BLUE PAPERS

Water & Heritage for Sustainable Development

Edited by Carola Hein, Matteo D'Agostino, Carlien Donkor & Zuzanna Sliwinska

Leiden-Delft-Erasmus Universities

2024 (Vol. 3 No. 1)

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Journal Description

Blue Papers: Highlighting the Critical Role of Water and Heritage in Sustainable Development

Water in all its forms is key to human survival and well-being. Humans have created intricate and ingenious solutions to survive and thrive in difficult and complex territories, and adapt to changes in social and environmental conditions. Remnants of past practices, structures and objects are still with us – in the built environment, in our institutions, in our ways of living and in our languages. Sometimes we call these objects and practices heritage, but more often they are so much a part of our everyday lives that we take them for granted.

As emphasized in the *UNESCO Thematic Indicators for Culture in the 2030 Agenda,*[1] culture is an important part of the Goals and Targets of the 2030 United Nations' Agenda for Sustainable Development. Stand-alone technological interventions cannot solve the complexities of the social, cultural and economic implications of climate change in the long term. New solutions require the engagement of local interested parties and local knowledge to address social and cultural dimensions of water and to create a new embedded water awareness in the built environment, in institutions and culture(s), so that we can preserve and protect our heritage, understand and learn from the past, and activate history and heritage for future sustainable and inclusive living.

The biannual peer-reviewed journal *Blue Papers* explores the complex relationship between water, culture and heritage to assess lessons from the past, to protect heritage sites, to make use of water heritage and to contribute to the development of inclusive and sustainable future water systems. The past can help build a new platform for awareness of water and heritage, which involves shared methodologies and terminologies, policies and tools that bridge disparate fields and disciplines. To achieve this, we also need to rethink the role of water in the UN Sustainable Development Goals (SDGs). Water is not fully captured in *Goal 6: Ensure access to water and sanitation for all*; it is also an integral and inseparable key to all SDGs that carry us forward to a more sustainable future.

All issues of the journal will be loosely based on themes that link to water, culture and heritage, including (but not limited to):

- Transcending the nature-culture divide
- Tangible and intangible aspects
- Integrated discourses and practices

1. The UNESCO Thematic Indicators for Culture in the 2030 Agenda (UNESCO Culture|2030 Indicators), https://whc.unesco.org/en/culture2030indicators/.

