evening to enrich the soil with dung and urine so that the water meadows were naturally fertilised by water and arable land by sheep. This method of production was invented during the French Revolution and the Napoleonic Wars, when self-sufficiency was necessary, and it remained a part of England's rural history.

The forts of Jaipur were primarily part of a triangular defense network: Jaigrah, a military stronghold protecting the cities of Amer and Jaipur, and Nahargarh, a strategic lookout and protection from the northwest. Built at high elevations, they provided visual coverage of trade routes, valleys, and potential enemy approaches, creating a network that combined governance, defense, water security, and economic management. Water, human resources, and materials were shared across forts. If one fort falls short or has shortages, others can support it through tunnels and strategic outposts.

The infrastructure and network values of stepwells are fascinating and often underappreciated. They were not just utilitarian water storage spaces but rather part of a more extensive integrated infrastructure network that supported sustainable urban planning, agriculture, and community life. While the primary function is harvesting and storing water for year-round use, many stepwells have overflow systems that channel excess water into tanks, farms, and other stepwells. The design features multilevel construction with

descending staircases and platforms that allow access to water at various depths, as the water table fluctuates. A single stepwell can store thousands of litres of water, which is crucial during periods of drought. They are often embedded within the city's urban grid, located near temples, palaces, markets, and community centres. They are part of a distributed water network of the city, forming a chain of water structures, such as a catchment hierarchy strategically placed to serve different neighborhoods, many of which are connected to irrigation channels to support agriculture. While scientific aquifer mapping is not known, traditional builders intuitively understand the hydrology. They designed these structures with a deep awareness of underground water behavior, thus forming a living breathing groundwater network.

Across the examples presented, infrastructure and networks organised relationships between settlements, productive landscapes, and their surroundings into coherent territorial systems. As heritage, they preserve the spatial logic through which water coordinates production, ecological functions, and everyday life.

IDENTITY VALUES

Beyond their physical and functional qualities, traditional water systems also embody a fundamental intangible value: they reflect the identity of communities that create, maintain, and rely on them. Rooted in local knowledge, practices, and traditions, they are an inherent part of the regional culture and identity.

Watermills reveal fundamental ways of living and working in this rural environment, which is why they are essential in defining the identity of the Sierra de Cádiz. Nevertheless, the profound socio-economic transformations of the 20th century altered the functionality of the rural territory, leading to the abandonment of certain artisanal practices, such as milling, which culturally characterised the society of the Sierra de Cádiz. This led to the disuse of water mills, which remained in ruins as relics of a bygone era. Their persistence in the territory and their delicate state of conservation imply a triple approach: study them to extract the wisdom they contain, protect them to prevent their disappearance, and reactivate them to become a living network of the place.

Salt Field production has been handed over from one generation to another. The unique lifestyle and agricultural activities are integrated with the environment, forming a distinctive cultural landscape and earning these villages the nickname 'salt villages. ' Salt fields in Danzhou reflect an ancient attitude of adapting to uncertain futures, while prioritising human survival and quality of life. These salt fields are essential to the local village's identity and culture. Local villagers have also begun to develop tourism to maintain a unique landscape formed by salt fields.

The water meadows were gradually abandoned in the mid-19th century, when farming became mechanised and artificial fertilisers were introduced. Generally, water meadows are poorly protected; it is estimated that only 4% of individuals and trusts are 'well preserved,' whereas 40% have been destroyed since 1998. The Harnham Water Meadows are protected for their archaeological remains and status as a Site of Special Scientific Interest (SSSI) due to their vast diversity. (Historic England, 2018)

The identity value of historic structures, such as Jaigarh Fort, Nahargarh Fort, and the Stepwells of Jaipur, extend beyond their physical and functional roles. They symbolise regional pride, cultural continuity, architectural ingenuity, and environmental intelligence. The Jaigarh Fort, also known as the Fort of Victory, embodies the military prowess of the region's kings. It protected the cities and was never conquered, giving it an aura of invincibility and pride. Home to the enormous cannon, the foundry and armory in the fort, along with its advanced rainwater harvesting system, reflects self-reliance and craftsmanship, adding to the identity of eco-conscious foresight and blending defense with sustainability.

On the other hand, the Nahargarh fort formed the northern defense ring and showcased refined palace architecture with the Indo-European flair. Now a space for art galleries, films, and public events, it has become a living cultural landmark that connects the past with the present. Its identity lies in being a protector-turned storyteller.

Apart from being a water source, the stepwells served as community nodes—places of gathering, rituals, trade, and daily chores, such as washing and fetching water. In some cases, they also serve as subterranean temples, abounding in carved images of the region's male and female deities. Some were designed with ornate pavilions, reflecting their importance to public life. In desert cultures, access to water = power; thus, stepwells reinforce social equity when shared among communities. It was considered highly meritorious to commission a stepwell as an act of philanthropy, or in the memory of a loved one. Some of them are still used in colorful festivals and sacred rituals.

These examples demonstrate that the identity value of traditional water systems lies in their continuing capacity to sustain meaning, memory, and cultural practices across generations. They connect communities to their landscapes through shared histories that continue to shape their local and regional identities.

CONTEMPORANEITY

While differing in geography, function, and cultural context, the selected traditional water systems revealed a remarkably consistent set of heritage values. Their heritage significance lies not only in their physical structures but also in the knowledge, relationships, and practices they embody. Together, these values demonstrate that traditional water systems are best understood as cultural landscapes where environmental, social, productive, and cultural dimensions have co-evolved over time.

Collectively, these values deepen our understanding of what these systems represent in the past, what they may contribute to the future, and what can be sustained if the traditional water systems and infrastructures that connect them remain in place.

Their relevance becomes even more evident today, as many interventions have drifted from their environments and functional programs, becoming speculative, decontextualised, or disproportionate, and treating place as a neutral support devoid of intrinsic qualities. These tendencies and reactions have renewed interest in values that reconnect design with place, in pursuit of more sustainable, adaptable, and context-responsive architectures and systems. Undeniably, traditional water systems are significant in the presence of collective memory, culture, and ways of life, which still offer valuable lessons for contemporary society. They are a source of knowledge about traditional building techniques, use of locally adapted materials, natural resource management, and strategies for integrating interventions within the territory. Drawing these systems in their territory is a fundamental methodological tool for revealing these qualities.

However, the lessons that these constructions offer should not be limited to their environmental performance, which dominates much of today's discourse. More comprehensively, they reveal the complex and dynamic cultural, social, economic, architectural, and environmental relationships that have evolved. From this perspective, traditional water systems offer enduring lessons extending beyond their material forms. As Paul Oliver recalls, vernacular architecture, in general, is 'the root of our culture and what gives it meaning.'

Recognising traditional water systems as heritage resources with architectural and territorial significance also means acknowledging the ways of life that they embody. As such, they demand protection and preservation. Even without reference to climate change, their value to contemporary society is undeniable, and they continue to reveal knowledge that warrants greater attention from public institutions, helping ensure their legacy endures.

People Practices

This mosaic collage (page 138/139) is a collection of human-related water practices in the analysed cultural landscapes. Within our worldwide collection, we distinguished four main categories.

Domestic water

People fetch or use water for household purposes, such as filling containers. Simultaneously, these places were used for meetings and communication. Women often perform these tasks.

Fishing practices

Interaction with water is driven by the intention to gather fish, mussels, and aquatic plants. We see people fishing using all boat types made from local material and in different shapes that suit the circumstances. Various tools and methods have been developed in different locations, ultimately serving the same purpose.

Farming

Drainage or irrigation Water nourishes crops, and people use various tools for water collection and irrigation.

Others

This category includes unique activities related to water. These activities can have spiritual meaning or are part of a contemplation for enjoyment, refreshment, and meeting.

Fig. 1
A woman washing clothes in the backwaters of the Kuttanad Kayalnilam Farming System. Adapted from a photograph by Inge Bobbink.

Above the ground

Domestic

Fishing

Farming

Other



Fig. 2
Collection of activities performed by water workers. By the authors.



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

Monica Veras Morais[1], Gerdy Verschuure-Stuip[2], Emmanouela Armoutaki[3]

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.

1 Dr ir. M. Veras Morais, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands; M.VerasMorais@tudelft.nl 0000-0002-0223-7429

2 Dr ir. G. A. Verschuure-Stuip, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands 0000-0001-8688-6372

3 Ir. E. M. Armoutaki, Department of Environmental Structures, Directorate of Engineering Projects, Iraklion Regional Unit, Crete

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INVISIBLE WATER SYSTEMS

'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 Jaguaribe[1] 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 rangeland, 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).

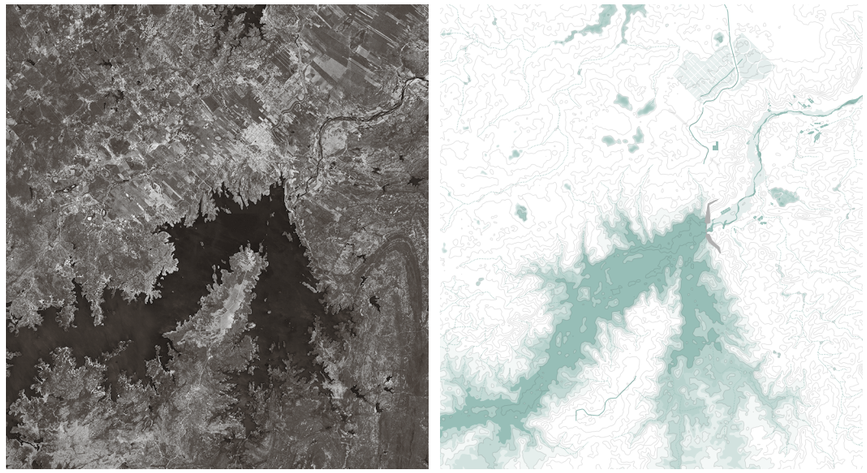
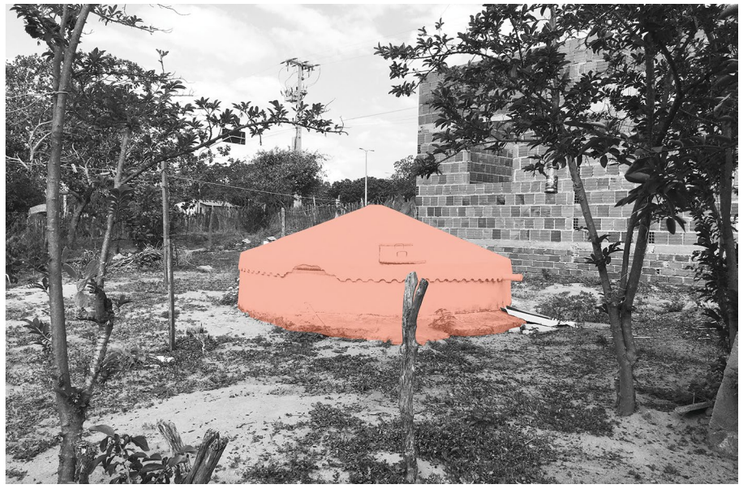


Fig. 3
Rainwater harvesting in Jaguaribara. The cistern is semi-buried to keep the water at a mild temperature until it can be manually extracted and purified for consumption. Adapted from Veras Morais (2020).



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 *puçá* 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 limestone 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).

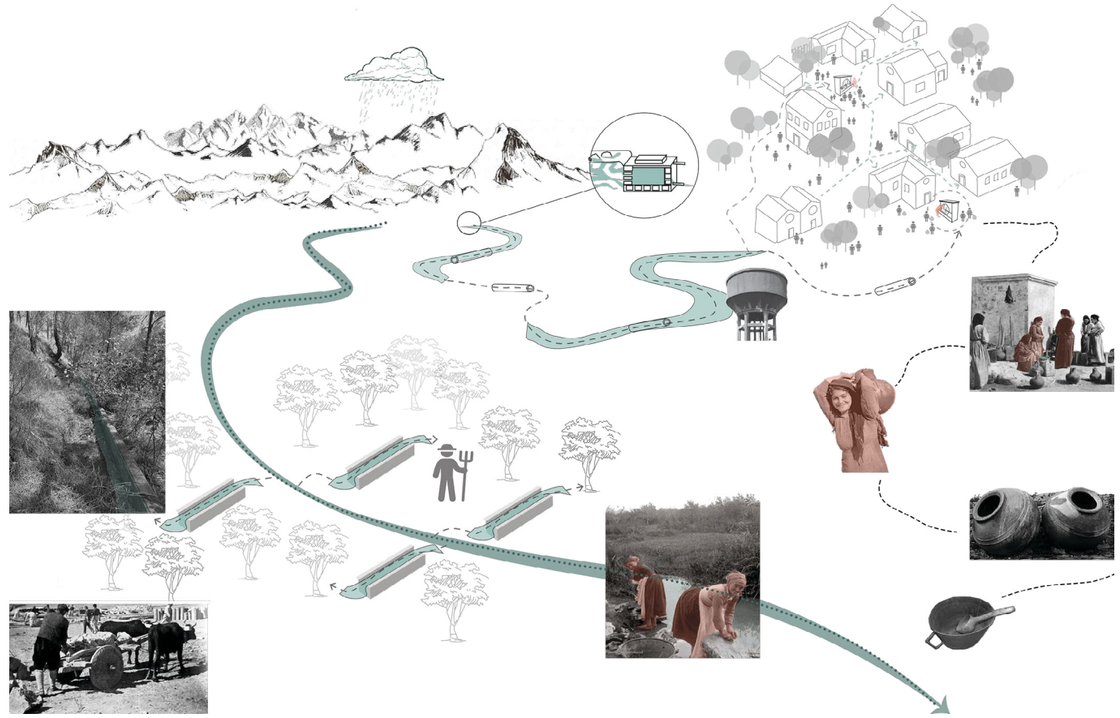


Fig. 7
Routes from the Teratsia Spring in the Paphos Mountains to Pomos village. Image by Xenia Georgiadou, adapted from Georgiadou (2023b).

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

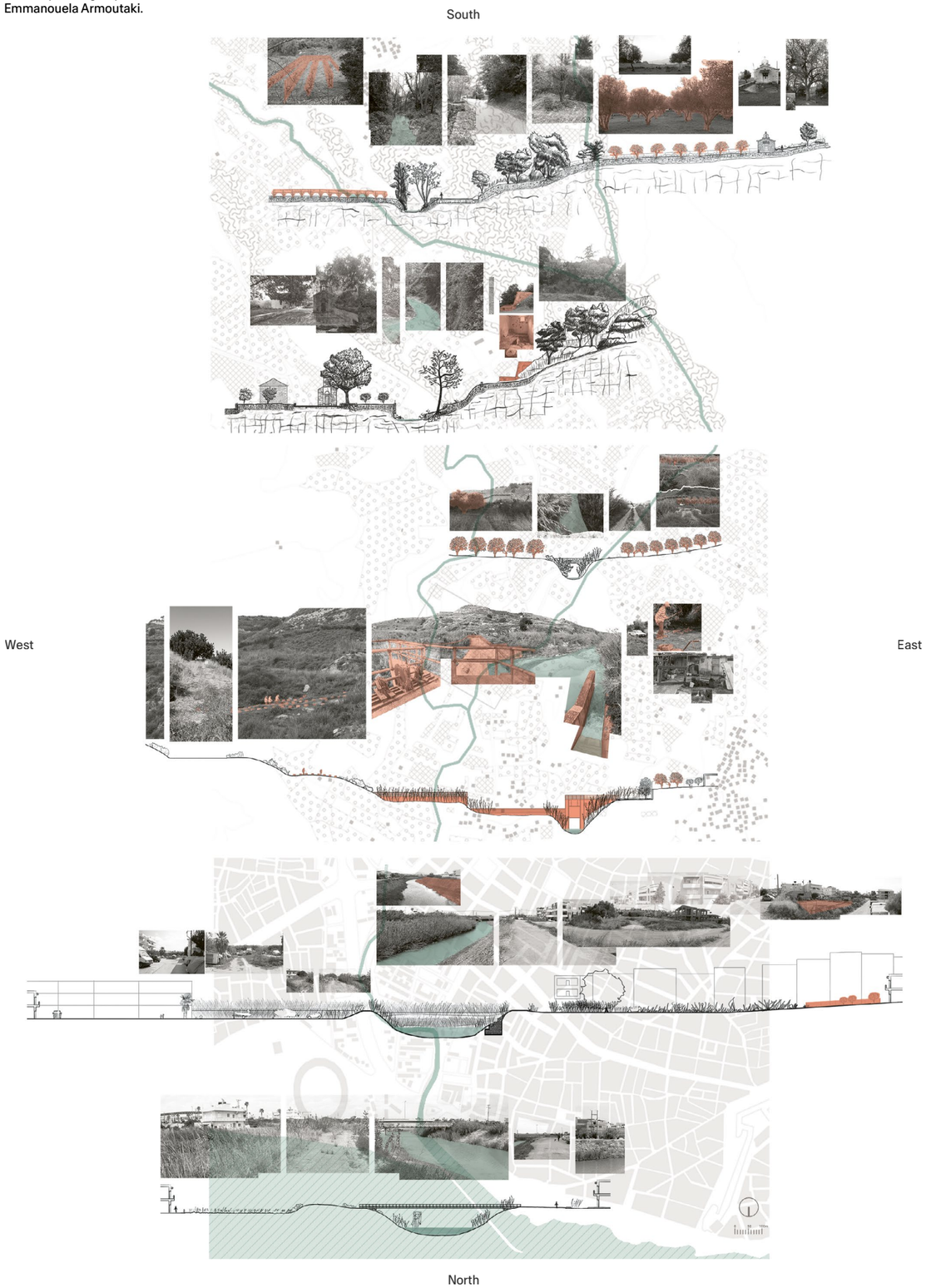
Fig. 9
The flow of the Yofyros River: nature (top), fields (middle), and city (bottom). Adapted from Armoutaki (2022).







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 *iagúiara* 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.

Part III

Circular Water Stories in Practice



Fig. 1
Counter-mapping workshop with the 'Soldados' highland community in the southern Ecuadorian Andes. Adapted from a photograph by David Fajardo.

Co-design

Through Visualising Waterscapes

Catalina Rey-Hernández[1]

The academic research field tends to conceptualise and categorise reality and detach it from its context to generate knowledge that is often accessible only to expert peers. Usually, these results do not return to the socio-political environment of the study object. However, knowledge production is a dynamic process where visual methodologies can play an essential role in generating specific data for research, co-creating new insights with the communities involved, and communicating findings to engage with a broader audience. In that sense, drawings can make knowledge more visible; therefore, a visual translation into a standard, understandable language can bring academia closer to society. In that context, the research work developed through the Circular Water Stories (CWS) lab aims to investigate complex traditional water systems and to translate them into understandable drawings that convey complex knowledge through a common language that different disciplines and audiences can relate to and easily understand. This essay is a personal reflection on using drawings in research as a graphic tool for conveying ideas and co-creating knowledge. Furthermore, through two concrete experiences, I explore how these visualisations can translate complex realities and information into an understandable language, returning knowledge from academia to society.

1 Ir. C. Rey-Hernández, Water Resources Management Group, Department of Environmental Sciences, Wageningen University & Research, the Netherlands;
catalina.reyhernandez@wur.nl
0009-0001-9516-1047

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In academic research, knowledge is often produced in ways that seem disconnected from everyday life, creating a separation between the research outcomes and the people they are meant to serve. This detachment, while necessary for academic analysis, makes knowledge inaccessible to the public, as it is often framed in technical languages and scholarly discourse. Such a gap can alienate those who can directly benefit from research insights. (Karlsson, 2007)

However, knowledge production is not a one-way process. It is dynamic and co-creative with researchers and subjects engaging in reciprocal relationships (Mitchell et al., 2011). Researchers are not detached observers and do not merely extract information; they shape their findings through continuous dialogue with their subjects and adjust their perspectives as they gather new insights (Mitchell et al., 2011). This dynamic process emphasises the importance of methodologies that bridge the gap between technical academic knowledge and the broader public, thus making research more accessible and meaningful to civil society (Karlsson, 2007).

Visual methods, mainly drawings, maps, diagrams, schemes, and sketches, have emerged as powerful tools that make complex knowledge visible and translate it into a more universally understood language (Vass et al., 2022). At the same time, visual methodologies play an essential role in the dynamic nature of knowledge production through collaboration and co-creation. Modern research practice increasingly emphasises interdisciplinary approaches and collaborative efforts, bringing diverse perspectives and expertise together. This collaborative environment fosters the dynamic exchange of ideas, leading to innovative solutions and new forms of knowledge. Co-creation through visual methods involves researchers, practitioners, policymakers, and communities shaping the research process (Galvaan, 2007).

OPENING THE RESEARCH

The approach to academic research often prioritises text-based outputs, which, while effective in specific contexts, can be limited in their ability to convey complex multidimensional realities. By contrast, visual methodologies offer alternative means of communication that can transcend linguistic and disciplinary boundaries. Drawings, schemes, diagrams, maps, etc. can clarify intricate concepts into more understandable frameworks, allowing for more inclusive communication during the research and better dissemination of the results to fellow researchers and the communities involved in the investigation process (De Lange et al., 2007).

At the same time, during the process of researching through visualisation, new questions arise in the investigation and incentivise us to delve deeper into case studies and start mapping other values that are usually not drawn or considered in this kind of practice. This visual method helps us make connections between spatial, social, and cultural aspects by mapping the intangible and dynamic aspects of each case. It is certainly a challenge to draw something that is sometimes difficult to grasp or that is constantly changing over time, such as social aspects, human actions, seasonal ecology, or the spiritual-symbolic aspect of a place. However, finding ways to diagram these aspects through systematic, in-depth research based on visualisation can create integrative images that people in the field can read and understand comprehensively (Bobbink et al., 2022).

As these aspects are difficult to uncover, their visualisations are based on consulting cultural and historical sources, often conducted by sociologists, anthropologists, or historians (Bobbink et al., 2022). Therefore, this visual translation is critical in interdisciplinary research, in which communication across different fields of expertise is crucial. By transforming abstract or complex information into visual formats, researchers can engage with a broader range of audiences, including those who may not have the specialised knowledge required to grasp traditional academic output (Mac Entee & Mitchell, 2011).

Therefore, making knowledge more visible is essential for effective communication and dissemination. This is crucial for ensuring that valuable insights and findings are not confined to academic circles but are shared and utilised by a wider audience. For instance, visualisations such as charts, graphs, and infographics can convey complex data in precise, digestible forms, making it easier for non-experts to grasp key concepts and trends.

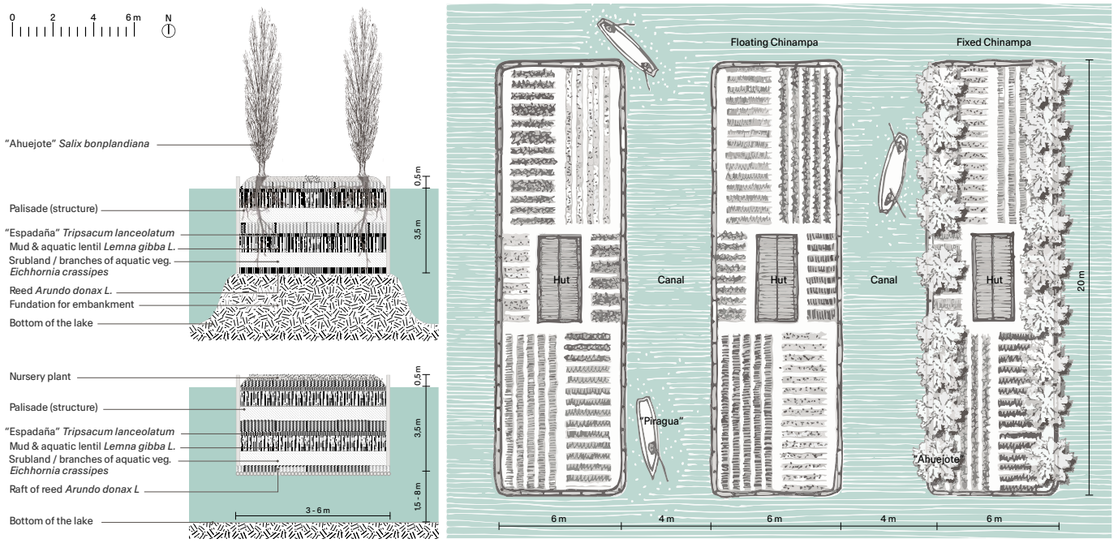


Fig. 2
Detailed plan and section of the Chinampas Farming System in Xochimilco, Mexico City, Mexico. Adapted from Bobbink and Rey-Hernández (2022).

On the other hand, using visualisations to gather data for a specific research project opens up different ways of relating to the case environment. For instance, drawings help to initiate conversations more informally and dynamically when working with people. Thus, as researchers, we can uncover insights that are often unexpressed in traditional interviews or discussions. Working with visual methods in a careful manner can also foster more intimate interactions that enhance trust and commitment between the researcher and the socio-political context and the environment being investigated (Vass et al., 2022). In that sense, research becomes a co-creation among different actors rather than a one-way output that benefits only academia. This approach to collective research development creates an opportunity to consider other voices, worldviews, perspectives, and positionalities that enrich the discussion, and therefore, the research results.

Hence, when translated into visualisations, these research results bring academia closer to society through a common language. By doing so, drawings ultimately bring back the gathered knowledge to the communities

involved in the research process and to a broader audience of 'non-academics'. Furthermore, in the case of the CWS lab, most students work with cases that are often in their hometowns, familiar to them, or closer to their own culture. In this way, they position themselves as subjects of research, generating insights from their own experiences rather than solely from the case study's academic research. Thus, the resulting visualisation already contains the positionality and vision of a 'non-expert' who can tell a more intimate story about the research itself.

Beyond enhancing communication, drawings and visualisations possess significant persuasive power, particularly in shaping political narratives and influencing public opinion. Visual representations can simplify complex, abstract concepts into immediate, emotionally compelling images that can shape attitudes and drive action (Tufte, 2001). Beyond enhancing communication, drawings and visualisations possess significant persuasive power,

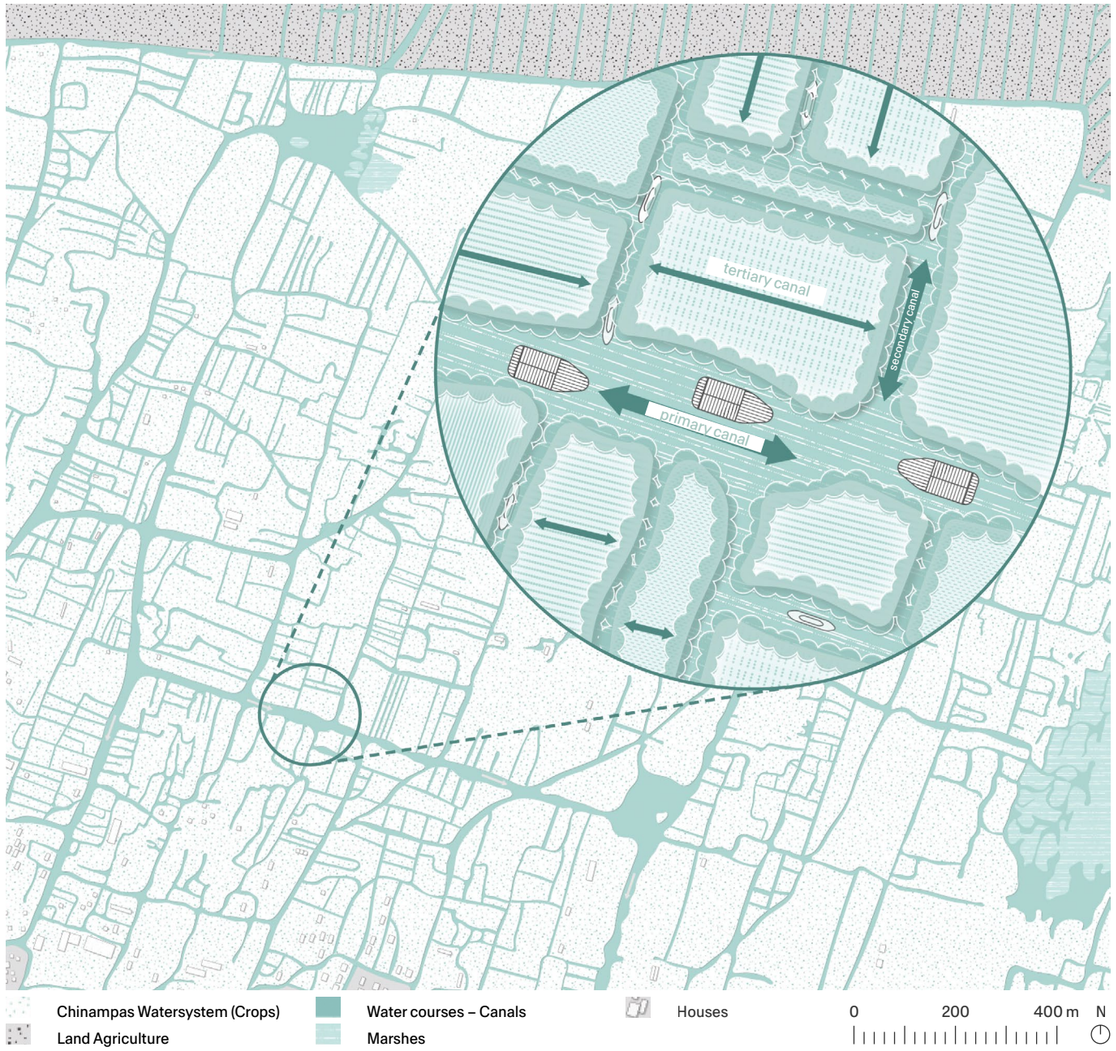


Fig. 3
Overall (current) plan of Chinampas Farming System. Adapted from Bobbink and Rey-Hernández (2022).

particularly in shaping political narratives and influencing public opinion. Visual representations can simplify complex, abstract concepts into immediate, emotionally compelling images that shape attitudes and drive actions (Bresciani & Eppler, 2010). This power makes visualisations not only tools for conveying information but also instruments of political persuasion. By framing social, environmental, or economic issues visually, researchers and activists can advocate for change, challenge dominant narratives, and mobilise collective action, often making them a potent force in shaping political discourse and public policy (Slocum, 2013).

VISUAL METHODS IN PRACTICE

The potential of visual methodologies to bridge the gap between academia and society has been illustrated in many examples. Here, I will dive into Traditional Water System research and reflect on my own investigation as a doctoral researcher.

CWS research investigates traditional water systems, which are often complex and deeply embedded in cultural, environmental, and technological contexts. Owing to their intricate networks and historical significance, these systems can be challenging to understand through text alone. However, by translating these complex systems into visual representations, this study aims to make this knowledge accessible to a broader audience. The drawings produced in this project serve as a common language, enabling people from different disciplines and backgrounds to meaningfully engage with the material. (Figure 1)

As part of the CWS lab at TU Delft, we recognise the significance of Traditional Water Systems[1] and seek to understand and document their beauty and wisdom. The research involved an extensive graphics-based analysis, developing a method for studying landscapes through systematic data collection, and the creation of comparative drawings, maps, and diagrams. This visual methodology aims to uncover the underlying logic of these water management practices and identify potential design and strategic principles that can be applied to modern landscapes and urban design. To achieve these objectives, we employed an Illustrative Method (Bobbink et al., 2022)[2], grounded in the form-layer method (Steenbergen et al., 2008), as an analytical tool to understand the relationship between the water system and its landscape. The layers reveal the topographical relationship between the structure and form of the interventions, their cultural expressions, spatial experiences, and the use, maintenance, and circularity of traditional human-made water systems (Bobbink, 2019).

Case studies were mapped using this method, which emphasises the spatial and visual elements of water systems. It presents them in a standardised format to help viewers gain a clearer understanding of the geomorphological and sociocultural contexts surrounding these systems (Bobbink et al., 2022). As the drawings evolved simultaneously, a set of thematic drawings and diagrams accompanied by a unified legend for all cases was developed (Figure 2). Throughout the process, it became more apparent which layers (such as soil, height, and relief maps) needed to be combined to capture the essence of the waterscape. Each set of drawings includes diagrams representing the climate zone, flow directions, regional water system, topographical and soil maps, and development of the water system over time. Additionally, technical drawings of the catchment area were created to illustrate the interactions between water elements, waterworks, ecology, and usage (Surajaras & Rey-Hernández, 2022) (Figure 3).

The visual analysis of Traditional Water Systems worldwide has provided valuable insights into landscape-based methods for water-related settlements. By understanding water and land management systems rooted in resource circularity, we can derive specific design strategies applicable to current urban-rural challenges concerning sustainability and resource consumption patterns. Visual learning from these landscape-based approaches enables us to redefine the role of landscapes as multifunctional providers, recognising natural entities such as wetlands and lakes as potential areas for multifunctional development that integrate cultural heritage with social, economic, and ecological values (Rey-Hernández & Bobbink, 2022).

As stated by Bobbink, the Illustrative Method is a site-social analysis that has the potential for further refinement; incorporating interviews and site surveys will enhance the method's precision and depth (Bobbink et al., 2022). The incorporation of this ethnographic aspect into the analysis and visualisation of research has been at the core of my own doctoral investigation, in which I work with counter-mappings and drawings based on interviews and workshops with the communities involved in my case studies.



Fig. 4
Process of co-creating the map for the PhD case study (Yanuncay River Highlands, Ecuador). The Soldados highland community discussed issues and challenges and subsequently translated into the visualisation of this map. By the author.

In this regard, as a trained architect and landscape designer, I communicate through drawings and visualisations. Recently, I further developed this 'research by drawing' a method through my doctoral investigation in which I am researching the politics of design in riverine landscapes. This study investigates how river management through landscape design and territorial planning has produced socio-material transformations that directly affect river communities and their livelihoods, prompting local confrontations with imposed designs. To do so, I have been working closely with communities living along a river in the Ecuadorian Andes to create visual narratives through counter-maps that support their struggles through visual argumentation (Figure 4). (Rey-Hernández et al., 2026b)

In this context, counter-design practices can be defined as 'constellations of co-resistance and liberation' that detach design from the 'professional hands' and open it to a broader audience of non-experts and civil society (Daigle and Ramirez, 2019). Counter-maps can manifest as acts of resistance that create alternative collective futures in opposition to top-down visualisations and materialisations (Latour, 2008). This form of counter-design invites communities, civil society, and researchers to actively criticise the dominant narrative of space, place, and territory by powerful actors and provide alternative territorial representations (Oslender, 2021).

This process allowed me to co-create a visual tool that would remain within the communities to support their socio-political struggles against imposed extractivist projects (Figure 5) (Rey-Hernández et al., 2026a). At the same time, the maps provided me with the data necessary to develop my academic research. In this way, the collaboration in this project generates new insights into the socio-political territory of the river under study, bringing that knowledge back to the communities involved through the co-creation of the map. An essential point to highlight in these cases is the connection we have created between my research and work in Traditional Water Systems research. The interdisciplinary relationship between the two cases created the opportunity to present my doctoral research as a lecture in November 2023.

This essay highlights the potential of visual methodologies as essential tools for co-producing knowledge and bridging the gap between academic research and society. Through the integration of drawings, diagrams, and other visual representations, complex realities, such as Traditional Water Systems and territorial struggles, are transformed into accessible, understandable forms that can resonate across disciplines and with a broader public. However, the use of drawings, diagrams, and other visual representations goes beyond communication. It serves as a means of knowledge production and political persuasion, unveiling patterns, relationships, and insights that may not be immediately apparent through text-based analysis.

Visual methodologies not only simplify complex knowledge, but also facilitate deeper engagement and collaboration between researchers and communities, promoting a dynamic process of co-creation. By working alongside the communities involved in the research, these methodologies ensure that their voices, experiences, and perspectives are central to creating a more inclusive, ethical, and participatory research practice. Furthermore, these visual tools can influence political narratives and mobilise collective action, making them a potent force for social change.

Ultimately, visualisation not only enhances communication, but also democratises knowledge, bringing academic research closer to society and enabling its use as a tool for both understanding and transformation. The CWS lab and research presented here exemplify how the Illustrative Method and other visual tools can translate intricate systems into a common language, foster cross-disciplinary dialogue, and enhance public understanding. This approach represents a significant shift towards more inclusive and accessible forms of knowledge production with the potential to inspire future research practices grounded in collaboration, participation, and interdisciplinary approaches. As the academic landscape continues to evolve, the role of visual methodologies in research will become even more important, offering new ways to generate, communicate, and share knowledge that transcends traditional academic boundaries, and engages a wider audience in meaningful and impactful ways.



Fig. 5
First counter-mapping exploration for the PhD case study (Yanuncay River Highlands, Ecuador). Issues and challenges were discussed by different actors (riverine communities, academics, artists, farmers, activists, students, architects, territorial planners and local authorities) and subsequently translated into the visualisation of this map. By the author.

NOTES Co-design

1. https://circularwaterstories.org/analysis/
2. The Illustrative Method is developed by the CWS lab and uses mapping, visualisations, narratives, or simplified graphics to clarify complex water concepts.

Stories from Akalapuzha

Reading Rivers as Systems and Places

Naeema Ali[1], Inge Bobbink[2], Monica Veras Morais[3], Amina Chouairi[4], Amritha P K[5] and Anjana Bhagyanathan[6]

Kerala's rivers, lakes, backwaters and beaches are central to the state's ecological, economic and socio-cultural identity. Renowned both as tourist destinations and as vital spaces for local communities, these water bodies have long served as settings for stories that reflect Kerala's unique relationship with water. This essay emerged from a field visit to Kerala, where the editorial team of this book was invited by the National Institute of Technology Calicut through a graduate of the Circular Water Stories (CWS) lab, who had worked on the Kuttanad Kayalnilam Agrosystem. During the visit, the team conducted a workshop with Indian colleagues and students. Presented as a diary, the essay reflects on these exchanges and explores how shared experiences and local perspectives contribute to an understanding of Kerala's water landscapes.

1 Ir. N. Ali, Witteveen+Bos, United Arab Emirates;
naeema.ali9@gmail.com
0000-0002-3498-3397
2 Dr ir. I. Bobbink, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands
0000-0002-3130-7369
3 Dr ir. M. Veras Morais, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands
0000-0002-0223-7429
4 Dr ir. A. Chouairi, Landscape Architecture and Spatial Planning, Department of Environmental Sciences, Wageningen University & Research, the Netherlands
0000-0003-3218-0782
5 Dr Amritha P K, Department of Architecture and Planning, National Institute of Technology Calicut, India
0000-0002-2503-7120
6 Dr Anjana Bhagyanathan, Department of Architecture and Planning, National Institute of Technology Calicut, India
0000-0002-2596-7619

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Fig. 1
River Akalappuzha in Kerala, India. By the authors.

Water is a leading character in the Booker Prize-winning novel The God of Small Things (Roy, 1998) and in other popular novels, such as The Covenant of Water (Verghese, 2024). They depict water as a visible or invisible force that channels the lives of communities living beside it, connecting the past, present, and future. However, from a sustainable development perspective, Kerala's water bodies stand at a crossroads. A recent census by the Union Jal Shakti Ministry or Ministry of Water Resources for India reveals that out of Kerala's 55,734 water bodies, more than 9,000 are abandoned, with many suffering from encroachment and pollution. Back in 2008, the state's own Water Resources Department identified and recognised the need to adopt an 'integrated, multi-sectoral approach to the planning, development, and management of water resources'. In this light, we ask:

How can we shift from viewing rivers as isolated water bodies to reading them as living systems shaped by, and shaping, communities that live along their margins?

This question was at the heart of the Kerala Netherlands Water Dialogue, a four-day workshop hosted at the Department of Architecture and Planning at NIT Calicut, and curated by the CWS Research Group. The workshop brought together students, researchers, and academicians from Kerala and the Netherlands as well as key knowledge partners, including the Kerala State Tourism Department and the Netherlands Innovation Network in India (NIN). Participants explored Akalapuzha (Figures 1 and 2), a lesser-known arm of the river landscape in Kerala, illustrating the complex interdependence between water and local communities.

A CONFLUENCE OF WATER STORIES

The workshop tested the CWS research methodology for reading complex water systems and understanding their impact. Originally developed within the Landscape Architecture master track at the Delft University of Technology, the CWS approach is rooted in site specificity, emphasising that different sites have unique characteristics and require different design approaches. However, the Illustrative Method (Bobbink et al., 2022) is versatile and can be applied to water-sensitive areas worldwide, particularly in regions where the relationship between people and water is visible and critical for development and people's lives.

The workshop aimed to provide students with hands-on experience in analysing water systems. The drawings we refer to as water stories illustrate the interactions between various elements of the riverscape. We collected water stories on crabs, clams, birds, mangroves, fishermen, locals, tourist boat operators, brackish and fresh water, and the saltwater barrier, all living together along the river. Any attempt to understand the river is also an attempt to understand its unique relationship with it. Water stories are intended to serve as tools for stakeholder discussions, helping authorities, administrators, local communities, designers, and planners develop informed visions and policies for the area, grounded in a river system perspective.

Fig. 2
The picturesque landscape of Akalapuzha. By the authors.



WHAT IS A WATER SYSTEM PERSPECTIVE?

The word 'puzha' in Malayalam translates to 'river,' a natural body of water that flows across land towards the sea. Nevertheless, to truly understand a river such as Akalapuzha, we must look beyond its physical flow. Imagine standing on its banks and seeing not just a river but a living, breathing system—a network where water, land, and life interact in complex ways. This is the essence of the water systems perspective. Most people view a river as just a channel through which water flows. However, the water system perspective encourages us to recognise the intricate forces shaping the river and its surroundings. This is about understanding the diverse ecosystems that thrive along the river, the communities that depend on it for their livelihoods, and the varying qualities of water that sustain life. Picture all of these elements as characters in a story, each playing a crucial role in the narrative of the river.

This perspective is the core of the CWS approach. By adopting this view, we move beyond seeing a river as merely a physical entity within its catchment area. Traditional river and water management disciplines often focus on topography, climate, and geology but overlook the influence of human activities, including construction, agriculture, fisheries, transportation, and tourism. Authorities and planners usually neglect these dynamics, focusing only on the visible water body. However, understanding the river as a system also entails acknowledging the human impacts on its flow and health. In densely populated regions, such as Kerala, it is essential to understand how natural and human forces shape rivers and incorporate this into spatial planning policies. This comprehensive approach enables the creation of resilient, multifunctional, and innovative solutions tailored to the unique dynamics of a river and its surrounding environment.

A JOURNEY ALONG THE AKALAPUZHA RIVER

In understanding the river through its stories, we see not just water, but a powerful force that binds us all — shaping our past, defining our present, and guiding our future.

The Akalapuzha River flows unnoticed in the coastal landscapes of Kerala and is mainly overshadowed by the more famous water bodies in the surrounding region. The river plays a critical role in the daily lives of local communities, offering invaluable insights into the complex relationships between water, culture, and livelihoods. Although the Kerala State Tourism Department is only beginning to explore ways to develop a river for localised tourism, growing interest from local communities has already led to the construction of small-scale jetties for houseboats and water tourism. (Figure 3)



Fig. 3
Small-scale jetties and structures along the shoreline used to attract local tourists. By the authors.

However, the unregulated use of water bodies for tourism can lead to unsustainable development, with ecological consequences, such as the clearing of mangrove forests, that disproportionately affect local livelihoods. The Akalapuzha River was selected for application to the CWS methodology. This decision was driven by the need to understand the river's dynamics from both environmental and socioeconomic perspectives, ensuring that any development considers the river's ecosystem and the communities that rely on it.

Sixty-four third-year students from NIT Calicut conducted an in-depth analysis of the river's tidal waters, natural resources, and the diverse communities that depend on them. The outcome was not a conventional master plan or design intervention, but a comprehensive exploration of life surrounding the water, a process that recognised rivers as systems rather than isolated bodies of water (Figure 4). Whether it was a bund constructed across the river to divert freshwater to the paddy fields and for domestic

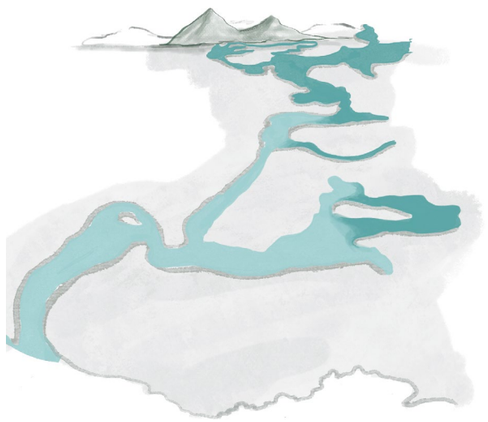


Fig. 4
The backwaters from the hills to the sea. By the authors.



Fig. 5
Overview map of the stories along the river. By students of the National Institute of Technology Calicut (NIT Calicut).

purposes or fish traps laid for daily catches, the flow of water and human activities are inextricably linked, each influencing the other in ways that are often similar to unseen currents.

The illustrative methodology of the CWS lab was central to students' exploration. By translating the river's complex dynamics into vivid drawings, students can weave together tangible and intangible elements: natural features, local practices, and the broader ecosystem. These drawings were more than an analytical lens: they were stories that captured the river's life and legacy, providing a narrative that resonated with the community's traditions and practices.

Through fieldwork, community interviews, collaborative design sessions, and roundtable discussions, students created water stories that reflected Akalapuzha's rich cultural tapestry (Figure 5). These stories also illustrate local practices such as fishing techniques and indigenous construction methods, which embody the principles of sustainability, resilience, and circularity honed over generations (Figure 6). The CWS approach transforms complex data and observations into compelling, relatable stories that connect stakeholders, ranging from local communities to planners and policymakers. At the heart of the CWS approach, this work goes beyond academic research.



Fig. 6
Sunset view of the river, where people gather clams and local communities come together for leisure. By the authors.

Mapping was not about fixing the river on paper, but about tracing the layers of decisions, memories, and movements that shape it.

The students focused on three zones along the Akalapuzha River. Each zone presented a different context, allowing the students to explore the diverse dynamics of the water system. Through the mapping exercise, the students began tracing how bunds, sluices, fish traps, mangrove edges, and jetties intersected with the rituals of daily life. These drawings made the tension between natural hydrology and human intervention more visible. The mapping process became a means of unpacking how past decisions, often invisible in policy documents, have reconfigured the landscape with long-lasting consequences for ecology and equity. Rather than starting with top-down data, students began on the ground, mapping from experience, encounters, and intuition. In doing so, they laid the foundation for a new way of interpreting the river, one that is attentive to its scale, history, and many overlapping layers of use, meaning, and transformation. (Figures 7 and 8), respectively.

FIELDWORK BY THE RIVER

It is in the river's shifting moods and layered margins that its complexity unfolds — Akalapuzha is not one place, but many.

The fieldwork component allowed the students to immerse themselves in the landscape and gather information. Students explored the brackish creeks, walked along bunds, observed salinity shifts at different times of the day, and stood under the shade of coconut groves to trace how the river lived within and around the community. They encountered not only the river's physical characteristics, but also its many moods and margins: how it retreated during certain tides, surged with others, and nourished one bank while eroding another. This embodied engagement fostered a new kind of observation: attentive not only to species or water depth but also to the rhythm of everyday practices. By documenting the improvisations of local fishermen, the intricate roots of the mangroves that were home to crabs, and the textures of nets and coirs, the students gathered information shaped by place, experience, and perspective. (Figure 9)

Fig. 7

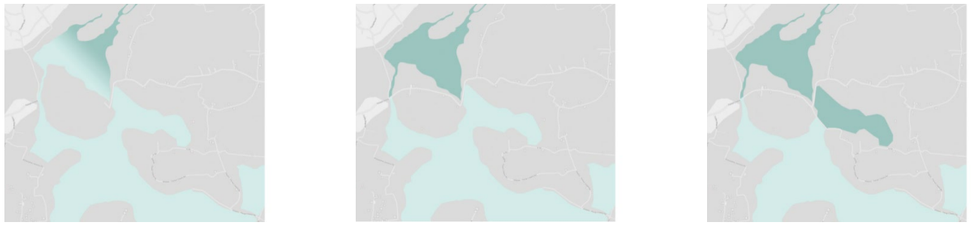


Fig. 8

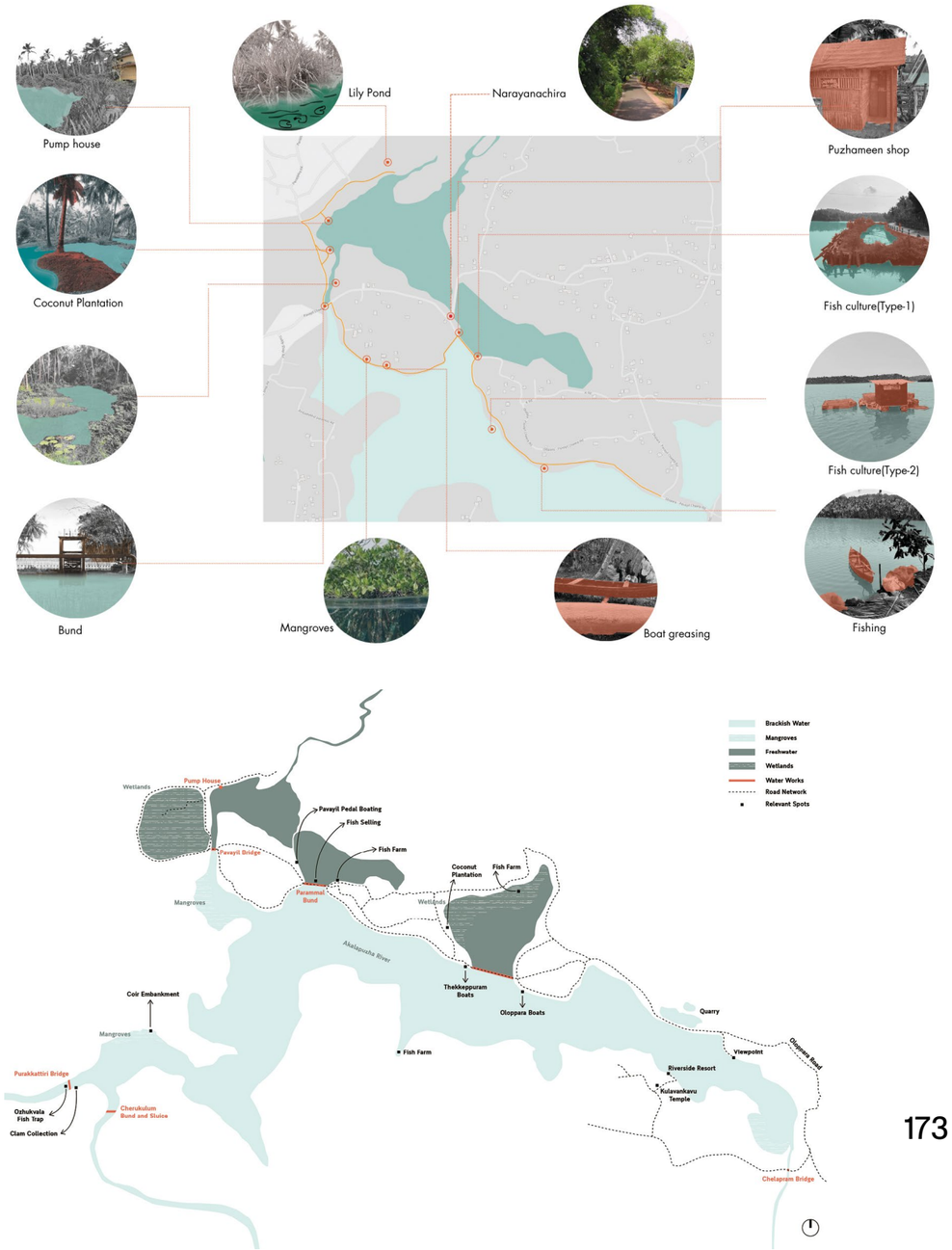


Fig. 7
Maps showing changes in the Akalappuzha River landscape. By the authors.

Fig. 8
Maps produced during the workshop, showing the different elements of the Akalappuzha River landscape (top) and the students' key observations (bottom). By students of the National Institute of Technology Calicut (NIT Calicut).

These weren't just stories — they were lived experiences, passed down through families and formed by years of working with and making money from water.

One of the most potent parts of the workshop was listening to not-so-hidden voices along the river. These are not just stories; they are lived experiences, passed down through families, and formed by years of working with and making money from water.

By engaging with local stakeholders, such as residents, fishermen, farmers, and local communities, the students gained insights into the river's socio-economic and cultural dimensions. These interactions enabled the students to gain a nuanced understanding of the challenges involved in managing a water system that is deeply intertwined with the livelihoods and traditions of the local community. These conversations pushed the students to rethink what counts as knowledge. The riverbank became a meeting ground, not just for land and water, but also for people with different roles, memories, and views. It showed that understanding a river means listening to those who live by it, working with it, and carrying its changes daily. (Figure 10)

The construction of bunds to separate freshwater from saltwater reflects human dominance in these landscapes. This raises the question of whether they are landscapes of coexistence or exploitation. (Figure 11 and 12), respectively.

WEAVING NARRATIVES

By bringing drawings, stories, and observations together, the students learned to tell the river's story without simplifying it.

The students participated in collaborative design sessions, in which they synthesised their findings into comprehensive water stories. The students used a combination of drawings, diagrams, and maps to convey their ideas, ensuring that the narratives were accessible to a broad audience and pushing boundaries beyond the discipline of landscape architecture.

By documenting what they observed during their field visits, students captured not only the technical aspects of the water system, but also the deep cultural connections that sustain it. The resulting visual essay offers a glimpse into the students' creative process, revealing the role of water in everyday practices and shifting livelihoods based on the changing conditions of the river. Each drawing depicting traditional fishing practices or construction techniques reveals how sustainability and climate resilience are embedded in everyday life along a river. Living documents invite reflection,





Fig. 9
Students collecting information on site and documenting their observations through photographs and sketches. By the authors.





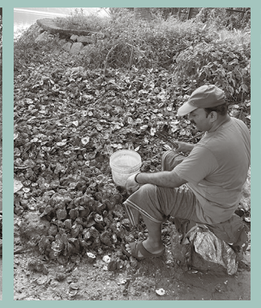






Fig. 10
Site interviews were at the heart of the field visit. Conversations with fishermen, farmers and residents helped students understand what the river meant to each of them. Photographs by students of the National Institute of Technology Calicut (NIT Calicut).

Fig. 11
Cross-section showing a typical bund used to separate freshwater for agricultural use. By students of the National Institute of Technology Calicut (NIT Calicut).

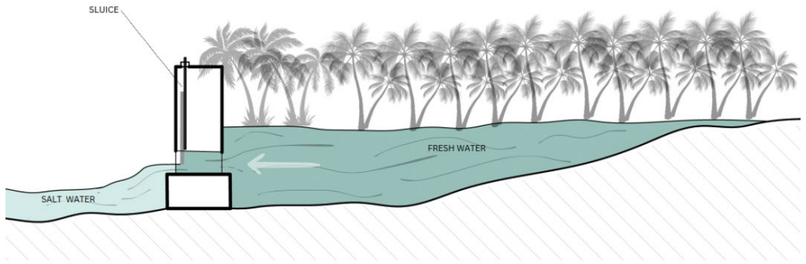


Fig. 12
Section showing life on either side of the bund. By students of the National Institute of Technology Calicut (NIT Calicut).

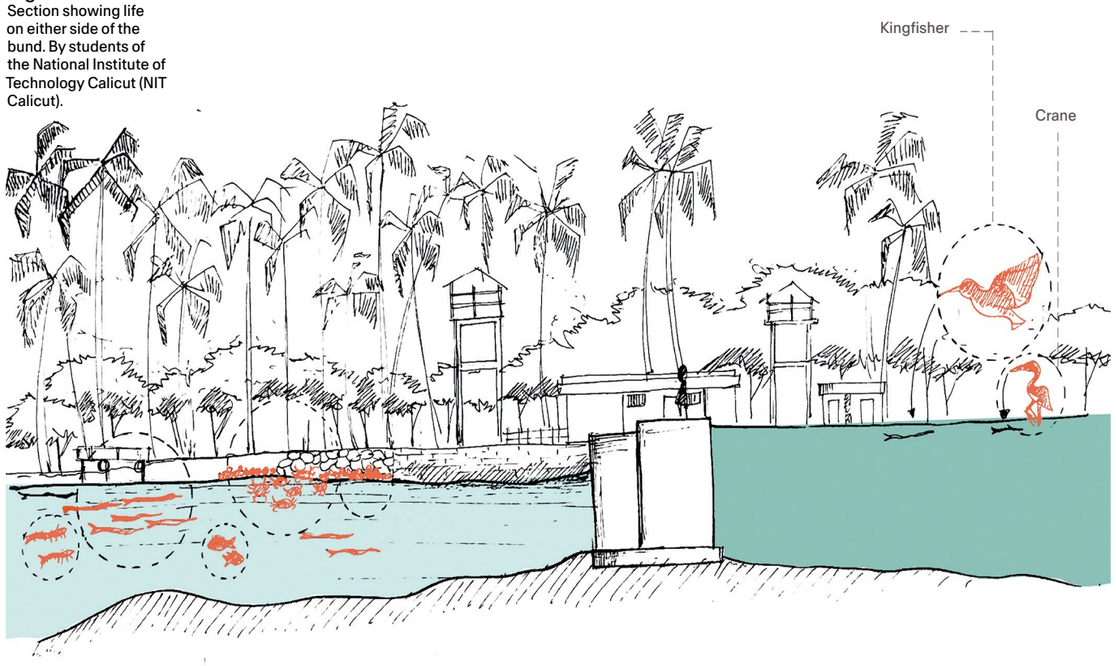
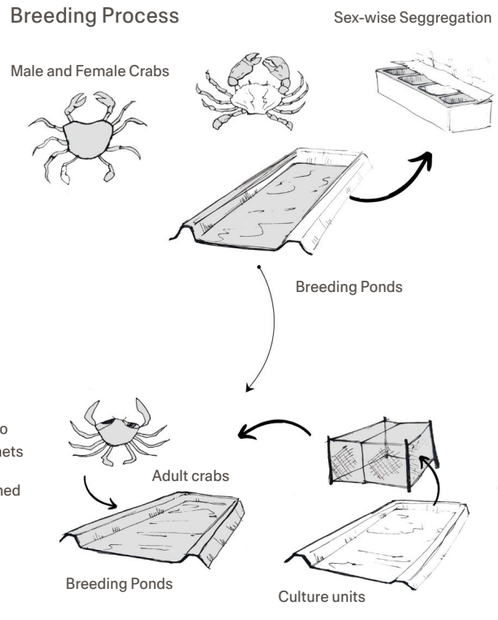
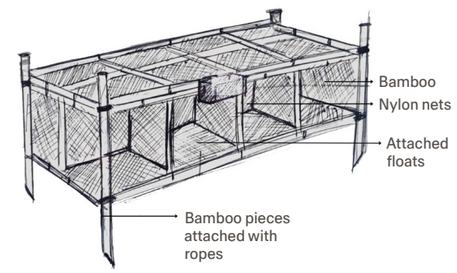


Fig. 13
Drawings documenting cage aquaculture and students presenting their work at the end of the workshop. By students of the National Institute of Technology Calicut (NIT Calicut).





Crab culture
Crabs are reared using the fattening process, where the offsprings are allowed to grow in a pond until the exoskeleton is hardened.



conversation, and further iterations. The power of the water stories lies not just in what they depict but in what they provoke: a reimagining of how rivers are seen, valued, and stewarded. (Figures 13, 14, 15 and 16)

WATER DIALOGUES

The workshop also featured a symposium titled 'The Kerala Netherlands Water Dialogue[1], attended by distinguished guests, including Dutch Consul General Ewout de Wit; Attaché for Science, Technology, and Innovation of the Netherlands Innovation Network - Sandra Kalidien; and Policy Adviser to the Dutch Embassy, Arun Thekedath. Dr. Inge Bobbink, an Associate Professor at TU Delft delivered a compelling talk titled 'Dutch Landscape and the CWS of the Netherlands'. Dr. Anjana Bhagyanathan, Assistant Professor at NIT Calicut, sheds light on the Traditional Landscapes of Kerala.

A roundtable discussion on the Role of Academia and Knowledge Institutions in Transdisciplinary Water Projects was moderated by Monica Veras Morais of TU Delft, Naeema Ali of Witteveen and Bos Architects Dubai, and Amina Chouairi of Università Iuav di Venezia, Italy. The discourse has delved into interdisciplinary approaches to address water management challenges.

The event provided a platform for meaningful exchanges of ideas and expertise and for collaboration between Indian and Dutch academia on water and climate.

A WAVE OF COLLABORATION

No one walked away from the river unchanged!

Over four days, what began as a design workshop unfolded into a deeper act of learning about water, places, and ways of seeing, reading, and designing with water. For the students, this meant shifting focus from individual sites to broader systems that connect bunds, mangroves, fish traps, and memories. For the community, it meant seeing their lived experience reflected not in plans or policies but in stories drawn from the ground up. Moreover, for the CWS team, it was proven that methods developed in classrooms half a world away could find meaning and relevance in water-sensitive areas elsewhere such as Kerala.

This was never just about a single river or lake. It was about reading the landscape as a network of flows and frictions: saltwater and freshwater, tourism and tradition, protection, and disruption. The students' drawings captured these nuances, not as problems to fix but as relationships to understand. In doing so, they began to view the river as a living system shaped by more than just hydrology, climate, and topography.

This workshop's ability to bring together diverse forms of knowledge and culture in the same space made it distinctive. A method developed in the Netherlands encountered a river in Kerala, and the encounter changed both. The result was not a master plan but something more durable: a way of thinking that cuts across disciplines and geographies.

The Akalapuzha River offers a new curriculum rooted in observation, exchange, and respect. It reminded everyone involved that the future of water lies not in grand plans but in how we learn to see and work together. Suppose that these collaborative currents continue to flow. In this case, they may help us imagine a future where water is not managed in isolation but

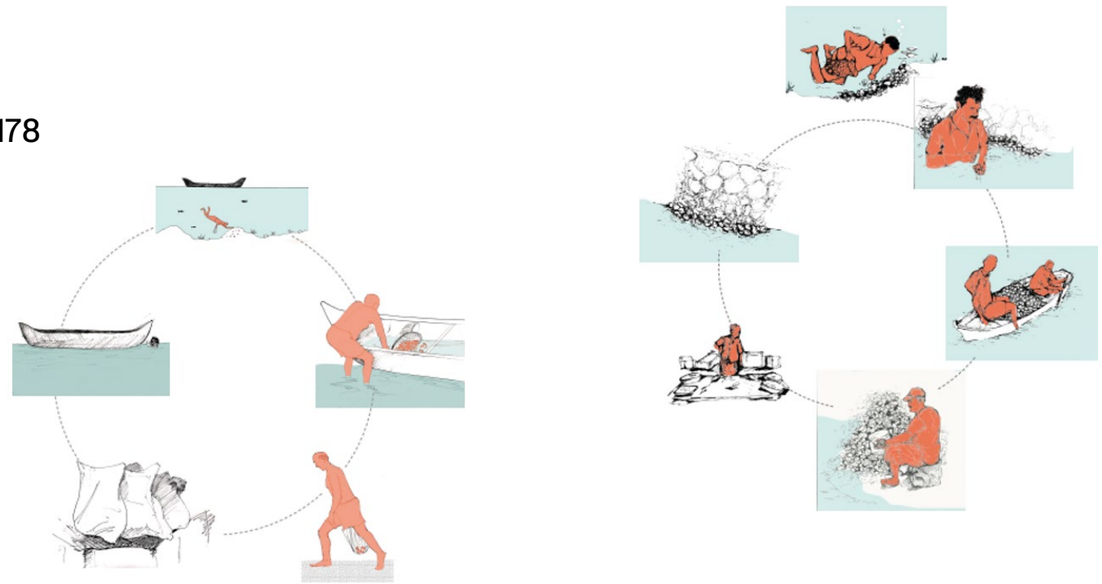


Fig. 14
Workshop drawings documenting (left) clam collection and (right) oyster collection. By students of the National Institute of Technology Calicut (NIT Calicut).

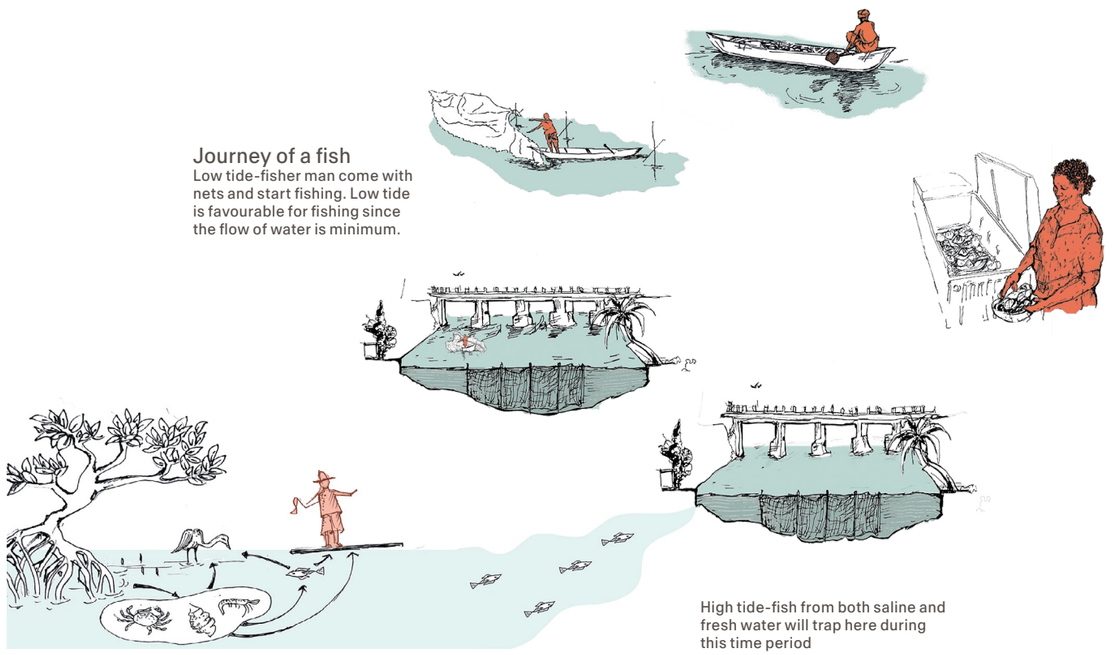


Fig. 15
Workshop drawing showing the journey of a fish. By students of the National Institute of Technology Calicut (NIT Calicut).

understood as part of the broader systems that sustain life. The hope is not just to replicate this workshop elsewhere, but to keep refining the way we listen to water, not only through science or design, but also through stories that make it legible, personal, and political.

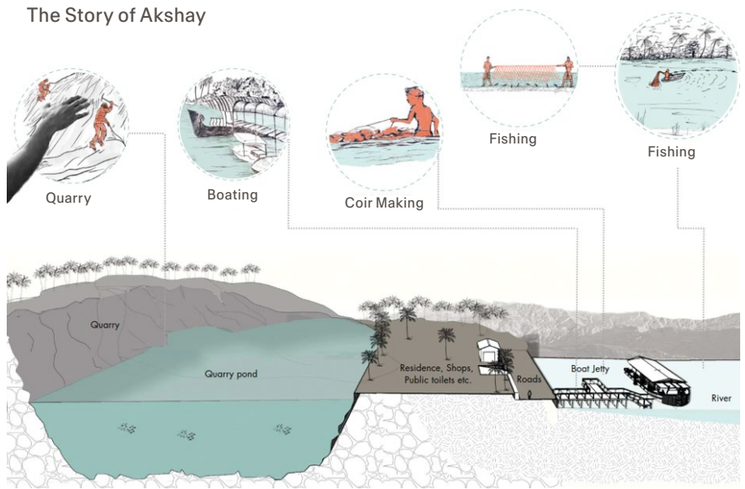


Fig. 16
Drawings as a way of reimagining rivers from a systems perspective by interlinking multiple narratives. By students of the National Institute of Technology Calicut (NIT Calicut).

NOTES Stories from Akalapuzha

1. We gratefully acknowledge Dr. Mohammed Firoz C, Dr. Amritha P.K., Dr. Anjana Bhagyanathan, and the faculty and students of the Department of Architecture and Planning, NIT Calicut, for their valuable support in preparing and organizing the Kerala-Netherlands Water Dialogue workshop. We also thank Mr. Ewout de Wit, Mr. Dhoya Sneijders, Ms. Sandra Kalidien, Mr. Arun Thekedath, and Ms. Aleena Joseph, representing the Dutch Embassy, the Consulate General and the Netherlands Innovation Network in India, for their support and presence during the workshop.



Fig. 1
View from the bridge over the Loudong River, the largest tributary on the south bank of the Lanyang River, looking east towards the mountains. Adapted from a photograph by Keng Ching Chen.

Calling to Map

Taking the Water System as a Base for Development

Keng Ching Chen[1] and Inge Bobbink[2]

This essay presents a nuanced examination of the evolving hydrological landscape of Taiwan's Yilan Plain. Combining personal narrative with historical and spatial analysis, the author employs the Circular Water Stories (CWS) perspective developed within the lab, returning to Taiwan after graduation to examine how traditional water systems have influenced local settlement patterns, agricultural practices and cultural identity. Drawing on field observation, archival material, and mapping, the essay also reveals how natural dynamics and shifting political regimes have altered these relationships over time. More than a technical study, it is also a personal diary of rediscovery and reinterpretation, calling for the reintegration of traditional knowledge into contemporary water planning and resilience thinking.

1 Ir. K. Chen, Economic Affairs Department, Yilan County Government, Taiwan (R.O.C.); kenchen2040@gmail.com
2 Dr ir. I. Bobbink, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands 0000-0002-3130-7369

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Standing atop the bridge, I look over the lush green landscape. The Yilan Plain, also known as the Lanyang Plain, is a river delta known for its natural features and close relationship with water, bordered by high mountain ranges that open to the Pacific Ocean to the east (Figures 1 and 2). Yilan is known for its rich natural resources and agricultural activities (Figure 3), because of its abundant water resources, springs, hot springs, rivers, hyporheic flows, and natural ponds, which are rich in layers of stories and traces awaiting discovery. My training and studies at the CWS Lab in the Netherlands enabled me to do so by utilising a simple yet effective tool, mapping.

Fig. 2
Map of northern Taiwan showing the location of the Lanyang Plain. By the authors.

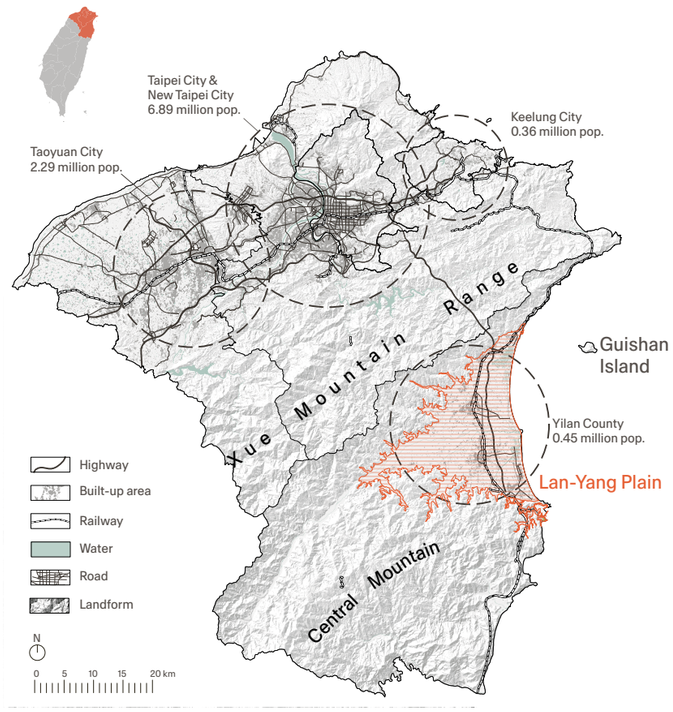


Fig. 3
Rice fields in winter, commonly found in Yilan and kept inundated, create striking reflections of the sky. By the authors.



Living in a delta involves constant negotiation with water. I am drawn to this entanglement between humans and nature— the co-authors of stories layered across a shifting palimpsest. I have come to realise that to truly understand cultivated landscapes, one must first read the story of nature, and then the narrative written by human hands.

Before me unfolds, a river flowing endlessly from the mountains to the sea, carrying both the power to destroy and the capacity to nurture the land. As every Yilaner knows, memories of flooding are deeply ingrained and bound to the Lanyang River's restless course, which has repeatedly erased towns and villages. Historical records testify to the hardships of farming under constant threat, preserving a lingering sense of struggle against the water.

However, another story is also discussed. The river also carries gravel and sand to form an alluvial fan that feeds vital aquifers, and the downstream deposits fine sediments that nourish wetlands and sustain diverse life. The river embodies a profound paradox in these twin acts of erosion and renewal. Water both takes and gives, shaping not only the enduring challenge of living beside an untamed river but also its enduring beauty. (Figures 4 and 5), respectively.

During the Japanese colonial period (1895–1945), a new balance emerged between humans and water. The introduction of Kasumi levees marked a shift towards a segmented, rather than a fully enclosed, flood-control system. Continuous reinforced embankments faced the river to withstand its force, while carefully placed openings allowed floodwaters to enter and slow down. Through this deliberate permeability, water can swirl, deposit sediment, release nutrients, dissipate flood energy, and gradually moderate the river's behavior, fundamentally reshaping prevailing notions of flood control.

Originating along Japan's Jōganji River[1], this system embodies an ancient principle: to accommodate rather than exclude water. Because Taiwan's rivers share key characteristics with those of Japan—steep gradients, short courses, and highly dynamic channels— this technique proved particularly well suited to Yilan. Since its construction in 1930, the Kasumi levee system has protected Yilan hinterland for nearly a century, reclaimed land for agriculture and settlement, and enabled rural life to flourish within its sheltered reach. When the original technical plans are aligned with the contemporary atlas, it becomes evident that the newly developed areas remain secured by this monumental intervention, while Yilan's principal townships continue to rely on their protection. (Figure 6)

Fig. 4
The Lanyang River is the major river in Yilan County, originating from mountain streams and running through the middle of the plain. By the authors.



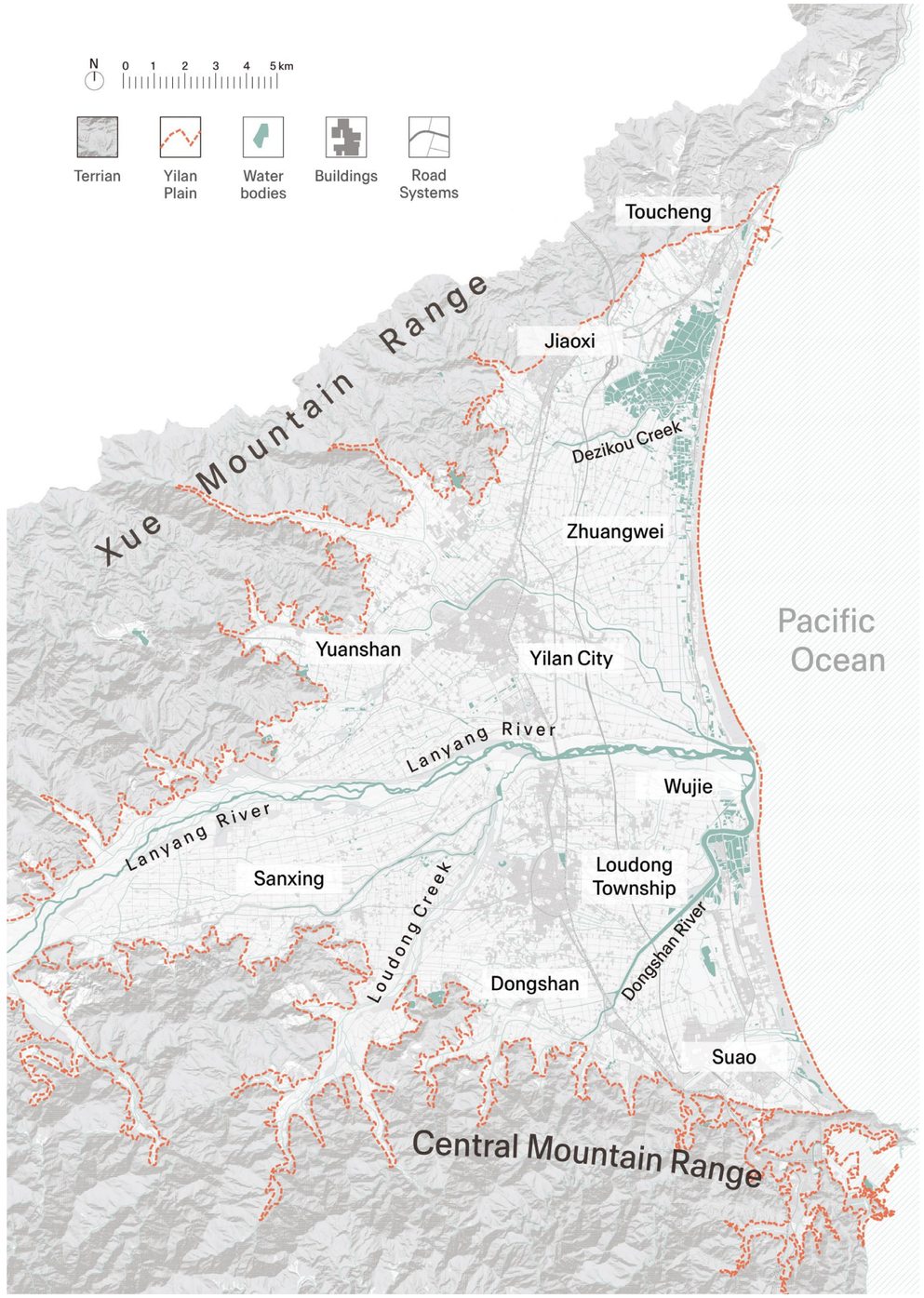


Fig. 5
The Lanyang Plain is a river delta formed by the confluence of many streams and rivers. By the authors.

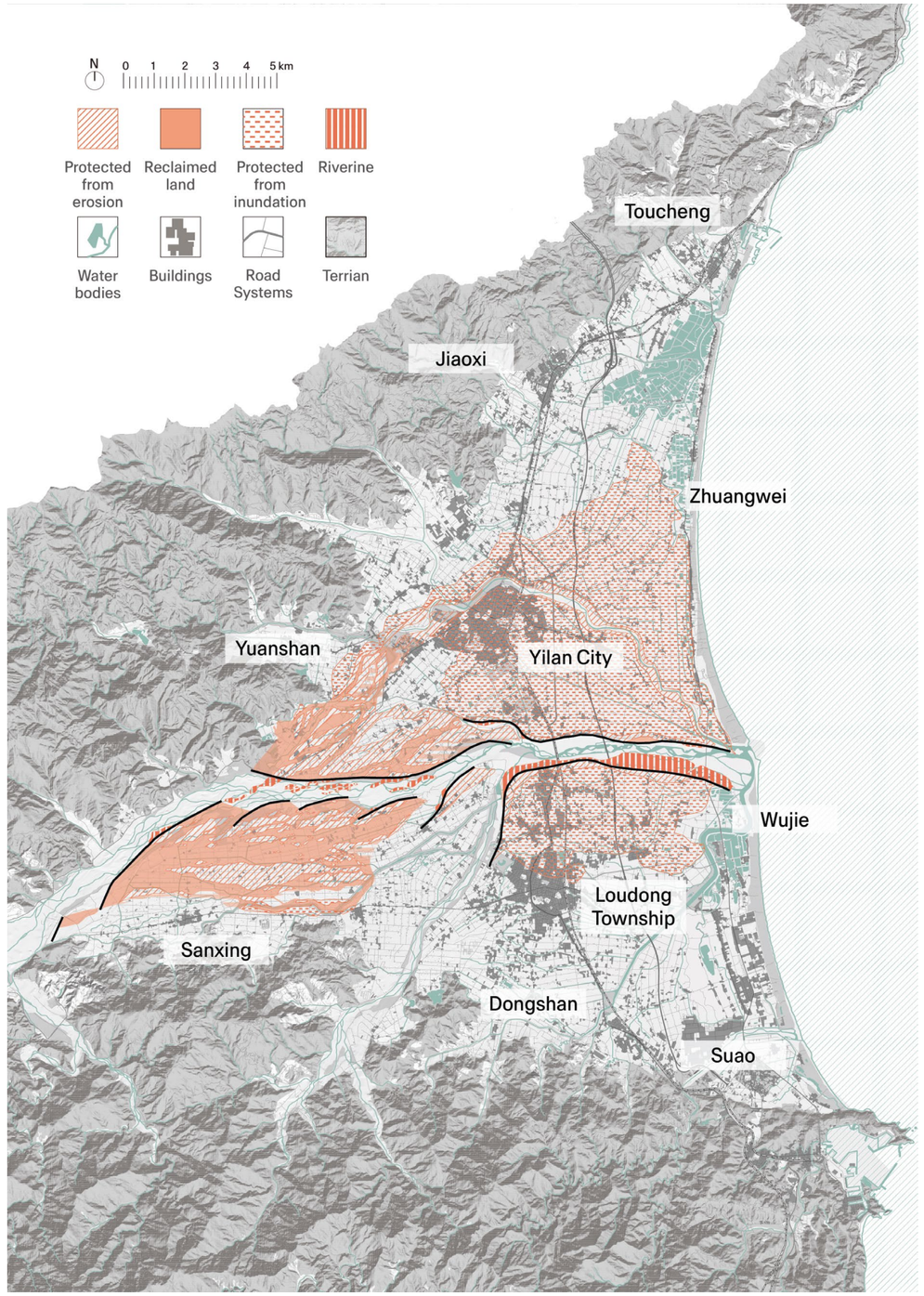


Fig. 6
The Kasumi levees and the reclaimed area. The drawing reconstructs how the Kasumi levees protected large areas of the plain from erosion and inundation, based on historical maps from Academia Sinica (n.d.).

What the Japanese brought to Yilan was not merely the implementation of new methods, but a systematic way of thinking about and managing water, as shown in the sourcing of irrigation water. The authorities consolidated numerous scattered irrigation systems constructed during the Qing Dynasty (1644–1911), many of which originated from the spring zone at the edges of a series of alluvial fan toes.[2] This system forms the basis of today's agricultural landscape, a coherent water system that harnesses the fan's abundant groundwater and spring flows. (Figures 7, 8 and 9).

Within this broader trend of modernisation, a key breakthrough was the use of concrete, a critical material that transformed both the effectiveness and reliability of water infrastructure. Early irrigation channels constructed from stone and wood were structurally fragile and highly vulnerable to storm damage. These were later replaced by concrete channels, which offered greater durability, reduced leakage, and enabled more precise measurement and control of water flow.

Japanese engineers have also integrated irrigation and drainage systems, and many primary irrigation channels have drawn water from drainage canals in higher areas before returning it to rivers or adjacent waterways. This interconnected design allows surplus water to be reused downstream, significantly improving the overall water-use efficiency. (Figures 10, 11 and 12)

Beyond the modernisation of channels, new methods have been introduced to extract greater volumes of water and retain it for longer periods within human-made systems. A notable example is the Meizhou system, which originated in Da Jiao Xi Creek. Its water-intake culvert was engineered to capture the hyporheic flow beneath the riverbed, thereby increasing the water supply to approximately 480 ha of downstream farmland (Figure 13). By stabilising flows and reducing the labor demands of irrigation, advances in hydrological knowledge and engineering have transformed earlier, rudimentary systems into a more sophisticated and efficient water infrastructure (Figure 14).

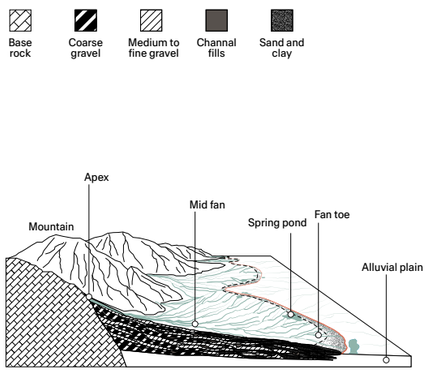


Fig. 7
Conceptualised hydrogeological section of an alluvial fan, illustrating infiltration through coarse upper-fan deposits and possible spring emergence near the fan toe. Alluvial-fan morphology and depositional framework adapted from Spearing (1974) and informed by Nilsen (1982); subsurface configuration simplified from local geological borehole data.

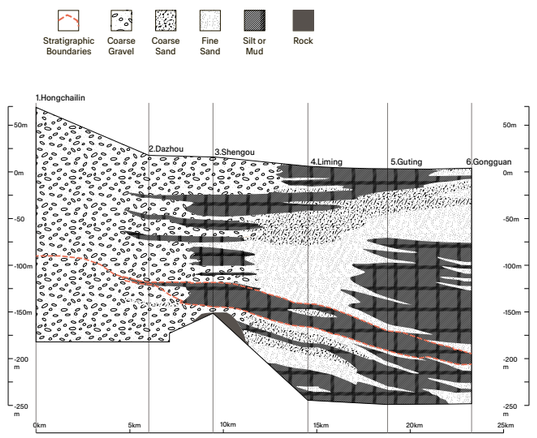


Fig. 8
Cross-section showing how soil types change along the gradient from the upper to the lower plain. The alluvial fans consist primarily of gravel, based on data from National Chiao Tung University (2013).

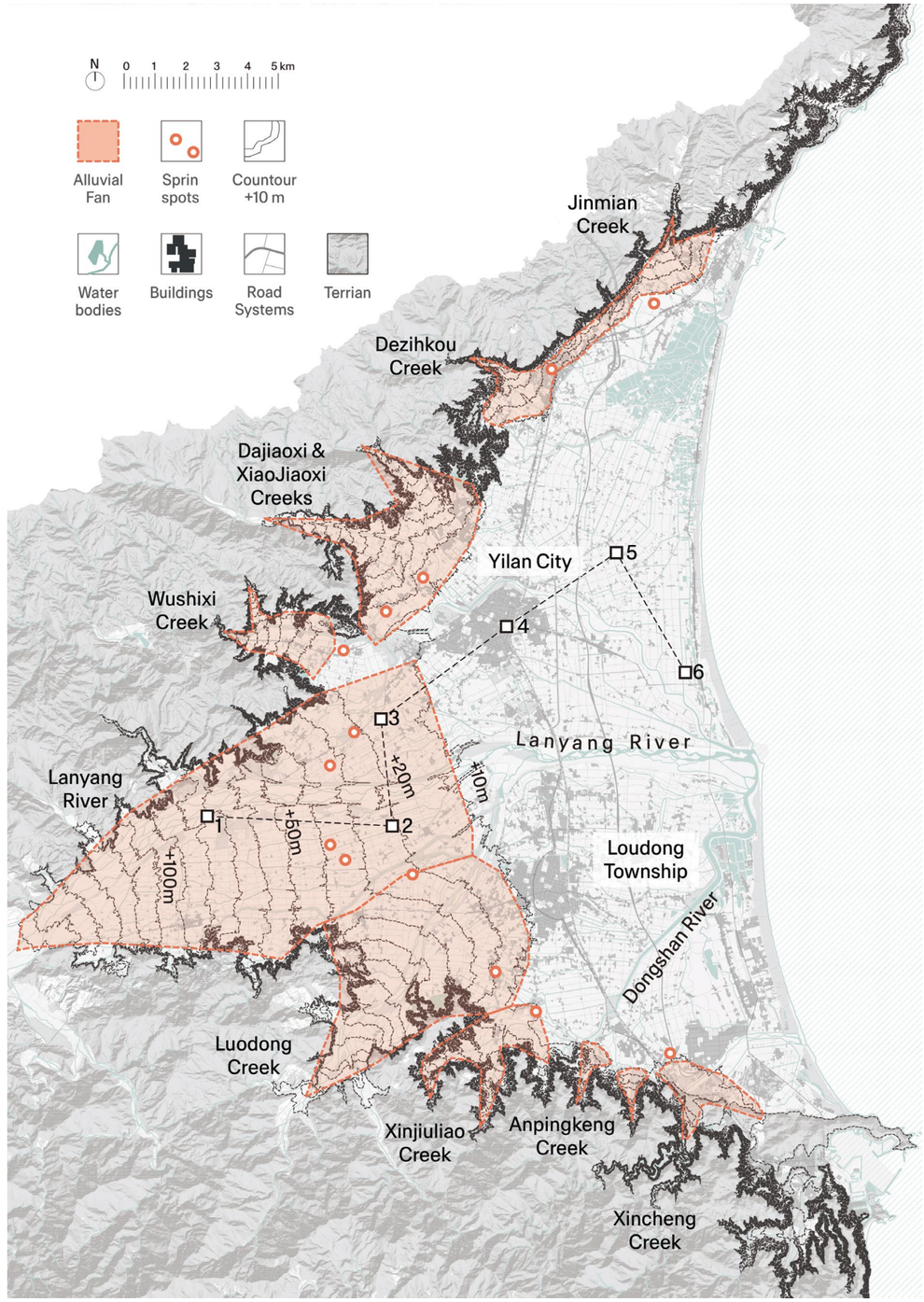


Fig. 9
Alluvial fans of the Lanyang Plain. Drawing after Chang (1995) and Chang et al. (1995).

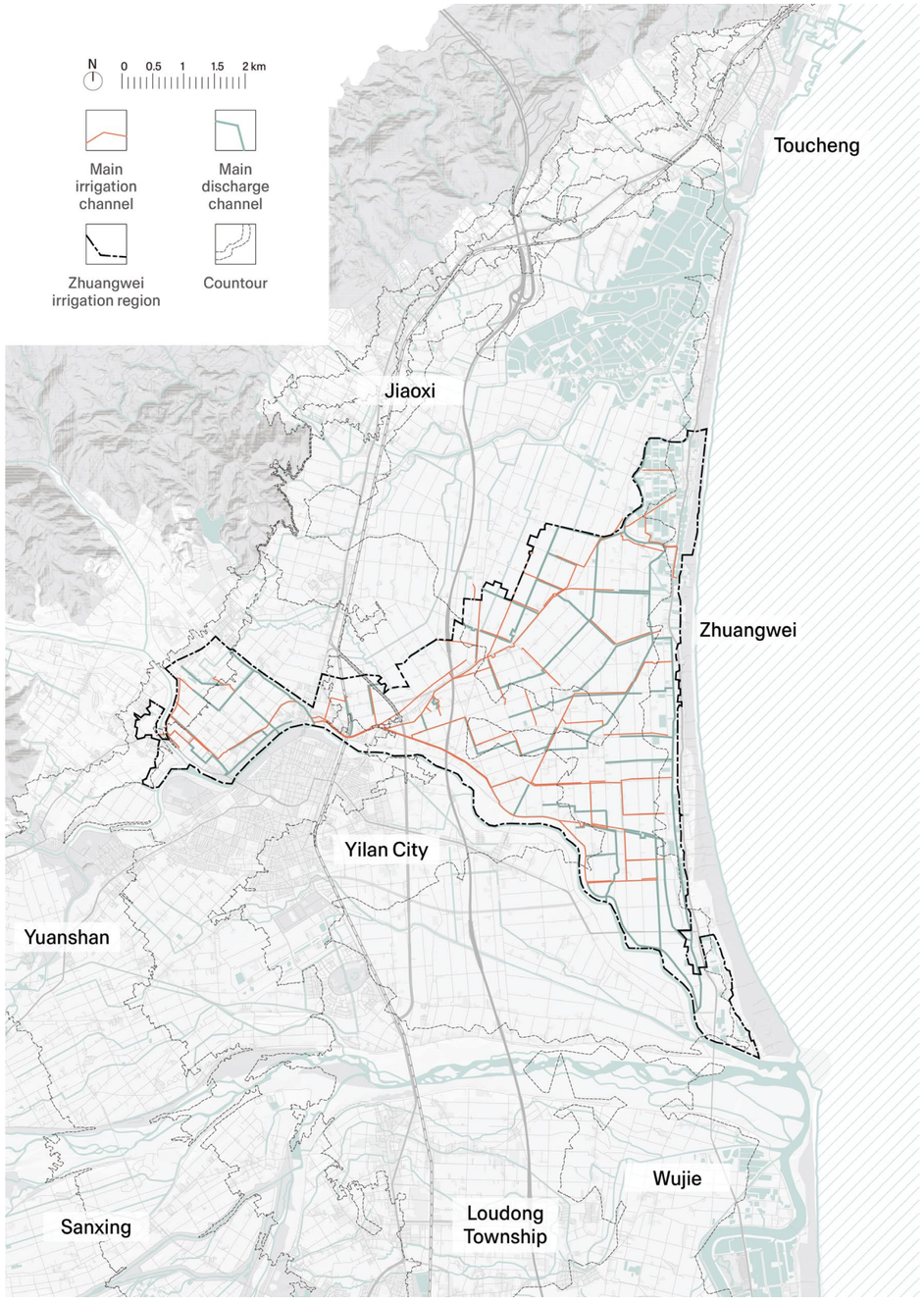


Fig. 10
Current water system in Meizhou, showing multiple water intake and outlet points. Drawing based on data from the Yilan Management Office (n.d.-a, n.d.-b).

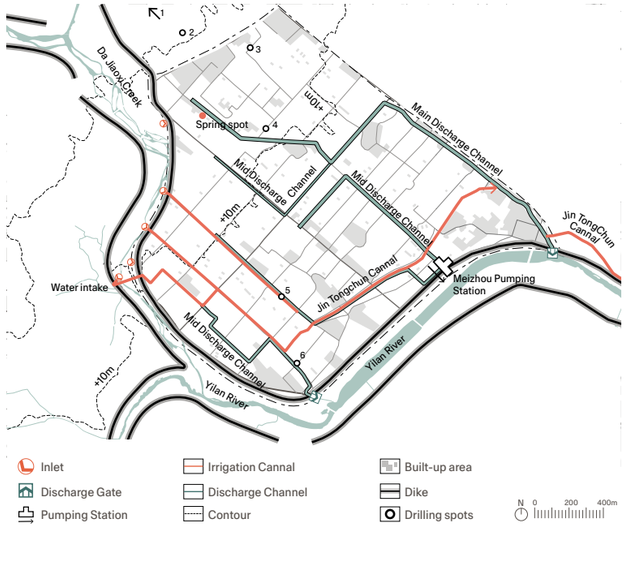


Fig. 12
Irrigation and drainage system in Meizhou and Zhuangwei region. By the authors.



Fig. 14
Water gate of the irrigation system in Meizhou, which forms the outlet of the water-collecting culvert. Adapted from First River Management Office, Water Resources Agency, Ministry of Economic Affairs (2011).

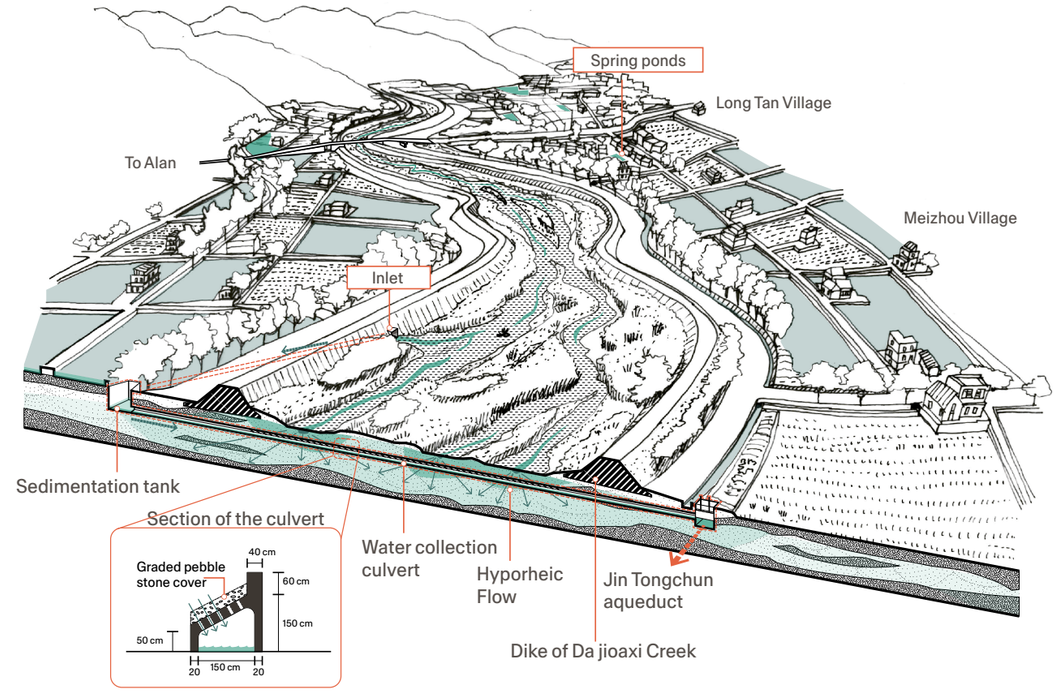


Fig. 13

WATER IDENTITY

The clean, reliable, and managed water flow enabled a distinct water-based way of life. In Meizhou, the culvert that enables hyporheic flow supports not only agriculture, but also daily routines, enabling activities such as laundry, vegetable washing, and other household uses. The related spaces—washing platforms, staircases, and access points—became informal gathering places for families and neighbors, serving both practical needs and social interaction.

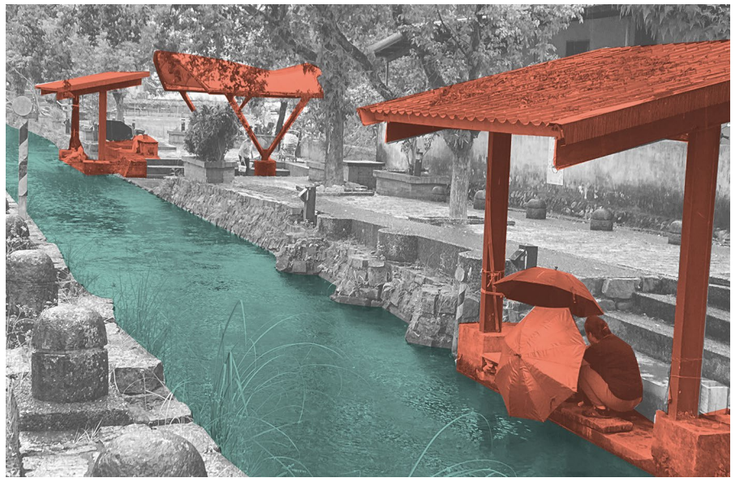
The story of Meizhou is echoed throughout the Yilan Plain. Yilaners can easily enjoy refreshing midday baths in neighborhood ponds or fish beside channels during holidays. Generations of ancestors have shaped these numerous pleasant water spaces, and modern infrastructure has ensured access to clean and abundant water. Together, these practices and spaces have fostered a distinctive water-centred identity unique to Yilan. New designs are learning from these old water features, and the community is raising funds to create new water pavilions. (Figures 15 and 16), respectively.

OVER-COMPLEXITY

However, reliance on concrete and endless technical adaptations is risky. This became evident during several field surveys where the complexity of the water networks stood out. In these agricultural lands, a single road may be flanked by two or three ditches on each side, each with different water levels that intersect and overlap. Multiple 'water highways' and 'water intersections' crisscross the landscape. Understanding the system requires repeatedly drawing and redrawing the connections between these channels. (Figure 17)

DEVELOPMENT THAT LACKS SUSTAINABLE CONSIDERATION

As the water system becomes more complex, its capacity to adapt to future challenges weakens due to long-term climate and land-use changes. Climate change results in intense, short-lived rainfall followed by long dry periods (National Science and Technology Council, & Ministry of Environment, 2024). At the same time, the decline in farming has left vast fields abandoned or underused, creating a 'blank canvas' for large, luxurious villas



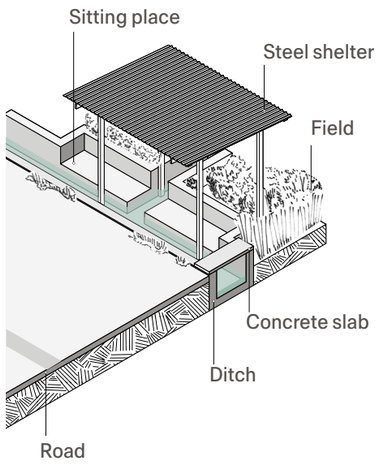


Fig. 15
Main channel of the Meizhou irrigation system. The pavilions and staircases were added as part of a recent redesign. By the authors.

Fig. 16
Axonometric drawing of washing places created by residents. By the authors.

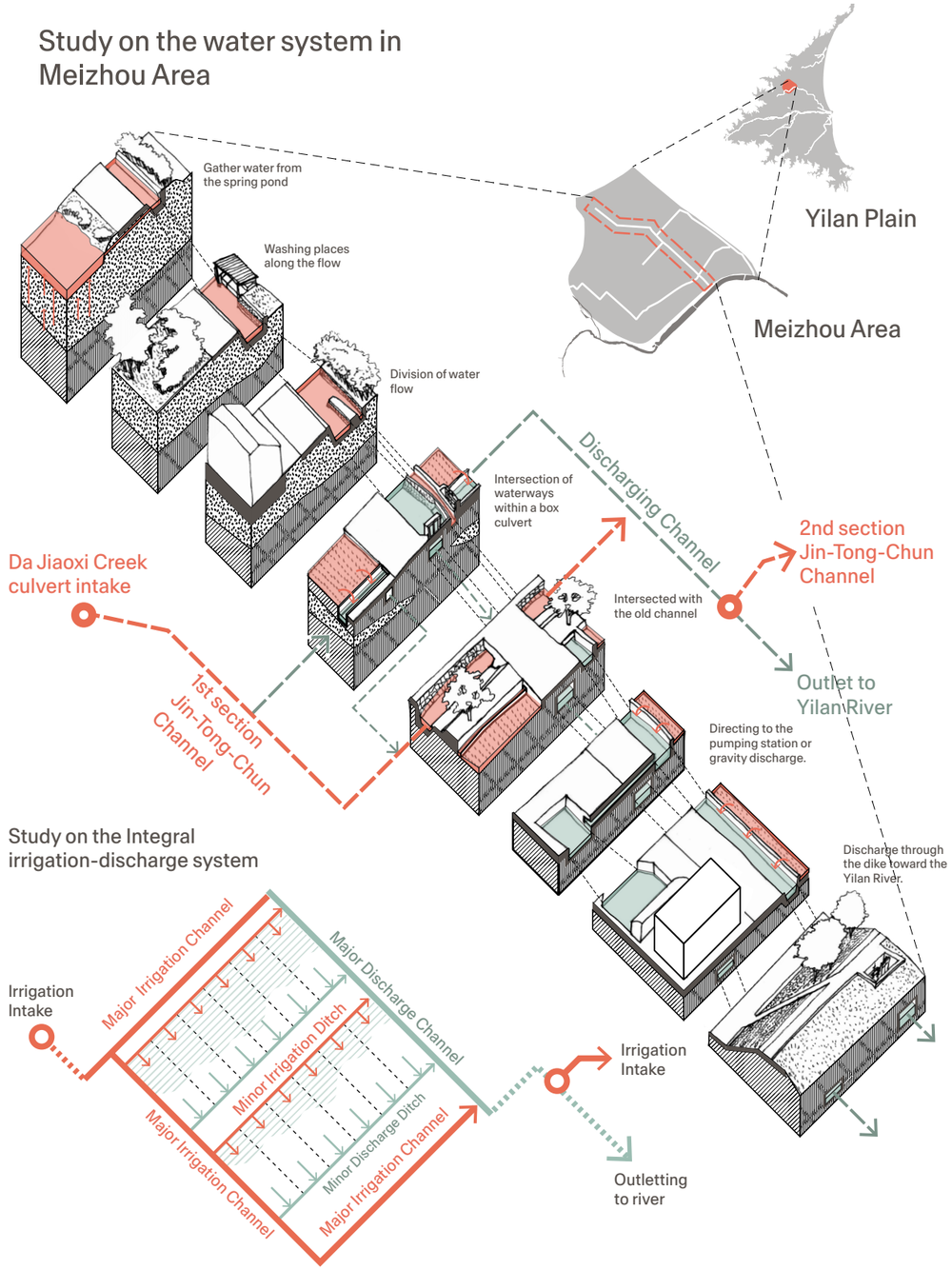


Fig. 17
Study of the Meizhou water system combined with spatial relationship diagrams, illustrating the complex network of pipes and ditches. Using one section of the area as an example, the drawing shows how the function of water channels changes with elevation: some irrigation ditches become drainage channels only a few hundred metres downstream. As the terrain becomes lower, the drainage network grows increasingly complex. The outlet to the main river includes both a gravity discharge and a pumping station designed to manage extreme rainfall events. By the authors.

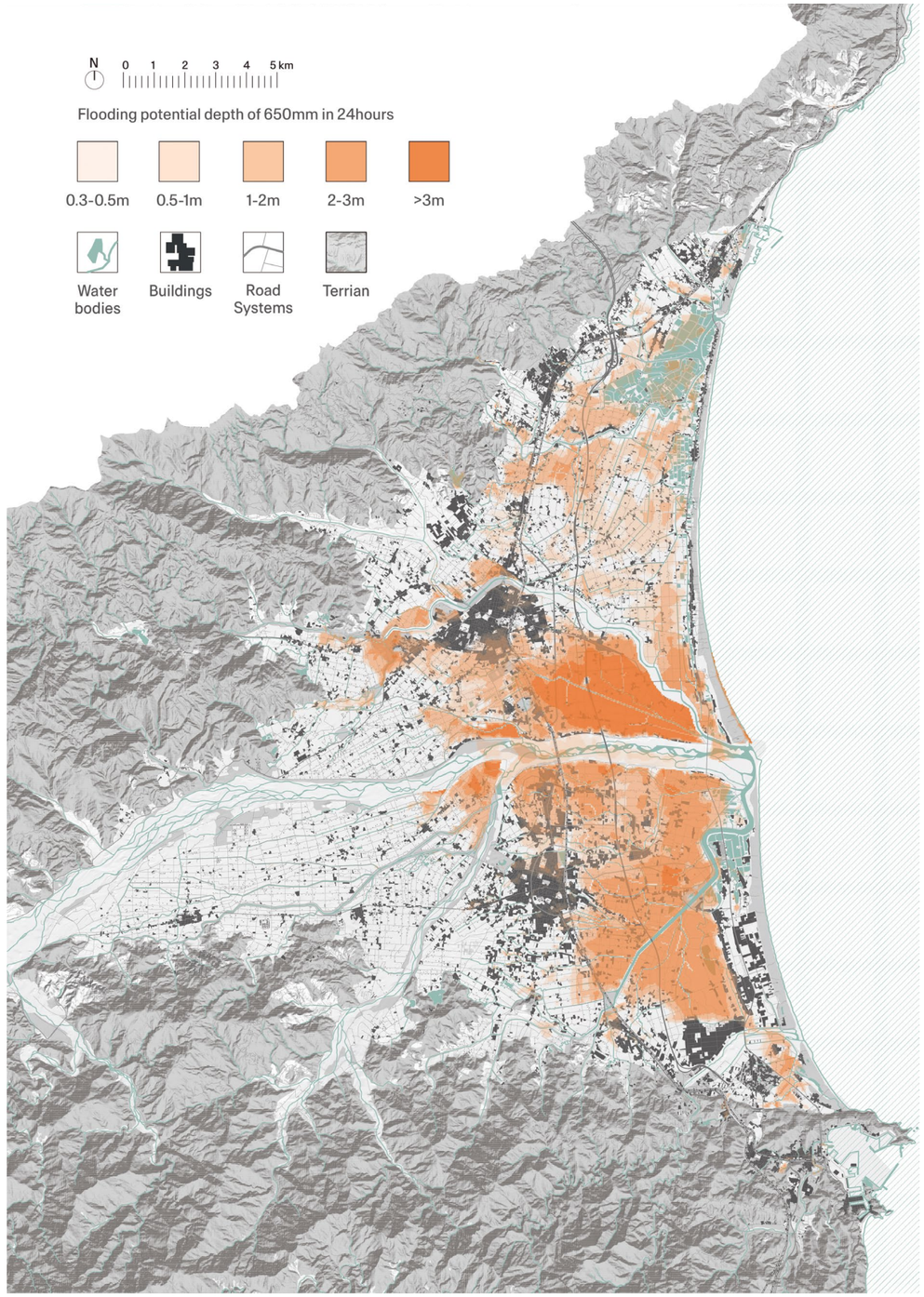


Fig. 18
Overlay of flood potential maps (650 mm of rainfall in 24 hours) with the current landscape, highlighting the urgency of development within a sustainable and resilient framework. Based on data from the Water Resources Agency, Ministry of Economic Affairs (Taiwan) (n.d.).

for retiring urban dwellers (Figure 19). However, short-term problem solving and single-purpose approaches are the main solutions to these issues.

Rural land is currently accompanied by the spread of impervious surfaces, which accelerates runoff and increases flood peaks. In response, expanding the drainage infrastructure and adding more pipes to accommodate changing land-use patterns are the best options. However, because public land is finite, this approach forces waterways to be built beneath road surfaces rather than as open spaces as they were once. Such an approach may address immediate demands; however, the complexity of the system makes maintenance more difficult and reduces the character of waterways, turning them into pipes and losing their role as shared public spaces. (Figure 18)

In addition, because authorities are falling short in thinking about long-term transitions and fixing immediate problems under public pressure, water management has become a problem only for engineers and not spatial designers. Designers play a key role in placemaking but are absent in most planning processes and major meetings. Over time, these vital, life-linked waterways have been reduced to mere pipes and underground structures, and with this transformation, Yilan's water-centred identity has gradually faded. It is increasingly imperative to reconsider the conceptualisation and management of waterways, moving beyond their conventional role as conduits for water transport, to recognise them as multifunctional landscapes that provide public amenity, enhance spatial quality, and deliver ecological services. (Figure 20)



Fig. 19
A parcel of land for sale (as indicated on the signboard) will most likely become the site of a villa. Adapted from a photograph by Keng Ching Chen.



Fig. 20
A ditch in Wujie Township showing vegetation thriving along its hardened edges (orange mark). Adapted from a photograph by Keng Ching Chen.

Fortunately, Yilan has a long-standing tradition of environmentally attentive development. Successive interventions have repurposed indigenous water spaces into prominent public landscapes that attract both residents and visitors, exemplified by projects such as the Dongshan River Park and the revitalisation of the Yilan River corridor (Figure 21). These initiatives facilitate renewed engagement with the natural environment and significantly contribute to Taiwan's landscape architecture canons. These concepts were realised in practice through the efforts of visionary decision-makers in the nineteenth century, forward-looking officials, and skilled designers, all of whom sought to understand and preserve Yilan's distinctive character.

Historically, Yilaners demonstrated a strong environmental consciousness, mobilising against polluting industries and advocating for sustainable development. During this period, the design and management of high-quality water landscapes were central concerns for authorities, with water serving



Fig. 21
The Dongshan River projects in the southern Yilan Plain, initiated around 1990, represent a groundbreaking example of river regulation and management in Taiwan. They illustrate comprehensive planning and intervention strategies. Adapted from Lai (1991).

as the fundamental design element. This represents a valuable yet fragile tradition, one that, after 30 years, risks being forgotten or overlooked by newer generations. As existing systems have once again become fragmented, they are no longer adequate to address the emerging challenges of climate change and land use transition. Rather than responding to these issues only partially and temporarily, Yilan must adopt a broader and more systematic perspective on the landscape as a whole and extend its vision beyond immediate concerns.

REFLECTION

Studying the Lanyang Plain has revealed that water has long been and continues to be central to the everyday lives of the Yilan people. Similar to many regions worldwide, Yilan's existing water systems no longer fully respond to contemporary climate variability or modern patterns of living. Thus, it is essential to critically re-examine these systems and distil the knowledge embedded within them. Mapping and documenting these networks is a crucial first step, as it uncovers hidden layers of understanding that can inform adaptive strategies for future landscapes and water management.

Through this short expedition, I am convinced that landscape architecture plays a distinctive role. It can bridge multiple perspectives, engage diverse stakeholders, and reinterpret enduring water systems as new, functional, and meaningful spatial interventions. In doing so, we honor the resilience of Yilan's people and their ongoing dialogue with water, one that landscape architects have a responsibility to help sustain.

NOTES Calling to Map

1. Jōganji River is a river located in Toyama Prefecture, Japan. Although relatively short, it has a very steep gradient. Combined with its location in one of Japan's regions with the highest rainfall, this makes the river highly prone to flooding. (National Highway Office, Hokuriku Regional Development Bureau, n.d.).
2. Water infiltrates the apex of the alluvial fan, where the substrate is composed primarily of coarse gravel. As groundwater pressure within the fan increases, water emerges as springs.

Lessons to Learn

Scaling Traditional Knowledge to Face Increasingly Complex Challenges

Inge Bobbink[1]

Anthropogenic climate change underscores that water is fundamental to sustaining life on Earth and therefore warrants great design intelligence.

This essay presents several landscape architectural graduate projects that incorporated key lessons from the analysis of traditional water systems. Throughout their studies, students engage with case studies as sources of learning and inspiration for spatial design. No design is conceived in isolation; instead, it invariably builds on designers' prior experience and intergenerational knowledge embedded in indigenous communities, whether implicit or explicit.[1] The Circular Water Stories (CWS) lab focuses on long-lasting water systems as a foundation for landscape architectural design and situates the lab's work within a landscape approach. This approach is understood as an integrative way to address complex, real-world water challenges across ecological, spatial, technical, social, cultural, economic, and institutional dimensions, while recognising multiple objectives, actors, scales, and trade-offs (Sayer et al., 2013). The Illustrative Method (Bobbink et al., 2022) helps operationalise this by making relationships among water flows, landform, infrastructure, livelihoods, cultural practices, and governance visible and comparable. Unlike contemporary interventions, the case studies capture the evolution of water-sensitive design over time, providing richer insights into how social, ecological, and economic dimensions interact within functioning landscape systems.

Fig. 1
Conceptual drawing of possible transformations of the dike-fish pond ratio in the Pearl River delta, China. Adapted from Ma (2025).

1 Dr ir. I. Bobbink, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands; i.bobbink@tudelft.nl
0000-0002-3130-7369

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Given the wide range of projects developed within the CWS lab, only a few lessons learned from traditional water systems were highlighted for each project. The selection aims to reflect the diversity of insights by showcasing the different facets of these systems. These brief descriptions cannot capture the full depth of the knowledge embedded in each project. For a more comprehensive exploration of the projects and the traditional water systems that inspired them, readers were invited to consult the CWS website[2], where detailed analyses and design outcomes are available.

Students are drawn to the CWS lab to deepen their understanding of water systems and to recognise the valuable knowledge embedded in traditional practices. At the outset of their graduation projects, they investigated traditional water systems as a case study. These systems are tailored to specific geographical and climatic conditions and functions, without advanced technological interventions. More importantly, these landscapes embody active community participation in shaping and maintaining the environment.

SITE AND DATA

Preferably, students choose a traditional water system site they are familiar with and can visit, or they choose a case that represents a particular landscape type and features specific water management techniques or rituals they want to work with. Some students are drawn to traditional water systems, which have nearly disappeared. Others are especially interested in sites with little water to determine how people survive.

Given the time constraints inherent in a graduation year, preferences are generally given to projects in countries with reliable and comprehensive datasets. Nevertheless, students who come from and choose to work in regions such as China or the African continent need to overcome limited access to standardised geospatial data. In such cases, foundational cartographic resources must be compiled by utilising publicly available tools, including satellite imagery, online databases, atlases, and relevant academic literature. Moreover, height and soil maps are essential for analysing the structure and functioning of a site's hydrological system. Historical websites, literature reviews, oral histories, and available topographical maps support documentation of cases in which the water system has disappeared. Understanding, selecting, and integrating all available documentation is critical for any water system analysis and design interventions.

NATURE-BASED INTERVENTIONS

Most human-made water systems examined in the lab have been engineered using nature-based interventions[3], relying exclusively on locally available materials. Over time, these systems have evolved incrementally through adaptation processes shaped by shifting environmental conditions and changing the needs of local communities. With the advent of industrialisation and the drive for large-scale infrastructure, some water systems have become increasingly disconnected from their immediate physical and cultural contexts. In such cases, students are encouraged to focus their analysis on the pre-industrial phase of these systems, when designs are still congruent with local conditions, available resources, and community-based management. Emphasising this historical context enables students to gain deeper insight into the human intelligence behind the different cultures that understood and worked with water as a life-sustaining element and driving force within the landscape.

METHOD

All students used the Illustrative Method (Bobbink et al., 2022), an analytical approach grounded in landscape architecture that has been progressively refined since the lab's establishment in 2019. This mapping method, illustrated throughout the book, provides critical insights into how the 'DNA' of landscapes, often originally shaped by indigenous communities, has been transformed into functional, adaptive water systems that serve various societal needs. The most instructive case studies are those characterised by complexity, layered narratives, and a spatial context in which urban development has not yet entirely supplanted the cultural landscape, such as the Kampung Naga System in Indonesia, where residents precisely understand the system's carrying capacity. When water usage exceeds this threshold, such as increased demand for irrigation, cooking, cleaning, and other needs, the system is at risk of collapse. In such situations, families are sometimes compelled to relocate to preserve the village's ecological balance. This method also enables students to transfer lessons from a traditional water system to a different site for the graduation project, using the case study as an analytical lens rather than as a model to be duplicated.

HOLISTIC AND INDIGENOUS

Circular drawing is a crucial tool in this reflective and analytical process. This drawing is instrumental in helping students conceptualise and visualise a given site's systemic, spatial, functional, and cultural dimensions. Circular drawings support critical thinking by offering a holistic overview of complex systems. Therefore, graduate students are strongly encouraged to develop circular drawings as an integral part of their design process. Whether used to guide development or as a post-design reflection tool, the drawing assesses whether the (urban) landscape proposal achieves a level of ingenuity and contextual sensitivity comparable to those of traditional water systems.

For their graduation project, students increasingly seek a holistic approach to restoring values perceived as lost or diminished. The notion of holistic restoration, as introduced by Pandey, offers a framework for simultaneously addressing ecological degradation, biodiversity loss, and sustainability challenges. This approach draws on cultural heritage, local knowledge systems, and community-based practices, and advocates for a more integrative model of environmental design. While the CWS lab initiated its research on traditional water systems by recognising the value of historical landscape-based knowledge systems, recent years have seen a broader resurgence of interest in indigenous epistemologies. The publication of Lo—TEK: Design by Radical Indigenism (Watson, 2019) reinforced this shift, underscoring the relevance of indigenous knowledge systems for contemporary architecture and urbanism.

HOPE AND AESTHETICS

In parallel, McHarg (1969)'s seminal work *Design with Nature* experienced a resurgence in landscape architecture curricula. More than 50 years after its publication, it profoundly influenced students. As Lewis Mumford noted in his review of McHarg's work: 'In presenting us with a vision of organic exuberance and human delight, which ecology and ecological design promise to open up for us, Ian McHarg revives the hope for a better world.' The

hope of contributing to a fairer and more sustainable world through landscape design remains a central motivation for many students. However, the lab is critical of the existing pedagogical imperative to guard against the reductive assumption that landscape architecture alone can resolve complex global challenges by embracing nature and indigenous wisdom. Therefore, students are encouraged to articulate a critical and context-sensitive understanding of their professional role.

Anne Whiston Spirn extends McHarg's ecological perspective by understanding the landscape as both a natural and cultural process. Her approach brings the ecological function, cultural meaning, and aesthetic experience into the same field of design. Aesthetics, in this context, is not treated as a visual embellishment but as a means of making water processes perceptible, experiential, and meaningful to people who inhabit a landscape (Spirn, 2000).

For many students, recognising the sustained and reciprocal relationships between people and landscapes has become an important turning point. It challenges the idea of the designer as an external problem-solver and instead positions the landscape architect as a participant in ongoing ecological, cultural, and spatial transformations. Combining these dimensions forms the basis of a rigorous and meaningful thesis within the CWS lab.

THREE APPROACHES

Following the analysis of traditional water systems, students reflected on their findings by identifying a range of value dimensions: landscape, strategic, functional, material, sustainable, tangible, and intangible. The findings inform students' graduation projects, either directly or indirectly. Notably, expressing appreciation for the depth of site-specific knowledge, communities involved in constructing, maintaining, and inhabiting these landscapes demonstrate an acute understanding of local environmental conditions and efficiently use readily available materials and practices that often enhance quality of life while minimising ecological impact.

Over several years, three primary approaches have emerged through which students engage with traditional water systems as both conceptual and analytical foundations for their graduation projects. The first is the interpretative approach. In this model, the selected traditional water system provided a contextual framework for design interventions. The original system is still physically present in the landscape, although it is often only partially functional and increasingly misaligned with the current environmental and societal conditions. Various pressures, ranging from population growth and changing lifestyles to rapid climate change, biodiversity loss, and water-related problems such as flooding, scarcity, and pollution, pose significant risks to the continued viability of these systems. These challenges are often interrelated and compounded, and demand multifaceted and context-sensitive responses. The traditional water system requires clarification, and sometimes restoration, to gain meaning.

Second, students engage with the transformation approach by reimagining a lost traditional water system at approximately the exact location. These projects do not aim to (partly) reconstruct the original system but rather to reveal the underlying essence of the historical water landscape, acknowledging it as a valuable repository of tangible and intangible memory. This approach catalyses the development of new (urban) landscapes that respond to contemporary challenges in which water plays a critical role. Traditional water systems have been altered.

The examples show that the distinction between the interpretation and transformation approaches is fluid, but helpful for understanding the designer's intention.

Third, the experimental approach involves dismantling and relocating traditional water systems to alternative sites. This approach holds significant promise for bolder exploration, particularly in landscapes that experience intense pressure from rapid environmental and societal changes. This approach exemplifies 'research by design' more explicitly than the other two approaches, offering a speculative, yet methodologically grounded framework for adaptive landscape strategies.

INTERPRETATION

Students using this approach typically select sites with which they are familiar and are often situated within their own cultural or geographical backgrounds. Through site-based inquiry, they encountered the ingenuity embedded in these systems. Many of these have been constructed, adapted, and maintained by indigenous and local communities for centuries. This engagement reveals the landscape's unique characteristics and highlights its heritage value.

To avoid the pitfall of reducing the traditional water system to a mere restoration project, students were encouraged to enhance their relevance by addressing contemporary needs. This approach invites a reinterpretation of the historical context, thus enabling the system to adapt. A thorough diagnosis is essential to understand why the system no longer functions, as this insight forms the basis for envisioning its future potential. Students interviewed community members and other knowledge holders, such as local NGOs, to determine which practices remain effective and which have deteriorated. Moreover, the site's cultural context plays a critical role. It is essential to consider whether the local community still engages with or desires to engage with, for example, agricultural practices for which the water system was originally designed. A commonly identified issue is the lack of available labor required for the system's upkeep and functionality. However, the long-term functioning of these systems cannot be sustained without economic outputs, such as agricultural products, or other tangible benefits, such as tourism. Regular physical involvement by local water workers, designers, and system keepers who actively manage, repair, and utilise it is essential for its continued viability.

Three projects employing the interpretive approach are examined to illustrate the lessons learned from traditional water systems through analysis and foundation for design: ancient salination in China, quenching thirst in Peru, and bridging the gap back to life in China.

ANCIENT SALINATION

In the case of the Sea Salt Fields on the island of Hainan, China, the project Ancient Salination: A Generator for the Sustainable Development of the Salt Villages in Danzhou addressed the declining salt industry. Currently, only a few local community members remain involved in salt production, and the practice is no longer economically viable. Parts of the system have fallen into neglect, exacerbated by the migration of younger generations from the island. Further investigation revealed that the degradation of salt fields has contributed to the deterioration of the coastal defense landscape, a

historically significant byproduct of salt production. Giving up salt harvesting poses a growing risk of flooding for coastal communities, especially with rising sea levels. To raise awareness of this issue and reinvigorate the local cultural identity, the project proposes partially restoring traditional salt-winning practices in this unique volcanic landscape and reimagining it as a sustainable tourist destination. This vision is plausible, given the artisanal nature of salt production at this site, which involves a variety of site-specific structures and materials, offering visitors a tangible and engaging spatial experience. Specially designed routes immerse tourists and locals in the ecological significance of coastal defense systems. Visitors are guided by the landscape to understand the maintenance of the coastal ecosystem required for salt production. (Figures 2, 3, and 4)

Lessons learned: The project positions ancient salination as a cultural heritage practice and catalyst for sustainable development to mitigate flood risks, enhance biodiversity, and promote recreational opportunities along the coastline.

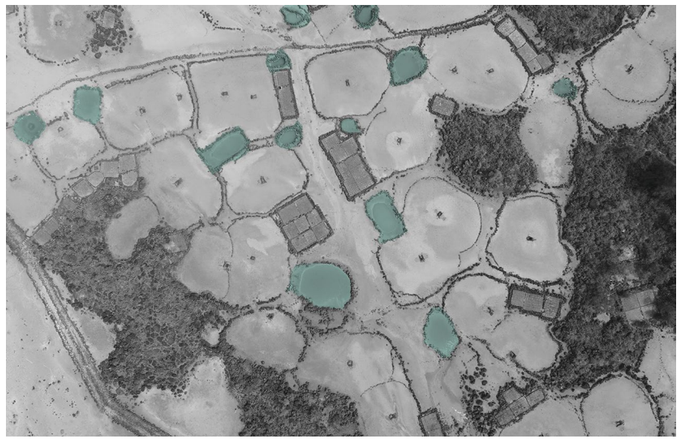


Fig. 2
The inundated salt fields collect seawater, initiating salt extraction. This concentrated brine is subsequently distributed over intricately carved volcanic stones designed to retain a thin film of saltwater. As further evaporation occurs under solar radiation, crystalline salt gradually accumulates and can be harvested. Adapted from a photograph by Ran Yan.

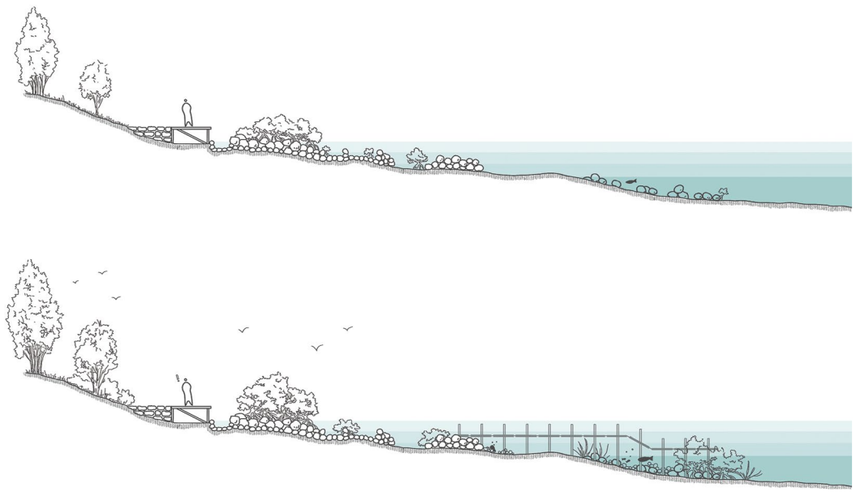


Fig. 3
Section 1 illustrates the design of the pathway along the shoreline using materials from the site itself. Section 2 depicts the second phase of implementation; the underwater structure stabilises the shore and creates new habitat spaces. Adapted from Yan (2021b).

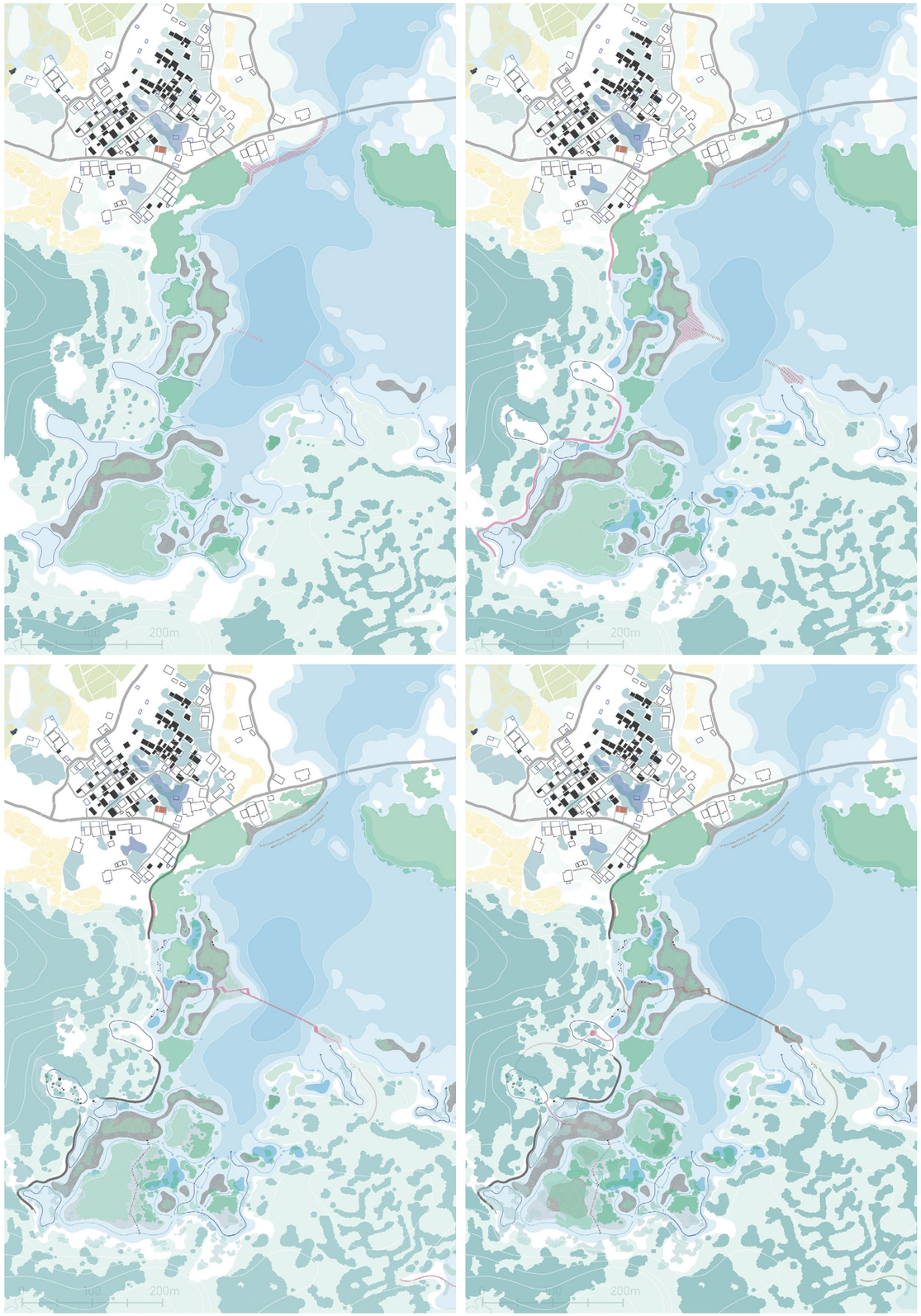


Fig. 4
A sequence of maps, the first showing the site before the interventions, illustrates the landscape changes resulting from the design's implementation. Adapted from Yan (2021b).

In the case of the Amunas water system in the Andes of Peru, the government began to recognise the harm caused by the decline of this ancient infrastructure to the growing water problems in Lima, the coastal capital. In her project, Quenching Thirst: Cooperation and Interaction by Living with Water from Huamantanga in the Hills to Lima on the Coast, reimagines the value of mountain water systems and their role in sustaining local and urban populations. Restoring the Amunas System helps regulate and stabilise the flow of the river towards Lima, ensuring a more consistent and reliable water supply and enabling the transformation of riverbanks into meaningful public spaces for education, community gathering, and renewed appreciation of water as a shared and finite resource.

By acknowledging and valuing the traditional water practices of highland communities, the project supports ecosystem restoration and offers local opportunities to improve living conditions. The revival and expansion of the ancient system, including the integration of retaining ponds, not only restores water infrastructure but also opens new possibilities for ecotourism. Hikers were invited to learn from the community and their ancestral knowledge. As local beliefs hold: 'If all the snow disappears, the world will end—natural waterfalls and lakes are creative places where worlds merge into one another, where you can find treasure or be bewitched by the mountain spirits—mountain lakes making up the eyes, where life springs up from an underlying world. ' Revaluing water needs to be rediscovered, especially by authorities and citizens. Therefore, the design extends beyond the local practice site along the river, bringing newly harvested water to the city. Water awareness plays a vital role in public space design, for example, by being able to touch or see it and by using and encountering its irrigation capacity. (Figures 5, 6, 7 and 8)

Lessons learned: Recognising these practices beyond their functional benefits reflects an appreciation for the circular, regenerative nature of the system. The project introduced new spatial compositions that use vernacular elements to foster deeper connections among people, water, and landscapes.

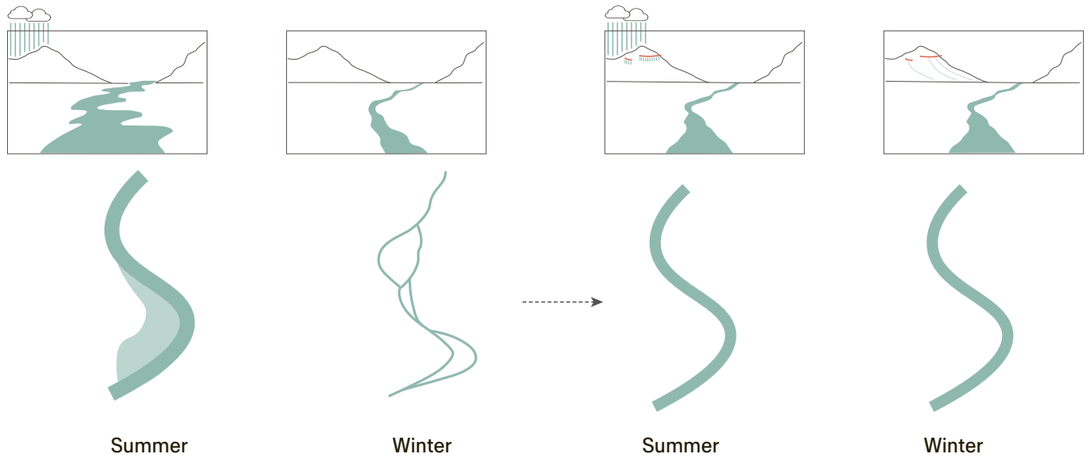
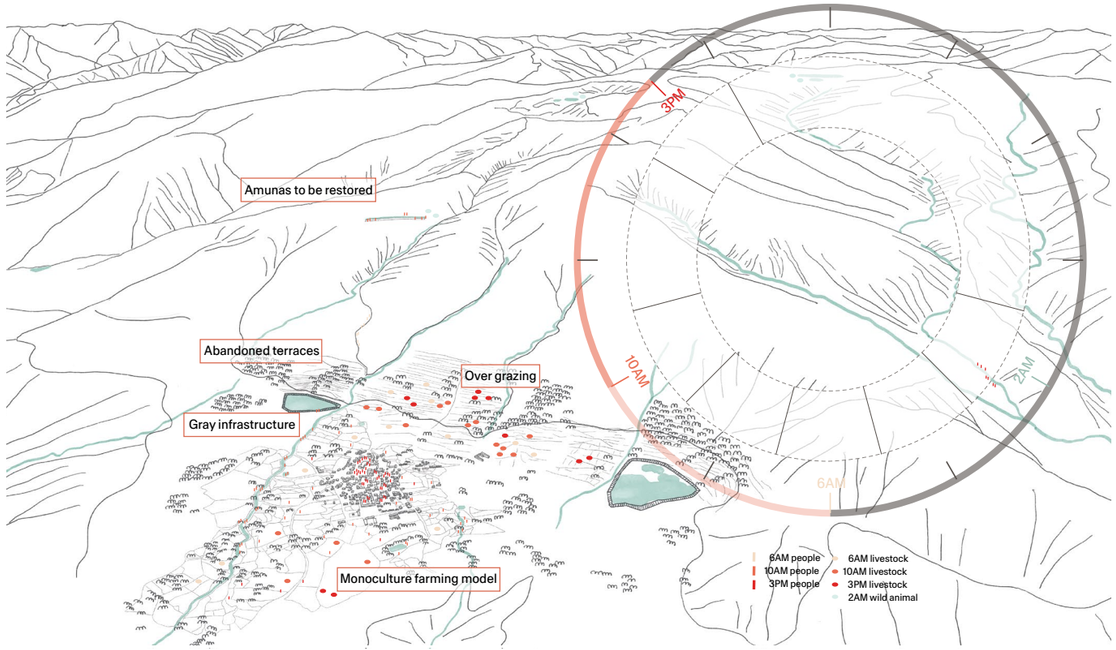


Fig. 5
Diagram of a more regular river flow, mitigating both flooding and drought. Adapted from Liang (2023b).



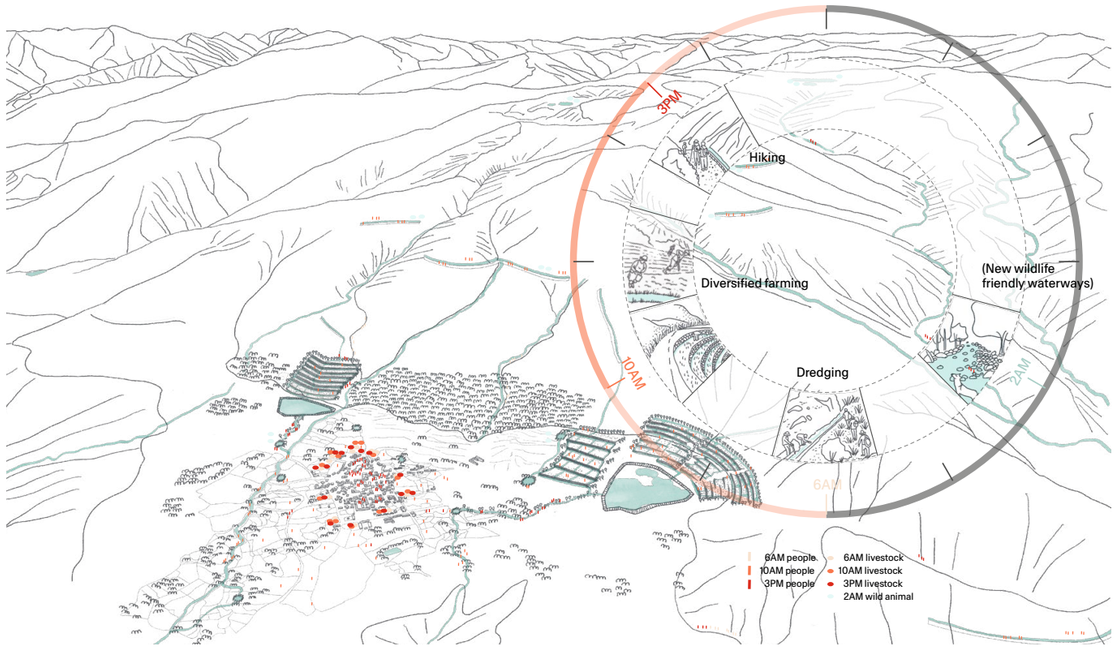
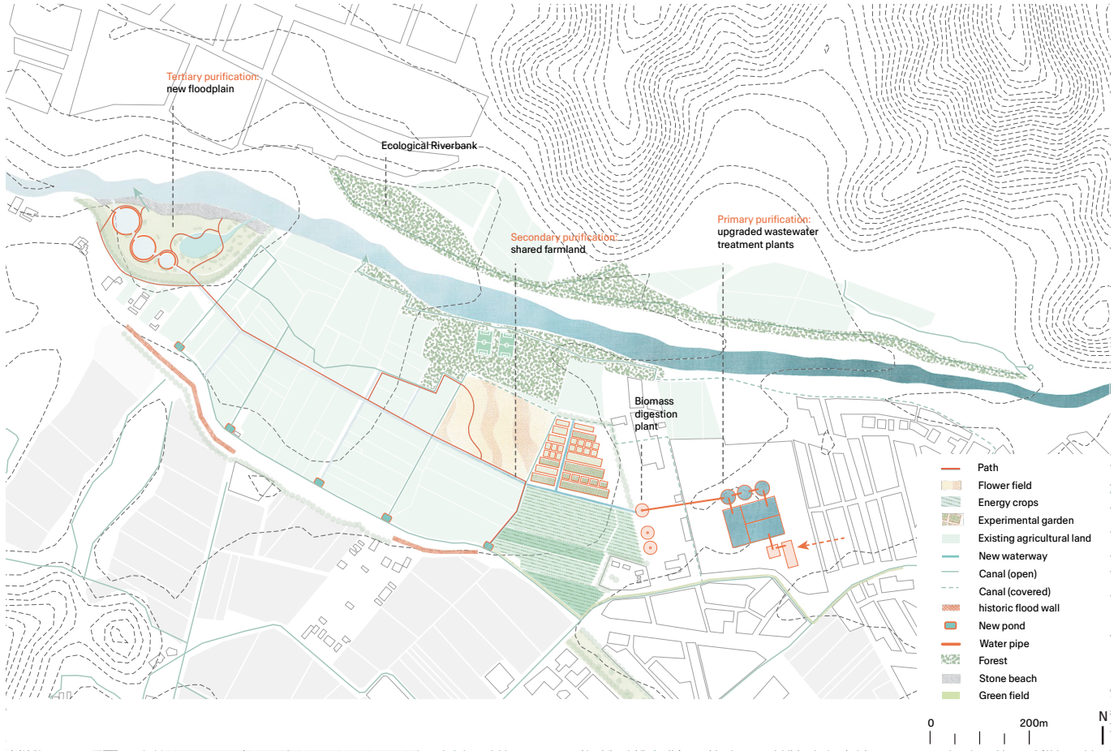
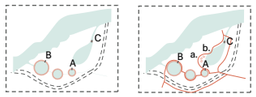
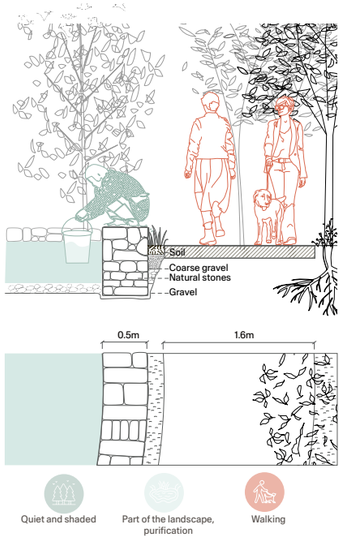
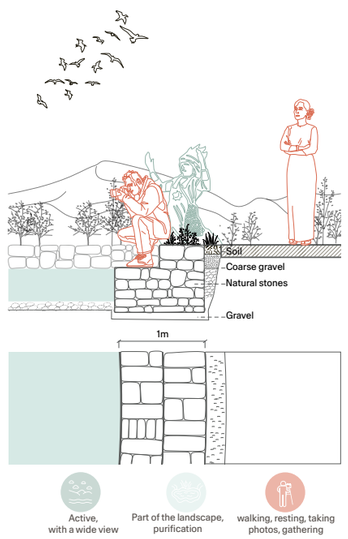


Fig. 6
The design enhances people's activity in Huamantanga. It is based on a well-functioning water system, which enables diversified planting patterns and a variety of products. A greater variety of activities and experiences attracts visitors and hikers. Ecological restoration and water management create a more consistent flow within the river system. Adapted from Liang (2023b).









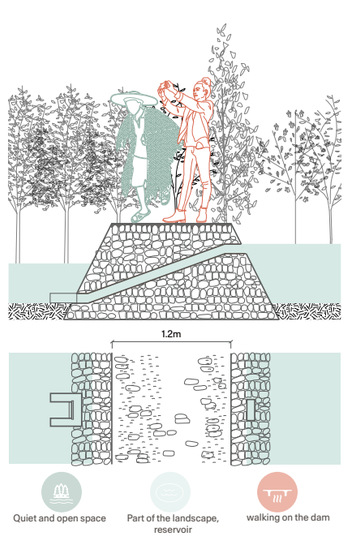


Fig. 7
The design incorporates vernacular materials within the park to strengthen the visual and cultural connection to the mountain village. Adapted from Liang (2023b).

Fig. 8
Three types of shared farms are proposed along the river: an experimental garden, an energy crop field, and a flower field, each serving as a model for sustainable agriculture. Treated recycled urban water irrigates the gardens, while strategically placed vegetation (shrubs, tree rows, and solitary trees) provides spatial structure, shade, soil stabilisation, and supports groundwater recharge. The design fosters a renewed relationship between people and water, encouraging respectful and efficient use of resources. Adapted from Liang (2023b).

BRING LINPAN BACK TO LIFE

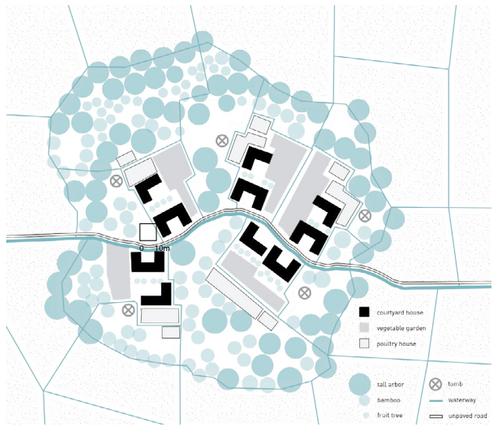
Having spent part of her childhood on the Chengdu Plain, the student approached the project with a personal connection to the region. She was particularly struck by the ingenuity of the Dujiangyan water project, a monumental hydraulic system initiated as early as 260 BCE that continuously developed over time. This ancient engineering feature comprises a weir head that diverts water from the river into an extensive irrigation network. The weir head consists of three key components: the Fish Mouth Levee, the Flying Sand Weir, and the Bottleneck Channel, which collectively earned the UNESCO World Heritage status system in 2000. Understanding the functionality of this complex infrastructure is a significant challenge. However, it was essential to grasp its profound role in regulating water flow and facilitating irrigation across the expansive Chengdu Plain. (Figure 9)

Over more than 2,000 years, the irrigation network on the Chengdu Plain has evolved into a sustainable Linpan System. Linpan typically comprises an almost self-sufficient cluster of approximately 20 farmsteads belonging to an extended family surrounded by trees, bamboo groves, irrigation channels, and cultivated farmland. Together, these elements support a circular and resilient lifestyle.

While thousands of Linpan once characterised the landscape of the plain, rapid urbanisation, the withdrawal of farmers, and the younger generation's pursuit of alternative lifestyles have led to a gradual decline in the system. The project *Bringing Linpan Back to Life: Revival of the Linpan Community, Sichuan, China* (Z. Zhang, 2023) seeks to reinterpret the Linpan model by emphasising its circularity and historical and cultural significance. Fortunately, local governments have recognised the value of these traditional settlements. Informed by social analyses, three new Linpan models—the modern pan, urban pan, and ecological pan—are proposed.

The Modern Linpan model primarily focuses on enhancing rural lifestyles and optimising land use. This is achieved through improvements to the residential environment and diversification of income sources. Environmental upgrades include relocating tombs and poultry enclosures; enhancing infrastructure, including roads, irrigation networks, and residential buildings; and expanding green spaces and communal activity areas. Although agriculture remains the primary livelihood, residents increasingly engage in tourism-related ventures. However, these developments have only a modest impact on the internal spatial organisation and circulation within the Linpan settlement. (Figure 10)

Fig. 9
Traditional Linpan, plan and circularity diagram. Adapted from Z. Zhang (2023).



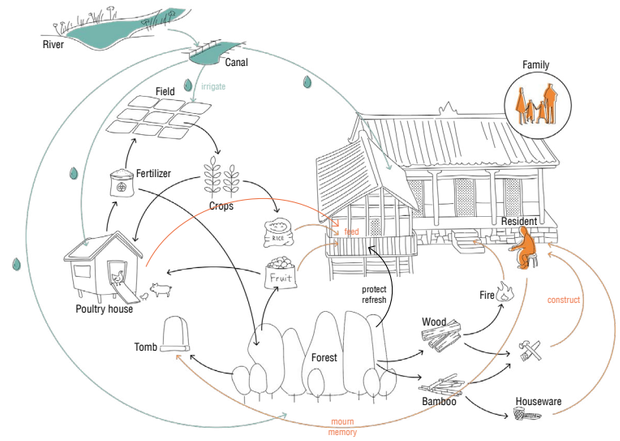
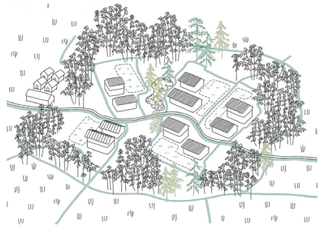


Fig. 10
Modern Linpan, plan and circularity diagram. Adapted from Z. Zhang (2023).



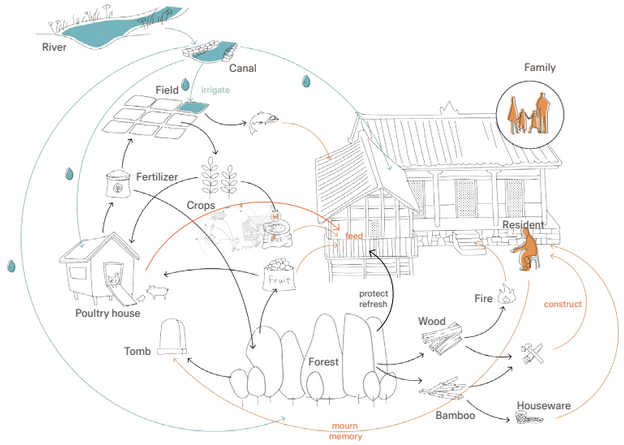


Fig. 11
Ecological Linpan, plan and circularity diagram. Adapted from Z. Zhang (2023).



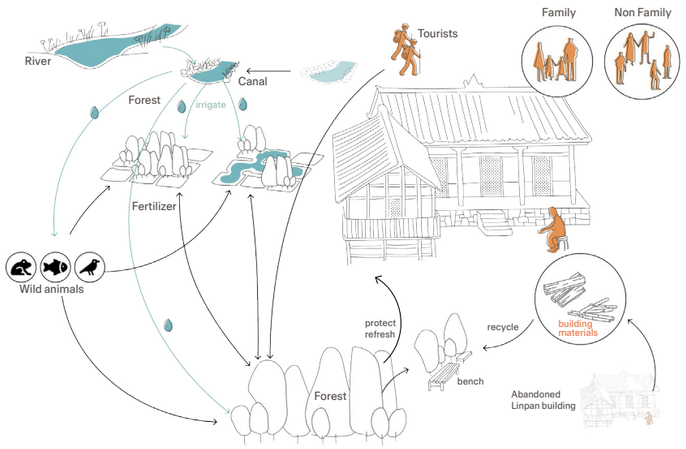
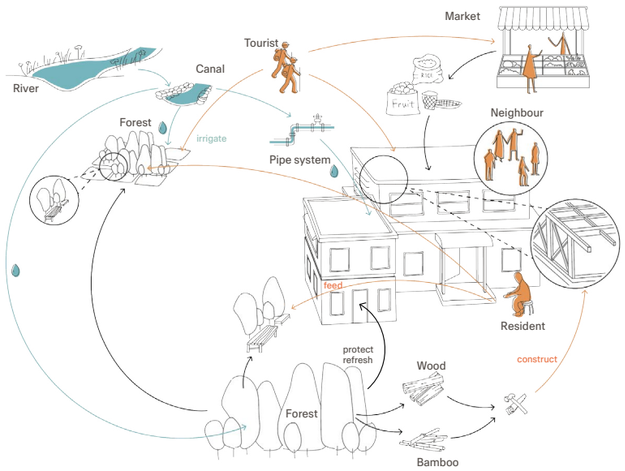


Fig. 12
Urban Linpan, plan and circularity diagram. Adapted from Z. Zhang (2023).





The Ecological Linpan model highlights significant lifestyle shifts and the reconfiguration of agricultural practices, as many residents no longer rely on farming as their primary livelihood. Increasingly, individuals commute to urban centres for employment, leading to a gradual reduction in on-site agricultural activities. As a result, the remaining farmland is repurposed for ecological restoration, including forest expansion, softening of the edges of irrigation canals, and the introduction of wetland systems. Agricultural functions are diminished within this emerging forested matrix, while ecological processes and biodiversity are gaining prominence. (Figure 11)

Urban Linpan responds to evolving lifestyles, shifts in agricultural functions, and the transformation of traditional family-based structures. It departs from the single-family homestead model by adopting alternative housing typologies, such as apartment-style dwellings that accommodate multiple households. In this form, Linpan functions more as a neighborhood, housing up to 150 residents. The inclusion of recreational facilities further supports this transition. As a circular system, the urban pan is characterised by more frequent exchanges of materials and resources with the external environment, reflecting heightened connectivity and systemic complexity. (Figure 12)

Lessons learned: By reinterpreting carefully designed circular living units rooted in traditional water management systems, this project offers sustainable living alternatives that respond to the demands of a rapidly transforming society and to the challenges posed by climate change and ecological degradation. These variants are designed to accommodate a range of contemporary lifestyles and support economic sustainability, while safeguarding the fundamental principles of the traditional Linpan typology.

In this category, we also find graduation projects such as Pop Out Milan, Unveiling Milan's urban renaissance through the rebirth of the Navigli Canal System as a landscape connection and social link (Filippoli, 2023), and The Canal Story, Canal du Midi, and Living Water Heritage (Sun, 2022). Due to their size and function, these Grand Works are manifestly visible in the landscape, and their heritage values are evident.[4] The endeavor to engineer these large systems and appreciate the craftsmanship and technical knowledge involved in digging and constructing these waterways and waterworks is not only locally meaningful but also regionally and nationally significant. Students transform these structures, which are no longer used for shipping goods, so that people can experience the landscape and stories of the past from a water perspective. Furthermore, in both projects, the water edges were partially softened to make the land-water gradient more flexible and therefore allow for greater biodiversity. In the Pop Out Milan, the system transforms into a green-blue recreational lung structure for the city.

TRANSFORMATION

Given the complexity and scale of traditional water systems, it is not always feasible to analyse all components within the scope of a single graduation project. For instance, regarding farm ponds on the Taoyuan Tableland in Taiwan, the graduate later discovered that the system also includes elements such as springs, washing houses, and upstream temples. These features were not incorporated into the design. The project focused on retention basins and proposed a reinterpretation of these structures in the context of urbanisation. In the project based on the Sprengen System[5], the historical water system no longer generates energy for mills but repurposes water elements to promote sustainable farming practices. In another case, the traditional

water system was a more abstract source of inspiration. Because of the existing polder-boezem system[6] and its position close to Amsterdam, a huge shipbuilding industry was established, which thrived from the late 16th century to the end of the 17th century. The sector disappeared, whereas significant portions of the water system remained intact. In the fourth example, the legacy of historical water knowledge disappeared, but was mentally reintroduced into the public realm through design. The project reactivates ancient expertise to address contemporary urban water challenges, while making the historical narrative of water visible and experiential. By embedding this knowledge into the city's public spaces, the design allows citizens and visitors to engage with the enduring significance of water management, thereby adding a new chapter to a century-long story.

Four projects employing the transformation approach were examined to illustrate how lessons are derived from traditional water systems through analysis and design: Farm Ponds of Tayuan in Taiwan, Revive the Sprengenbeek Landscape in the Netherlands, Intermotion Landscape in the Netherlands, and Revealing Rome's Water-Based Culture in Italy.

FARM PONDS OF TAOYUAN

Over 10,000 farm ponds were constructed on the Taoyuan Plain in Taiwan to retain water for irrigating paddy fields, vegetable gardens, tea plantations, and fish farming. These ponds are part of an extensive hydraulic system, including settlements and temples, fed by a network of canals that tap into rivers.

However, this traditional hydraulic landscape has been significantly altered by rapid urbanisation and the expansion of transportation infrastructure. Many ponds have been drained and built and rice fields and fish farms have steadily declined. In response to these changes, the graduate proposed a new application for the remaining ponds in her project titled Reviving Ponds in the Urban Network: *Towards Resilient Water Landscapes* (Kao, 2021). (Figure 13)

The design envisions the continued use of the pond system for fish farming and recreation, and more importantly, for stormwater management. During typhoons, which often bring intense rainfall over short periods, ponds could serve as crucial reservoirs to prevent urban flooding. This approach seeks to restore and enhance the network function of the original system by integrating new urban water structures accompanied by green infrastructure. (Figure 14 and 15), respectively.

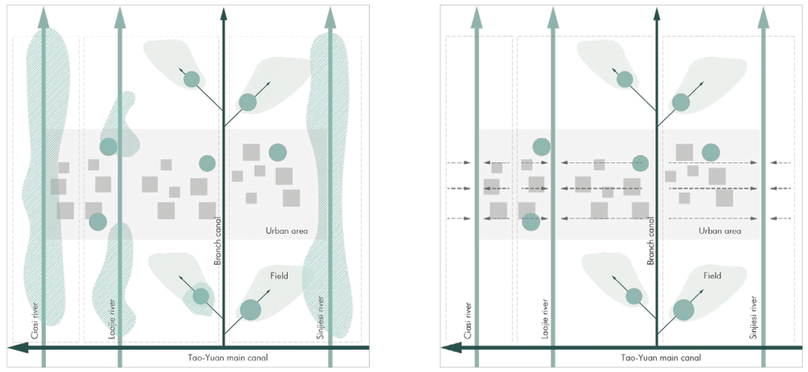


Fig. 13
Creating a robust water structure to mitigate flooding. Adapted from Kao (2021).

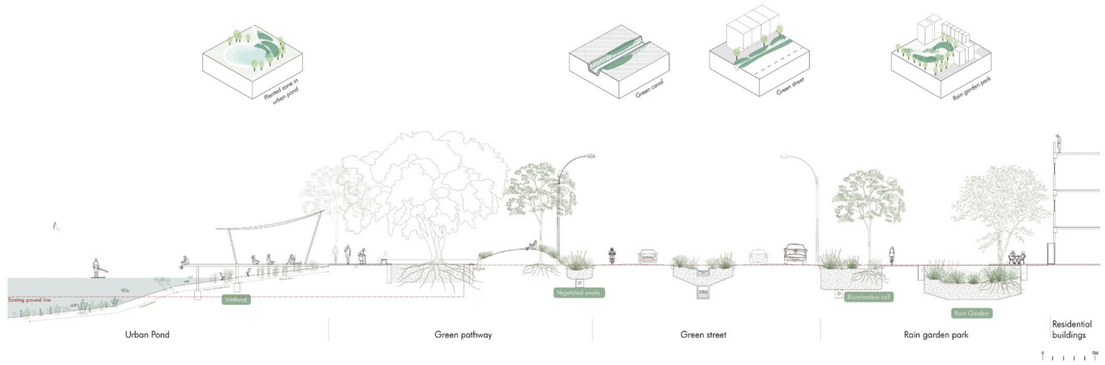


Fig. 14
Street runoff is collected in wadis, where the majority infiltrates the ground; excess water is conveyed through drainage pipes to the pond for filtration. Adapted from Kao (2021).



Fig. 15
The pond, located in the upper portion of the image, has been redesigned and extended with a secondary basin to establish a park landscape capable of seasonal water storage and filtration. The park's layout incorporates tree-lined walkways that offer shade and frame scenic views of the urban environment. Adapted from Kao (2021).



Fig. 16
The bridge connects adjacent neighborhoods and is designed as a crossing point and a social space for gathering, interaction, and engagement with the water landscape. Adapted from Kao (2021).

At the same time, the transformation of ponds balanced long, unobstructed view corridors in this densely urbanised region. The project underscores the importance of enhancing public awareness of the functional and cultural value of these traditional water systems, emphasising their role in fostering a deeper connection between communities, water, and cultural heritage. (Figure 16)

Lessons to learn: By recognising the traditional water system as a mediating infrastructure capable of storing excess water and releasing it to support plant growth, the design investigates new possibilities for its application within an urbanising context.

INTERMOTION LANDSCAPE

An analysis of the polder-boezem system and the industrial heritage of the Zaanstreek region in the Netherlands revealed the existence of a once-thriving global shipping industry.[6] Today, only those familiar with the history of the area can discern the remaining traces. The entrepreneurial spirit of that era served as a key source of inspiration for the design project, *Intermotion Landscape. An Experimental Design on Movement, Place Making and the Appreciation of the Cultural Landscape in the Zaanstad Area* (Chen, 2023b). A multifunctional boat serving as a mobile landscape intervention was central to this project. (Figure 18)

It hosts a peat garden, library, laboratory, and maintenance shed stocked with tools and materials to support the care of the peat polder landscape and the development of new public spaces within the town. Resembling a modern-day ark, the boat moves slowly through the landscape, observing, learning, and fostering sustainable transformation. The ship acts as a connector between the urban fabric and fragile rural peat landscape, emphasising the region's water-based connectivity while inviting participants to engage actively in the stewardship of their environment. (Figure 19)

Landscape transitions from a historically engineered, water-based industrial zone through a period of decline to a renewed vision of hope and resilience. When families are engaged in the shipbuilding industry, water management is integral to the community's well-being. In the current design proposal, water again emerges as a unifying element. The graduation project offers poetic reflection on water as a medium for transportation, connection, and cultural memory.

Lessons to learn: The shipbuilding industry has emerged from the polder–boezem system, a drainage infrastructure engineered to regulate water levels in low-lying areas. In this project, the potential of this water network for slow and sustainable transport was rediscovered. The elements of the system, such as sluices and piers, are reinterpreted as central public spaces, reviving their historical social and functional roles within the landscape.



Fig. 18
The boat, serving as a museum, library, shed, and viewing platform, navigates the landscape, fostering an ongoing dialogue with the surrounding landscape that intensifies at each stop. Adapted from Chen (2023b).



Fig. 19
Map of the design area illustrating the boat's navigational route through the peat landscape, including all designated stops and associated activities. Adapted from Chen (2023b).

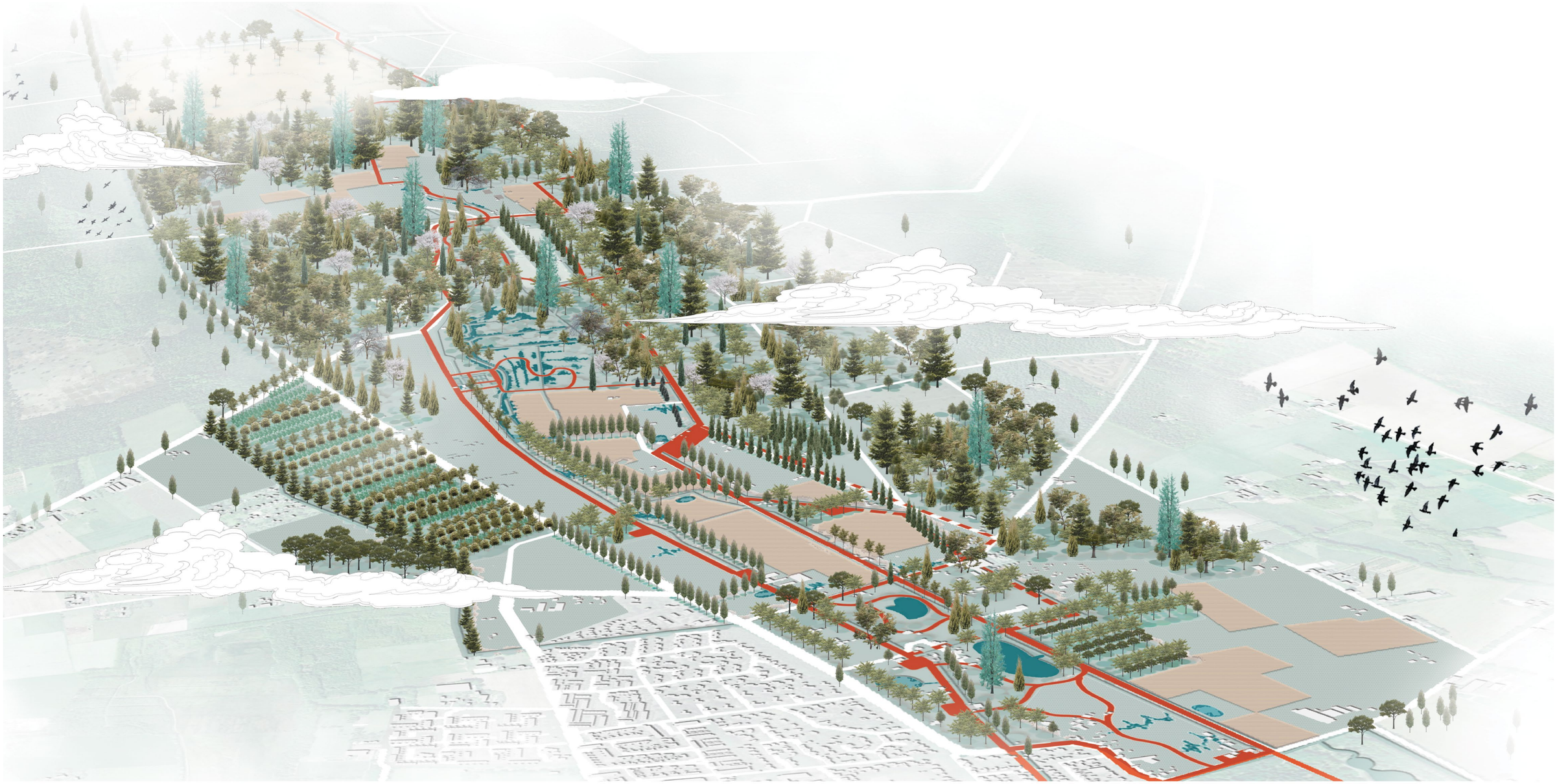


Fig. 17
The axonometric illustrates numerous water elements that form part of the Sprengen system. Carefully designed pathways reveal the system's historical function and structure and highlight the contemporary value of clean water for both natural ecosystems and renewed agricultural practices. Adapted from Jiang (2022b).

REVIVE THE SPRENGENBEEK LANDSCAPE

The human-made streams of the Sprengen System in the Netherlands are still in place and have been rediscovered by local historical organisations who step-by-step restore them, demonstrating the cleverness of people to pull the water out of the mountain and use its flow to gain energy. Because the water quality is excellent, people can touch it and feel its freshness and cooling effects. Waterworks, mills, and dams have vanished, but are partly reestablished as nice elements in the landscape, clarifying the former system. The project, *Revive the Sprengenbeek Landscape: Integrating a heritage water system into the renewed circular agricultural landscape at Vaassen, Veluwe* (Y. Jiang, 2022b), uses the system's understanding to accelerate the transformation of today's farming practices by diversifying the forest and crops in agricultural fields, ensuring that more water is stored and can infiltrate into the soil. (Figure 17)

Sprengen will be maintained as needed for production. Moreover, keeping Sprengen will benefit specific vulnerable and pristine ecological biotopes that are typical of the area's water quality and soil conditions. In the design, the Sprengen System served as a driver for ecological production.

Lessons to learn: The invention of the Sprengen System enabled the use of flowing water for milling, making it possible for the thriving paper industry to rise. Building upon this system, sustainable agriculture and the support of rare ecological habitats now offer a renewed interpretation of its value, one that emphasises the high quality of the water it provides.

REVEALING ROME'S WATER-BASED CULTURE

The project *Revealing Rome's Water-Based Culture: a resilient, dynamic and interactive layer* (Di Nicola, 2020b) draws inspiration from the ancient Roman understanding of water management.

Over centuries, the inhabitants of Rome, a city founded initially on marshlands, developed a technologically advanced society that coexisted with water in sophisticated ways. As the city expanded, the increasing water demand necessitated sourcing from the surrounding landscape. Water is transported over long distances via aqueducts and used for alimentary, sanitary, and recreational purposes. Today, however, water infrastructure is largely hidden from view, and many residents take the supply for granted, unaware of Rome's exceptional hydraulic legacy. In the face of contemporary climate challenges, such as intensified flooding and drought, and a city that does not act on them, the contrast with the ingenuity of ancient water management is striking. In response, the student mapped the remnants of Rome's historic water infrastructure within the city's historical centre, including the ruins of bathhouses, ponds, fountains, and statues. Surprisingly, many of these elements still exist, but are hidden and disconnected, both physically and culturally. When designing a water experience path within a selected area, the project re-establishes these connections by linking historical water features with newly introduced elements, such as infiltration zones and collection basins, designed to mitigate flooding and support urban cooling through vegetation. This project addresses contemporary environmental challenges and reactivates Rome's water heritage as a visible, functional, and educational part of the urban fabric. (Figure 20)

Lessons to learn: The project ensures the continuity and renewed relevance of this cultural legacy by uncovering Rome's historical water-based culture and enhancing it by transforming existing elements and introducing new ones.

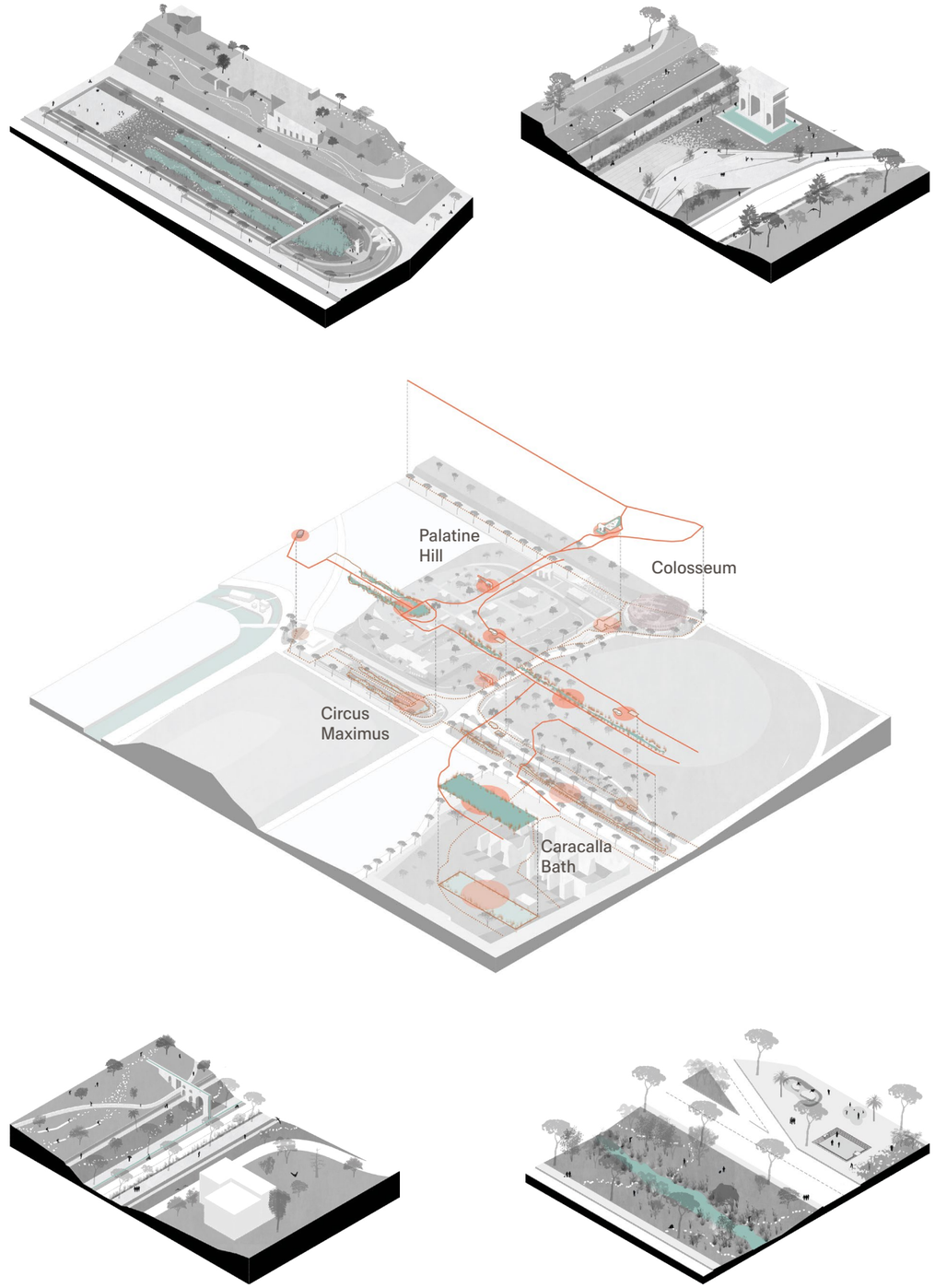


Fig. 20
A network of pathways connects historical and newly introduced water elements, which have been transformed into public spaces for rest and recreation, while offering opportunities to engage with and learn about Rome's rich, innovative water history. Adapted from Di Nicola (2020b).

EXPERIMENTATION

Students begin their graduation project by selecting a design site and identifying its specific environmental and spatial challenges. In response to these challenges, they selected a traditional water system case, either in its entirety or in part, that offers relevant insights for the selected context. This case study provides a foundation for experimentation, allowing students to explore how historical water management principles can inform innovative, site-responsive design interventions.

In addition to analytical research, experimentation is also an integral component of the design process. Through the interpretation and transformation approach, students engage in on-site experimentation with various elements of the traditional water system to explore how to restore, adapt, and expand it. This process allows them to assess what aligns with spatial composition and performs best from a technical standpoint. Experimentation is central to the projection approach as it encourages the emergence of unexpected insights and innovative ideas. It is inherently iterative, and involves cycles of conception, testing, and evaluation. Reflections arising from these cycles provide successive design proposals and refinements. Design experiments can occur at any process stage and address various concerns, including spatial composition, materiality, functionality, contextual integration, temporality, and beyond.[7]

The projection approach embraces experimentation to generate innovative design solutions grounded in the traditional water system knowledge derived from their case studies. This method challenges them to reinterpret and recontextualise historical practices in response to contemporary and future challenges. In several of the designs discussed in this case, the *Untold Waters*, traditional upstream water systems initially developed for agricultural purposes, are extended and adapted to structure downstream settlement areas, reintroducing and reimagining lost practices relevant to the design site. In the *Living with Drought Prone Landscapes* project, a traditional water system from a dry region is projected and tailored to a different yet increasingly drought-prone context on another continent as a proactive adaptation strategy. Two student projects that exemplify the projection approach are examined to illustrate how valuable insights can be drawn from traditional water systems: *Untold Waters* in South Africa and *Living with Drought-Prone Landscapes* in Rwanda.

UNTOLD WATERS

The practice of slowing, diverting, and utilising floodwaters to moisten soil has been developed across various cultures and environmental contexts, resulting in diverse and site-specific water management strategies. These approaches have demonstrated long-term sustainability mainly because of the deep local understanding of natural cycles and landscape dynamics, particularly among farming communities. In contrast to many contemporary solutions, which often depend on mechanised and linear infrastructure, traditional methods emphasise a hands-on approach. This approach prioritises direct human involvement, care, and application of local knowledge over purely engineered interventions.

In the project *Untold waters: Regrowing a coextensive urban riverine landscape through flood mitigation and rehabilitation strategies, South Africa* (Vollmer, 2025b), this hands-on methodology is central to the design. The project emerged through an iterative process of sketching and site-based thinking, which is particularly appropriate for the context of Sir Lowry's Pass River. Here, informal settlements on the riverbed represent a vulnerable community struggling with the challenges of daily survival. The project responded to these conditions through a deeply site-responsive and community-engaged approach to water and landscape resilience.

Recognising that human and nonhuman patterns in this context cannot be rigidly designed or imposed, the project adopts a similarly flexible and adaptive approach. This allows space for continuous experimentation, transformation, growth, and individual agency. Drawing inspiration from the Saaidamme water system on the opposite side of the mountain range, this project introduces simple water infrastructure and maintenance practices as fixed landscape elements. These interventions serve not only to guide the flow of water but also to provide a foundational framework upon which dynamic, unpredictable processes and narratives can emerge, evolve, and shape future landscapes. (Figures 21, 22 and 23)

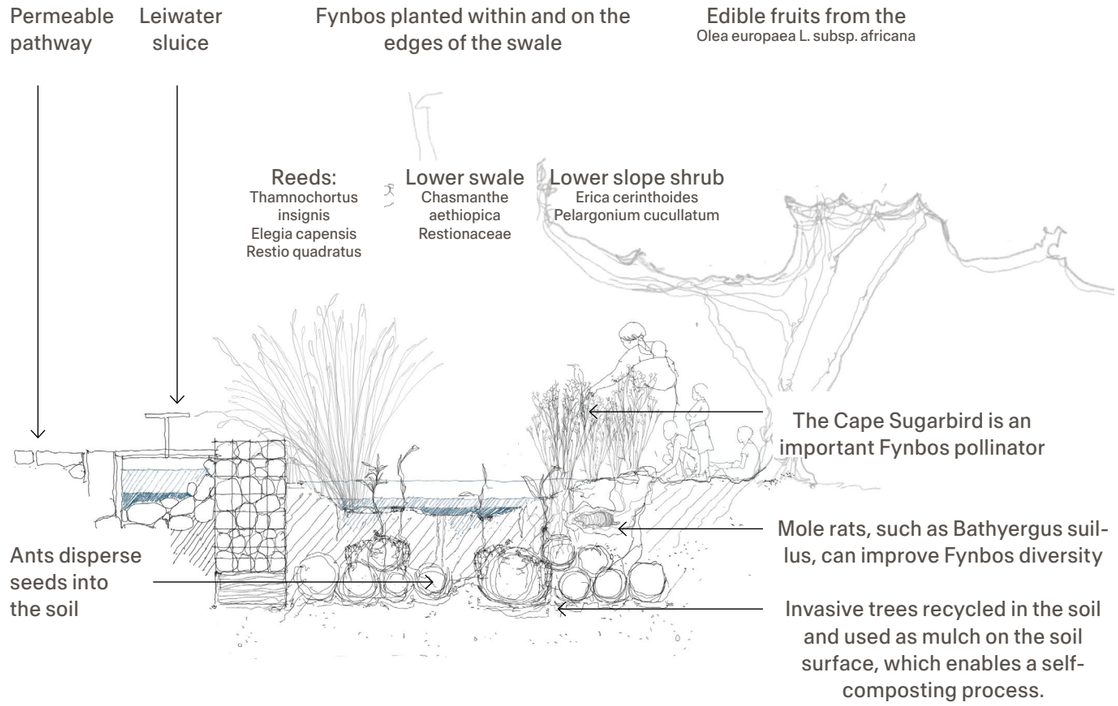


Fig. 21
The designed detail section illustrates a sheared water channel (positioned to the left) in conjunction with a swale—a shallow, engineered drainage feature intended to capture and manage surface water runoff, and elements of soil rehabilitation. Various Fynbos species are introduced, serving as biological soil stabilisers and valuable botanical resources that can be sustainably harvested for medicinal properties. Adapted from Vollmer (2025b).

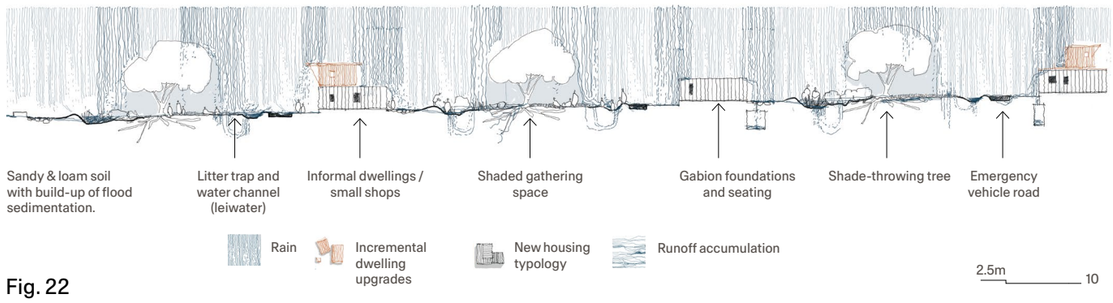


Fig. 22

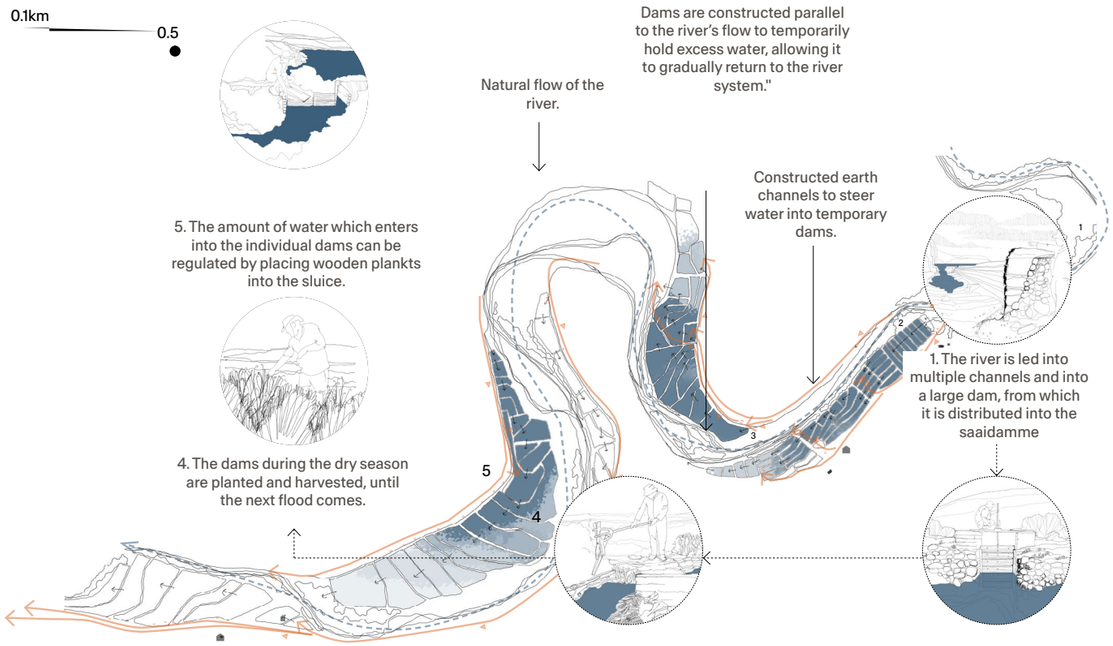


Fig. 23

Fig. 22
The village's relief is adapted through Saaidamme techniques to integrate water into its surroundings, protect houses from flooding, and capture rainwater in the swales. Adapted from Vollmer (2025b).

Fig. 23
Map of the Saaidamme built on Witkleigat farm in the Northern Cape, South Africa, illustrating the flow of water and the filling of Saaidam basins during the Hantam River flood. Adapted from Vollmer (2025b).

Lessons to Learn: The Saaidamme water system is a seasonal and manually operated system that relies on the active involvement of water workers for its functioning and maintenance. Water from the river is directed into a series of compartments by opening and closing sluices, forming temporary dams, and requiring the regular dredging of channels. This system is managed through direct on-site observation, reflecting an intimate and responsive relationship between humans and water. This close interaction forms the conceptual foundation for a design project, emphasising the value of human engagement in sustainable water management. The traditional water system also inspired the project's use of materials and techniques.

LIVING WITH DROUGHT PRONE LANDSCAPES

The *Living with Drought Prone Landscapes: Spatial Design Interventions for Rain and Dry Season Mitigation Systems in Ryabega* (Delobbe, 2024) demonstrates a compelling example of the experimentation approach. In this graduate thesis, the designer explored a nature-based water management system for an arid region, aiming to capture every drop of rain. Drawing on traditional knowledge from the Khadin Water System in Rajasthan, India, these principles are transferred to the Intara y'Iburasirazuba Plateau near Ryabega, Africa. The impression of the design site remains lush but exhibits signs of ecological decline, floods, and droughts. Contemporary water systems in the region are becoming increasingly inadequate in the face of escalating climate extremes, placing pressure on agriculture and local livelihoods.

In response, a design is proposed that integrates lessons from the Khadin system to create an infrastructure capable of mediating between rainy and dry seasons. This initiative is implemented incrementally in collaboration with local NGOs that engage community members in one of the country's most impoverished areas.

The community can proactively prepare for droughts and flooding by initiating the project immediately. The proposed system comprises small-scale interventions near individual households complemented by a larger regional infrastructure to facilitate rainwater infiltration into the soil. Strategically placed basins collect water for irrigation and capture sediment, which can then be used as natural fertilizers to restore and support agricultural cycles. Revised planting schemes have been introduced to enhance groundwater recharge and provide shade, thereby reducing the surface evaporation. (Figure 24 and 25), respectively.

Over time, the crop palette has gradually adapted to evolving climatic conditions, supporting long-term agricultural resilience. By focusing on water and humidity conservation, improving soil moisture retention, and ensuring reliable access to drinking water, the project aims to be locally sourced and community-built. Ultimately, it seeks to enhance Ryabega's

Fig. 24
The new water system implemented across the landscape. Adapted from Delobbe (2024).



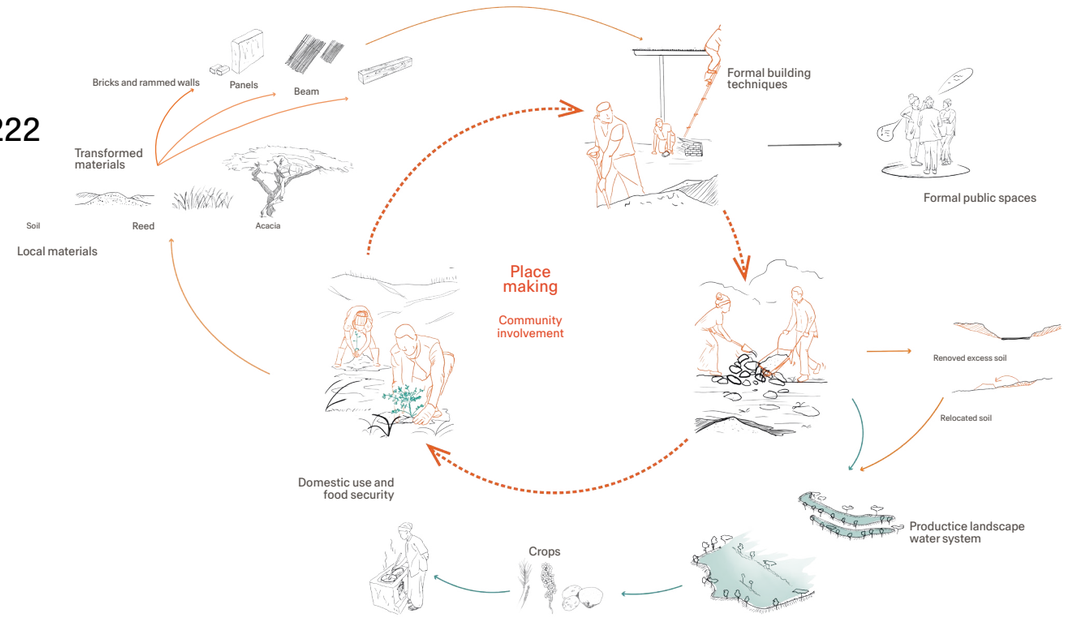


Fig. 25
The newly implemented design elements are grounded in principles of material circularity, emphasising the life cycles and provenance of materials. This approach highlights the narrative of each material—its origin, usage, reuse, and eventual reintegration into the environment or built system—thereby promoting sustainable design practices and resource efficiency. Adapted from Delobbe (2024).

water and economic autonomy, while reducing its vulnerability to climate change, drawing on practices already familiar in regions accustomed to similar environmental challenges. As these interventions take on a more architectonic character throughout the village, the quality and attractiveness of the public spaces are simultaneously enhanced. (Figure 26)

Lessons to Learn: By implementing a traditional water system from an arid region onto the design site in anticipation of similar climatic conditions, the project adopts a proactive strategy for environmental adaptation. It emphasises community involvement, as local inhabitants can construct and maintain the system and position capacity-building as a key component of long-term ecological resilience.

NOTHING NEW

In conclusion, to design a circular water story, it is essential to define and investigate the catchment area of the traditional water system and design site. A comprehensive understanding of the water cycle in this context is critical. This establishes a wider landscape framework in which water, land, ecosystems, settlements, livelihoods, cultural practices, and institutions interact. This landscape-based approach provides a grounded basis for addressing contemporary water challenges. Moreover, identifying water sources, mapping flow paths, and assessing precipitation levels, whether rainfall or snowfall, are crucial for understanding the context. Additionally, it requires analysing evaporation and transpiration rates, the morphology of water bodies, patterns of water use, and interactions among surface water, groundwater, and soil conditions were analysed.

Traditional water systems are nothing new, but they are a reminder that we do not need to reinvent the wheel when dealing with the growing impacts of climate change. The analysis revealed that long-lasting water systems offer rich, site-specific, and climate-responsive technical knowledge, complemented by a nuanced understanding of the social, ecological, and economic dimensions that have developed over time. The spatial patterns and forms of these human-made systems emerge from a deep-rooted sense of place

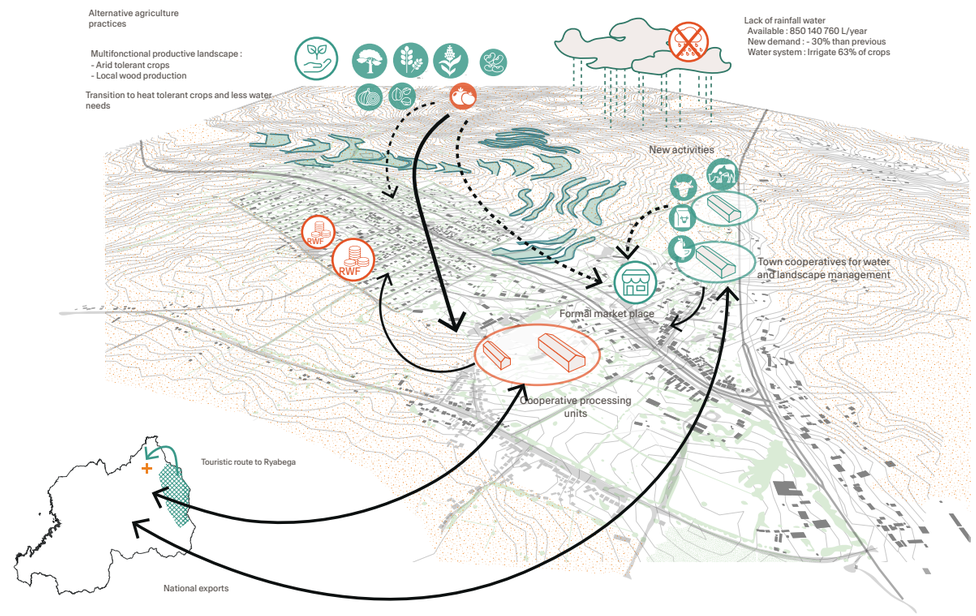


Fig. 26
The proposed design enhances the local village economy by integrating various productive activities. These include establishing acacia forests for timber and related products and developing dairy farming, poultry and beef production, and ecotourism initiatives. Collectively, these interventions aim to diversify income sources and promote sustainable rural livelihoods. Adapted from Delobbe (2024).

and are governed by underlying, systemic spatial logic. Engaging with these case studies fosters a critical awareness of the vital, yet often neglected, role of water in contemporary society.

The graduation projects illustrate that studying traditional water systems enables students to develop design approaches that acknowledge and respect the interconnections between water, the environment, and local cultural practices. Moreover, attending to ecological processes and temporal changes is essential to creating spatial interventions that are both resilient and environmentally responsible. Depending on the specific project site, the integration of elements, such as water filtration technologies, flood management infrastructure, or existing industrial facilities, may be part of the design. However, the inclusion of such interventions must be critically assessed, supported by well-substantiated reasoning, and thoroughly evaluated for their long-term impact on the landscape.

Perhaps the most profound insight gained from laboratory exploration is the renewed recognition of our responsibility to care for water as a valuable life-sustaining element. Traditional practices remind us that site-specific stewardship was integral to human survival. Long-lasting systems embody a way of life centred on a symbiotic, often also a spiritual relationship with water and, more broadly, with the natural world.

NOTES Lessons to Learn

1. Locals who gained knowledge by doing and living on a specific site for a long time.
2. https://circularwaterstories.org
3. Definition: Interventions that use the natural functions of healthy ecosystems also provide numerous economic and social benefits.
4. See *Grand Projects: Water as Infrastructure*.
5. A Sprengen System is a historical Dutch water management technique that uses artificial springs (called *sprengen*) to supply water for industrial or agricultural use, particularly for powering watermills. The springs were generated by piercing the slope and revealing groundwater to the surface.
6. A water management system in the Dutch delta designed to drain excess water from low-lying areas known as *polders* into a higher-level called the *boezem* network. From the *boezem*, water is further discharged into even higher external bodies, such as rivers or the sea. This system uses a series of pumps, canals, and sluices to manage water levels and prevent flooding in reclaimed land below sea level.
7. The experimentation definition is based on course description methodology (2024–25) of the master track of Landscape Architecture, TU Delft.

Part IV

Look It Up

Overview of Projects:
Climate, Soil and More

References

About the Authors

NAME AND COUNTRY	*	WATER TYPE		MAIN WATER ORIGIN			SOIL TYPE					SOIL TYPE				TECHNIQUE						USE						NO.
		fresh	saline	ground	surface	rain	sand	silt	caly	loam	alluvial	organic	volcanic ash	permable stone	solid rock	drainage	irrigation	pass on	infiltration	collection	retention	food production	domestic	energy production	transportation	ritual	others	map page 4/5
TROPICAL	(A)																											
Kampung Naga System, Indonesia	Af	■			■	■							■				■			■	■		■			■		26
Kuttanad Kayalnilam Agrosystem, India	Am	■	■	■	■	■	■			■						■	■								■			19
Angkor Wat Hydraulic City, Cambodia	Aw	■		■	■	■	■		■								■	■		■	■		■		■	■	defence	27
Yangpu Ancient Salt Field, China	Aw		■		■		■		■						■		■					■				■	salt	30
ARID	(B)																											
Jaguaribe River Basin, Brazil	BSh						■		■	■																		16
Qanat System of the Menara Gardens, Morocco	BSh	■		■					■	■							■			■	■		■		■	■	cooling	10
Hantam Saaidamme Irrigating System, South Africa	BWk	■			■	■		■	■								■		■	■		■						1
Khadin Water System, India	BWhw	■			■	■	■		■	■												■	■		■			22
Sultanate Waterworks of Delhi, India	BSh	■		■		■	■				■			■			■	■	■	■	■		■			■	defence	20
Fort Water System and Stepwells, Jaipur, India	BSh	■		■		■	■			■								■		■	■		■			■		21
Turpan Karez Water System, China	BWk	■		■			■								■		■	■		■		■	■					24
TEMPERATE	(C)																											
Chinampas Agrosystem of Xochimilco, Mexico	Cwb	■			■	■						■								■							new land	17
Amunas System of the Sierra de Lima, Peru	Cwb	■		■						■		■			■		■	■		■	■		■					18
Watermills of the Sierra de Cádiz, Spain	Csa, Csb	■			■	■		■			■						■	■			■			■				11
Watermills of the Rascafría, Spain	Csb	■			■	■	■								■		■	■			■		■	■				12
Harnham Water Meadows, England	Cfb	■			■	■		■						■		■	■			■								13
Canal du Midi, France	Csa	■			■		■	■	■	■				■			■	■			■				■			9
Sprengen System of the Veluwe, the Netherlands	Cfb	■		■		■	■		■								■				■			■				14
Polder System of Zaanstreek, the Netherlands	Cfb	■	■	■	■	■			■			■				■								■				15
Valli da Pesca Aquaculture System, Italy	Cfa	■	■		■		■	■		■														■				7
Roman Aqueducts, Italy	Csa	■		■		■								■			■	■		■			■			■		6
Sassi di Matera Water Harvest System, Italy	Csa	■			■	■								■				■		■	■		■					5
Navigli, Italy	Cfa	■			■		■	■	■					■			■	■		■					■			8
Street Communal Fountains, Cyprus	Csa	■		■										■				■		■	■		■				drinking	2
Water System of Heraklion, Greece	Csa	■			■									■			■	■		■								3
Alyki Lagoon Maritime Water System of Lemnos Island, Greece	Csa, Csb		■		■			■	■											■							salt	4
Hiti Pranali Water Stone Spout System, Nepal	Cwa	■		■					■									■	■	■			■				drinking	23
Honghe Hani Rice Terraces, China	Cwb	■			■	■	■	■									■	■	■	■						■		28
Xinghua Duotian Agrosystem, China	Cfa	■		■	■				■							■	■			■					■			29
Linpan System, China	Cwa	■			■	■	■		■								■			■	■		■		■	■		31
Weiyuan Flood-Adaptive Agricultural System, China	Cfa	■		■	■	■		■	■							■	■				■							32
Farm Ponds of Taoyuan Tableland, Taiwan	Cwa	■			■	■			■								■	■		■			■			■		34
Ksôkong Tsùn Farming System, Taiwan	Cwa	■		■	■	■	■	■	■								■	■	■	■	■				■			33
Saga Irrigation System, Japan	Cfa	■	■		■	■		■	■							■	■			■			■					35
Budj Bim Eel Aquaculture System, Australia	Cfb	■			■				■				■		■					■	■					■		25

* Köppen climate classification
Af Tropical rainforest
Am Tropical monsoon
Aw Tropical savana
BSh Hot semi-arid
BWk Cold dessert climate
BWhw Hot dessert with winter dry season
Cwb Subtropical highland
Csa Hot-summer mediterranean
Csb Warm-summer mediterranean
Cfa Humid subtropical
Cfb Oceanic or humid subtropical with year-round moisture
Cwa Monsoon-influenced humid subtropical
fish
crops
cattle farming

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Part II Traditional Water Systems

Vanishing Waters: Loss, Transformation, and Resurgence of Water Systems

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Feeding Waters: Emerging Perspectives on Traditional Agricultural Landscapes

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

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Part III Circular Water Stories in Practice

Co-design: Through Visualising Waterscapes

Catalina Rey-Hernández

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Stories from Akalapuzha: Reading Rivers as Systems and Places

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About the Authors

The name *Circular Water Stories* emerged from preliminary research conducted in collaboration with Susanne Loen and Maki Ruy.

Over the past seven years (2019–2026), many former and current students, researchers, and teaching colleagues have contributed, both directly and indirectly, to the development of the Circular Water Stories lab. We want to thank the second mentors of the graduation projects conducted within the lab, whose guidance also helped students translate knowledge gained through the study of traditional water systems into thoughtful and inspiring design proposals. We are also deeply grateful to Michiel Pouderoijen, whose GIS expertise was instrumental in enabling students to develop the detailed maps that became an essential part of their research and design work. These collective efforts have been invaluable to the development of both the lab and this publication.

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Contributors, accompanied by a biography in this volume, have either authored the essays or played a key role in developing and shaping the intermezzi.

Readers interested in exploring further work developed within the Circular Water Stories lab are invited to visit the Circular Water Stories website: https://circularwaterstories.org. *In addition to the projects featured in this publication, the website presents subsequent student work and will continue to document the evolution of the research as the lab develops.*



Bobbink, Inge

Dr ir. I. Bobbink,
Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands,
i.bobbink@tudelft.nl
0000-0002-3130-7369

Bobbink, Inge has been an Associate Professor in the Section of Landscape Architecture, Department of Urbanism, Faculty of Architecture and the Built Environment at Delft University of Technology (TUD), the Netherlands, since 2007. She holds a post-master's degree from the Berlage Institute and a PhD from TUD. In cooperation with others, she developed and coordinated, from the start of 2010, the educational program for the master track of Landscape Architecture. She teaches and supervises master and PhD students, lectures internationally, coordinates the graduate studio and other courses, serves on the education management team, and participates in diverse advisory boards. She is the founder of the Circular Water Stories lab. Her research focuses on identifying landscape-architectural and sustainability values in (traditional) water systems worldwide. The goal is to learn from the past and transform that knowledge for today's design challenges. Good mapping and drawings are crucial in this regard and require close attention. Therefore, developing an illustrative method and researching how to draw time as a design tool are ongoing topics in her research. In collaboration with colleagues, alumni, and students, various books and articles bear witness to this agenda.



Veras Morais, Monica

Dr ir. M. Veras Morais,
Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands,
M.VerasMorais@tudelft.nl
0000-0002-0223-7429

Veras Morais, Monica is a Brazilian researcher based in the Netherlands. She graduated in Landscape Architecture from Delft University of Technology (TUD), Faculty of Architecture and the Built Environment, within the Circular Water Stories lab (2020). Her work today explores shared landscapes through the evolving interplay of design, governance, and social-ecological systems. She approaches landscape architecture as a situated, time-based, and relational discipline, exploring how humans and non-humans jointly shape landscapes and contribute to their reimagining. Her research spans a range of contexts, from residential gardens and urban interstices to peri-urban territories. Her doctoral research at TUD examined the long-term transformation of shared residential gardens, leading to the development of design principles that support evolving social and ecological needs. More recently, she explored networks of urban leftover spaces as sites of multiple forms of inhabitation through the project Everyone's Land: Reimagining Urban Interstices for the More-than-Human. Currently, she is a postdoctoral researcher at TUD on the project FAIR: Fostering Water Circularity in Peri-urban Landscapes, in cooperation with Inge Bobbink, colleagues from Vienna, Austria and Florence, Italy, co-designing circular water strategies for European peri-urban regions and exploring how water, as a shared landscape resource, drives spatial transformation.



Chouairi, Amina

Dr ir. A. Chouairi,
Landscape Architecture and Spatial Planning, Wageningen University & Research, the Netherlands,
amina.chouairi@wur.nl
0000-0003-3218-0782

Chouairi, Amina is an Italian Moroccan landscape architect based between the Netherlands and Italy. She graduated at Delft University of Technology (TUD) in the Faculty of Architecture and the Built Environment in the Netherlands in Landscape Architecture (2020) and was part of the Circular Water Stories lab. She is a lecturer in Landscape Architecture at Wageningen University & Research and holds a PhD in Urbanism from Università Iuav di Venezia. Her practice centres on transitional wet territories, interrogating their contested epistemological, ontological and ethical matters from a landscape architecture perspective. Her doctoral thesis discusses the agency of the barene (brackish marshes) in the Venice Lagoon landscape and their urgent call for restoration. It acknowledges their role in unveiling and rethinking Venice as a city in a landscape, a fluid 'Venice-in-a-Lagoon'. Chouairi actively raises public awareness by showcasing overlooked areas of the Venice Lagoon through curated talks, symposia, and landscape explorations, among other formats. She has given guest lectures at, among others, the AA London, TUD, TU Munich, Ghent University, Université Libre de Bruxelles, the University of Virginia, and the National Institute of Technology Calicut. She was a finalist for the Canadian Centre for Architecture-Mellon Research Program, In the Hurricane, On the Land. Her research has been exhibited at the 10th International Architecture Biënnale Rotterdam, It's About Time and the 19th International Architecture Exhibition Biennale Architettura Intelligens. Natural. Artificial. Collective.



Ali, Naeema

Ir. N. Ali, Witteveen+Bos, United Arab Emirates
naeema.ali9@gmail.com
0000-0002-3498-3397

Ali, Naeema is an Indian landscape architect and climate resilience strategist specialising in nature-based solutions and water resilience. She currently works as a Project Manager at Witteveen+Bos, delivering multidisciplinary projects across Asia, Africa, the Middle East and the Netherlands. Over the past six years, she has shaped landscape-based approaches that translate climate and nature ambitions into decision-support frameworks, master plans, implementation roadmaps, capacity-building initiatives and investment strategies. Her work focuses on helping governments and development partners identify interventions that restore natural systems, strengthen local livelihoods and support nature-positive enterprises. She has contributed to initiatives connected to Baku 2040, Saudi Vision 2030, East Africa Marine Transport and the Dutch Develop2Build Grant Programme. As a researcher with *Circular Water Stories* and *Lo-TEK Office*, she collaborates with Indigenous researchers and communities to document locally rooted water-management practices and knowledge systems. She previously served as a Junior Rapporteur at World Water Week. Her experience across governments, businesses and communities has made her a strong advocate for bridging international finance and local environmental stewardship. Naeema holds a bachelor's degree in architecture from the National Institute of Technology, Calicut, India and a master degree in Landscape Architecture (2020) from Delft University of Technology (TUD), the Netherlands. She graduated from the Circular Water Stories lab, where she developed an integrated water management approach to landscape architectural design, using the case of the below-sea-level Kayalnilams in Kerala, India. This project, 'Land can sometimes be Water', was exhibited in the London Design Biennale, 2021, inside the India Pavilion.

Armoutaki, Emmanouela Maria

Ir. E. M. Armoutaki, Department of Environmental Structures, Directorate of Engineering Projects, Iraklion Regional Unit, Crete

Armoutaki, Emmanouela Maria is a Greek architecture engineer, currently working for the Department of Environmental Structures at the Directorate of Engineering Projects in Iraklion Regional Unit, Crete on public building projects. She holds a Master of Science in Landscape Architecture from Delft University of Technology, the Netherlands and a Bachelor of Science and a Master of Architecture in Architecture Engineering from the School of Engineering of Democritus University of Thrace, Greece. Her graduation project 'Yofyros. A river beyond banks', focused on revealing and redefining a river landscape and the locals living with water, connected to the place's water-related memories and traditions. She conducted het graduation project in the Circular Water Stories lab (2022). Armoutaki's primary professional experience on a wide range of projects, such as housing, playgrounds, and the restoration of historical heritage, progressively oriented her towards designing collective spaces open to everyone while incorporating their natural, cultural, and historical backgrounds.

Bazrafkan, Farnoosh

Ir. F. Bazrafkan, Echo Urban Design, the Netherlands

Bazrafkan, Farnoosh is a landscape designer based in Amsterdam with a master's degree in Landscape Architecture from Delft University of Technology, the Netherlands. She conducted her graduation project 'From ambiguous borderscapes to pluralism: An alternative landscape representation as a way of integrating 'nature' and 'culture' around the Hunze valley' in the Circular Water Stories lab (2022). Her interest lies in an interdisciplinary understanding of the landscape, between the natural world, cultural context and architecture as a human endeavour. She has long been inspired by biophilic theory and, in her work, seeks to ensure that people have exposure to and interaction with green environments and living ecosystems, and to unearth new connections, through research and design, between nature, cities and our place within them. Farnoosh currently works as a landscape and urban designer in Rotterdam, contributing to new residential projects and urban transformations where different scales, disciplines, and users intersect.

Bhagyanathan, Anjana

Dr Anjana Bhagyanathan, Department of Architecture and Planning, National Institute of Technology Calicut, India
0000-0002-2596-7619

Bhagyanathan, Anjana is a landscape architect, researcher and educator, and Assistant Professor in the Department of Architecture and Planning at the National Institute of Technology Calicut. Her work explores the intersections of nature, culture and spatial design, with emphasis on sacred groves, traditional landscapes, riparian systems, urban ecology and climate resilience. She engages with landscape urbanism practice, integrating ecological processes into urban design and planning frameworks. She leads interdisciplinary research on local ecological knowledge, environmental attitudes, deep ecology and sacred geography, translating traditional ecological knowledge into planning and nature-based solutions. Her publications examine the spatial logic and ecological significance of sacred landscapes, including their role in headwater and riparian conservation along the Malabar Coast. Through teaching, research and collaborative projects, she seeks to develop culturally grounded approaches to landscape restoration, water security, biodiversity conservation and resilient human settlements in India. She collaborated on the workshop Circular Water Stories, which is documented in the essay Stories from Akalapuzha.

Chandna, Anubhuti

Ir. A. Chandna, Architect and Urban Designer Stuttgart, Germany

Chandna, Anubhuti is an architect and urbanist specialising in sustainable spatial development and energy transition, trained in architecture in India and holding a master's in Urbanism from Delft University of Technology (TUD), the Netherlands. She graduated in Urbanism (2019) and became part of the Circular Water Stories lab out of interest. Chandna combines systems thinking, design, and visual communication to address complex spatial challenges. Now based in Germany, she previously spent five years in the Netherlands as a project leader and spatial designer at Generation. Energy, where she led integrated spatial–energy projects at regional and municipal scales. Her work bridges policy and design, using scenario building and serious gaming to support collaborative decision-making in the energy transition. Earlier, as a research fellow at the Charles Correa Foundation, she examined building crafts and heritage in Goa, and her formative experience with B. V. Doshi deepened her understanding of architecture's social and cultural dimensions.

Ching Chen, Keng

Ir. K. Chen, Economic Affairs Department, Yilan County Government, Taiwan (R.O.C.)

Ching Chen, Keng works as an assistant in the County Government of Yilan, Taiwan and is also a designer and passionate researcher. He holds a master's degree focusing on the Dutch lowlands and their potential futures, particularly the polder landscapes and their engaging character. After graduating from Delft University of Technology (TUD) in the Faculty of Architecture and the Built Environment, the Netherlands, within the Circular Water Stories lab (2023), he returned to Taiwan to work as an independent researcher, drawn to the river delta and its traditional water systems while exploring their renewed meanings today. His interests include participatory research, and with support from the NHBOS Institute (2024, Talent grant), he applies multi-method approaches to study public perceptions of landscape. As a government worker, Chen is enthusiastic about lobbying for funds for landscape projects, promoting farsighted visions, and acting as an intermediary among officials, designers, NGOs, and the public. He believes that, in addition to political means, serving people and the country is best achieved through environmental quality, thoughtful spatial design, robust communication, and cooperation.

Filippoli, Nicole

Ir. N. Filippoli, SAP Studio Architettura & Paesaggio, Italy,
0009-0008-6006-8775

Filippoli, Nicole is a junior landscape architect based in Bergamo, Italy. She earned a bachelor's degree in architectural design from the Politecnico di Milano and a master's degree in Landscape Architecture from Delft University of Technology (TUD), taking part in the Circular Water Stories lab (2023). Currently working at Studio Architettura & Paesaggio (SAP) in Bergamo, Filippoli focuses on projects that merge ecological restoration, urban design, and community resilience. Her recent work includes the landscape design for the restoration of the Geirato stream in Liguria, integrating nature-based solutions and adaptive strategies to mitigate flood risks and enhance biodiversity. Believing that design can actively shape resilient and livable territories, she explores how landscape architecture can reconnect people and place through ecological awareness and spatial innovation. Filippoli is also a member of the Associazione Italiana di Architettura del Paesaggio (AIAPP), which is affiliated with the International Federation of Landscape Architects Europe (IFLA Europe).

Liang, Wanning

Ir. W. Liang, volunteer, Qiandao Lake Water Source Project of the Water Fund in collaboration with The Nature Conservancy (TNC), China

Liang, Wanning holds a Master of Landscape Architecture from Delft University of Technology (TUD), the Netherlands (2023). Her research done in the Circular Water Stories lab explores how traditional water systems can inspire adaptive solutions for contemporary water challenges, with a focus on the Amunas system in the high Andes of Peru, a method of groundwater recharge that channels mountain streams into hillsides. She approaches water management through the lens of cultural-ecological dialogue, emphasising the reciprocal relationship between communities and their watersheds. By reinterpreting ancestral practices through contemporary design, Wanning seeks to create landscapes that balance ecological resilience with cultural continuity, transforming water infrastructure into spaces of shared memory and innovation. Outside of academia, she is drawn to water in all its forms, whether tracing the edges of lakes on long hikes, or imagining the hidden stories carried by rivers to the sea.

Pingyao, Sun

Ir. P. Sun, Co-hab Design Consulting (Zhuhai) Co., Ltd. | CAA City Planning & Engineering Consultants Ltd., China,
0009-0003-0428-9470

Pingyao Sun is a Chinese urban planner, landscape designer, freelance researcher, and executive director of the start-up company Co-hab Design Consulting (Zhuhai) Co., Ltd. She holds a master's degree in Landscape Architecture from Delft University of Technology in the Netherlands and in Town & Regional Planning from the University of Sheffield in England. Between her studies, she gained 6 years of professional experience at the Zhuhai Institute of Urban Planning & Design, where she advanced to Project Manager and Urban and Rural Planning Engineer. Her passion for environmentally friendly design and the relationship between natural and cultural landscapes led her to pursue a degree in Landscape Architecture at Delft. During her graduation project in the Circular Water Stories lab (2022), she explored the UNESCO heritage site, the Canal du Midi, which deepened her interest in adaptive water design, cultural landscapes, and sustainable development. After graduation, she continued to enhance her expertise through entrepreneurship and ongoing research in her free time.

P K, Amritha

Dr Amritha P K, Department of Architecture and Planning, National Institute of Technology Calicut, India,
0000-0002-2503-7120

P K, Amritha is an architect and landscape architect currently serving as an Assistant Professor in the Department of Architecture and Planning at the National Institute of Technology Calicut, where she also earned her PhD. Alongside her academic career, Amritha has professional experience with internationally renowned firms, HOK in the United Kingdom and Cracknell in Dubai, where she collaborated with interdisciplinary teams to develop landscape design strategies that integrate ecological functions with vibrant, inclusive public realms. Her research and publications span sustainability, landscape urbanism, environmental planning, waste management, Landscape conservation and restoration, building on her doctoral research on productive urban landscapes. She coordinated the Kerala–Netherlands Water Dialogue Workshop on NIT Calicut's side, which brought together students and researchers from Kerala and the Netherlands to explore the riverscape using the Circular Water Stories methodology.

Pouderoijen, Michiel

M. Pouderoijen, Department of Urbanism, Section of Landscape Architecture, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands

Pouderoijen, Michiel is a full-time research and teaching assistant of Delft University of Technology at the section of Landscape Architecture of the faculty of Architecture in the Netherlands. He started his career in architecture while always being drawn to design at every scale. He has been involved for twenty years in cartographic research on a broad range of aspects of landscape architecture in the Netherlands and abroad. His specialisation in applying GIS methods and techniques has resulted in extensive knowledge of maps and digital spatial data, and of their applications in spatial research and design. Michiel followed the development of the Circular Water Stories lab and helped mapping the projects whenever his knowledge was needed.

Rey-Hernández, Catalina

Ir. C. Rey-Hernández, Department of Environmental Sciences, Wageningen University & Research, the Netherlands,
0009-0001-9516-1047

Rey-Hernández, Catalina is a Chilean architect and landscape designer with a special interest in resilient and nature-based solutions to create design alternatives for a sustainable future. She gained her master's degree in Landscape Architecture from Delft University of Technology (TUD), the Netherlands and was part of the Circular Water Stories lab (2019). She has worked as an architect in Chile and as a landscape designer in the Netherlands. Currently, Catalina is a PhD researcher in the Riverhood project at Wageningen University & Research, where she focuses on territorial design and counter-design in riverine landscapes. Her research aims to investigate how river management through landscape design and territorial planning has generated socio-material transformations that directly affect river communities and their livelihoods, generating local confrontations with imposed designs. Within this framework, she is particularly interested in investigating how these confrontations are supported through instruments of counter-designs and counter-cartographies.

Rivero-Lamela Gloria

Dr ir. G. Rivero-Lamela, Departamento de Ideación Gráfica Arquitectónica, Escuela Técnica Superior de Arquitectura de Madrid, Universidad Politécnica de Madrid, Spain,
0000-0002-8683-0704

Rivero-Lamela, Gloria is a faculty member at the Department of Architectural Graphic Ideation at the Polytechnic University of Madrid. Until 2025, Rivero was a faculty member at the Department of Architectural Projects at the University of Seville. She trained as an architect at the University of Seville (2014), where she received the Extraordinary End-of-Degree Award, and completed a master's degree in Architecture and Historic Heritage (2016). She obtained her PhD from the same university in 2020, with a dissertation focused on the form and territorial structure of hydraulic architectures linked to productive landscapes. She has completed international research stays at Delft University of Technology where she got involved in the work of the Circular Water Stories lab and the University of Porto, participated in several international congresses, and published numerous articles in indexed journals. Her research addresses territory, heritage landscape, rural architecture, drawing, mapping, and cartography. She serves on the editorial board of the scientific journal Proyecto, progreso, arquitectura.

Sánchez Jiménez, Javier

Ir. J. Sánchez Jiménez,

Sánchez Jiménez, Javier is an Architect (Madrid, 2018) and graduated in Landscape Architecture in the Circular Water Stories lab (2023) at Delft University of Technology (TUD), Faculty of Architecture and the Built

Design Assistant
Municipality Amsterdam,
the Netherlands

Environment in the Netherlands. His main interest is the potential of space for storytelling, with an emphasis on the complex relationship between history, culture, function and perception. Understanding the spatial disciplines as a continuum and their evolution as a concatenation of stories with largely happy endings, he believes in the importance of continuing this by building our own tale and facing the challenges of our time. Water is, thus, for him, one of the most important (landscape) architectural materials, and one whose proper handling will be the key to our future. His work includes private gardens, public spaces, and, most notably, the landscaping for the domes of the Pavilion of the Kingdom of Spain for the 2020 Dubai World Expo.

Surajaras, Rapa
Ir. R. Surajaras, OKRA Landscape Architects, the Netherlands

Surajaras, Rapa is a landscape architect with a strong interest in the relationship between water, people, and changing environments. Originally from Bangkok, Thailand, where water has long played an integral role in urban life and culture, her upbringing inspired an enduring curiosity about how societies can adapt to environmental challenges. In 2017, she moved to the Netherlands to pursue a Master of Science in Landscape Architecture at Delft University of Technology (TUD). During her studies, she participated in the Circular Water Stories lab (2019), an experience that influenced her graduation project on adaptive strategies for living with water in informal settlements in Vietnam. The project received the Blauwe Kamer–Kuiper-Compagnons Graduation Award 2019 and second prize from IFLA Europe. Currently, as a Senior Landscape Designer at OKRA Landscape Architects in Utrecht, the Netherlands, she brings professional experience to projects across Europe and beyond. Working across diverse cultural and environmental contexts, she applies a water-sensitive approach to create resilient landscapes, bridging research and practice to develop adaptive strategies that enhance the quality of life for communities, cities, and the environment.

Tri Prestasia, Ayu
Ir. A. Tri Prestasia, Landscape Architect at PT. Desain Konstruksi Narutama, Studio Dekona, Indonesia

Tri Prestasia, Ayu is an Indonesian landscape architect with a special interest in the intersection of ecology, culture, and spatial design. After working on hospitality landscape projects across Asia and the West Indies, she earned her Master of Science in Landscape Architecture (2019) from Delft University of Technology (TUD), the Netherlands. Her thesis, 'The Living Estuary', addressed coastal erosion in Ghana's Volta Delta through an integrated landscape approach that connected ecological, spatial, and socio-economic systems of local communities. Fascinated by the dynamic relationship between water, people, and place, Prestasia joined the Circular Water Stories lab after she graduated and published her research on Kampung Naga, Indonesia. As a research associate, she is currently involved in initiatives exploring adaptive design and equitable ecological transitions in Indonesian landscapes. Through her practice and research at the Indonesian Dream Design Studio, she continues to advocate for integrating traditional water wisdom into contemporary spatial development, envisioning resilient landscapes that reconnect nature and culture.

Verschuure-Stuip, Gerdy
Dr ir. G. A. Verschuure-Stuip, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands
0000-0001-8688-6372

Verschuure-Stuip, Gerdy is an Assistant Professor of Landscape Architecture at the Faculty of Architecture and the Built Environment of Delft University of Technology, the Netherlands. She is a trained architect and holds a PhD in Landscape Architecture on Dutch country estates. She is the Program Leader of the Leiden-Delft-Erasmus program Global Heritage and Development and departmental education manager for Urbanism. Her research and education centre on themes such as landscape architecture, heritage, participation, and landscape biography. She collaborates on European and Dutch research projects across a wide range of topics, advises on European and national agricultural policy and feminism, and organises co-creative workshops. In Delft, she teaches several BSc and MSc courses in the Landscape Architecture and Urbanism master tracks. At the University of Leiden, she teaches interdisciplinary BSc and Minor courses on Heritage Landscape Design and Participation in the master's program Applied Archaeology, funded by the National Cultural Heritage Agency. She is greatly interested in the work of the Circular Water Stories lab and open to contributing to.

Yan, Ran
Ir. R. Yan, Buro Sant en Co landschapsarchitectuur, the Netherlands
0009-0006-3775-641X

Yan, Ran is a landscape designer with a master's degree in Landscape Architecture from Delft University of Technology, the Netherlands, within the Circular Water Stories lab (2021). Growing up in a riverfront city, she developed a deep curiosity about the relationship between water, landscapes, and communities. This interest has shaped her perspective on how landscape design can influence ecological systems and cultural identity. She is particularly drawn to landscape biography, water systems, and planting design, exploring how these elements interact to shape both natural and built environments. Currently based in the Netherlands, she works as a landscape designer. Her work and research reflect a continuous exploration of how landscapes evolve, how people engage with them, and how design can respond to both environmental challenges and local narratives.

Yitang, Kao
Ir. Y. Kao Project Manager & Landscape Designer, Taiwan

Yitang Kao is a Taiwanese landscape architect with professional experience in therapeutic landscapes and hospitality landscape design across Taiwan, Thailand, Shanghai, and the Netherlands. Kao earned a master's in Landscape Architecture from Delft University of Technology, where she was part of the Circular Water Stories lab. Her thesis, 'Reviving Ponds in the Urban Network: Towards a Resilient Water Landscape for Taoyuan County, Taiwan (2021)' explored reconnecting historic pond systems and urban fabric to strengthen blue-green infrastructure for climate resilience and was recognized by the Taoyuan City Government. Currently, Kao is a spatial design and project management professional, integrating landscape architecture and construction management to deliver projects from concept through implementation.

Yuan, Yuan
Ir. Y. Yuan, Harbin Institute of Technology, China

Yuan Yuan is a Chinese landscape architect who focuses on ecosystem sustainability. After completing her undergraduate studies at Harbin Institute of Technology, she decided to pursue a master's degree in Landscape Architecture at Delft University of Technology in the Netherlands, where

she gained extensive experience and knowledge of excellent European design concepts and methods. During her studies in the Netherlands, she joined the Circular Water Stories (lab, where she researched the circularity of the traditional water system in Yunnan's Hani terraced fields (2022). She delved thoroughly into the sustainability of agricultural systems and the millennia-long symbiotic relationship between terraced fields and residents, highlighting the tremendous importance of traditional wisdom for modern water and agricultural systems. She is currently a PhD student at Harbin Institute of Technology in China, where she conducts scholarly research. Her research interests include ecosystem service planning and biodiversity, to provide scientific and systematic theoretical underpinnings for sustainable landscape design.

Circular Water Stories

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

EDITORS:
Dr ir. Bobbink, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands, i.bobbink@tudelft.nl, 0000-0002-3130-7369
Dr ir. M. Veras Morais, Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands, 0000-0002-0223-7429
Dr ir. A. Chouairi, Landscape Architecture and Spatial Planning, Department of Environmental Sciences, Wageningen University &Research, the Netherlands, 0000-0003-3218-0782
Ir. N. Ali, Witteveen+Bos, United Arab Emirates, 0000-0002-3498-3397

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REVIEWER:
Francesca Dal Cin, CIAUD – Research Centre for Architecture, Urbanism and Design, Lisbon School of Architecture, Universidade de Lisboa.

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CIRCULAR WATER STORIES

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

Circular Water Stories brings together the work of alumni and tutors of the Circular Water Stories lab, a graduation studio in the MSc Landscape Architecture programme at the Faculty of Architecture and the Built Environment, TU Delft, the Netherlands. Drawing on several years of academic and design research, the book explores how knowledge embedded in traditional water systems and their landscapes can be uncovered, understood, and brought into dialogue with contemporary design.

At the heart of the book is the *Illustrative Method* developed by Bobbink and colleagues over years of teaching and lab research. Through drawings, maps, photographs, and other forms of visual storytelling, the method makes visible the spatial, social, and cultural relationships that shape water systems. It enables these systems to be read and compared across diverse geographical and cultural contexts, bringing to light relationships and forms of knowledge that have often remained spatially undocumented.

The book presents a rich collection of field-based case studies, original drawings, maps, and photographic interpretations. Its thematic chapters trace water across time and terrain, revealing the intricate connections between landscape, water, heritage, community, and design.

Circular Water Stories invites designers, landscape architects, students, academics, policymakers, local communities and other water practitioners to look beyond water as infrastructure to discover the cultural and spatial knowledge it holds. By revealing these stories, the book opens new perspectives on how inherited practices and long-term relationships with water can inform contemporary design and contribute to more resilient, situated, and sustainable water landscapes.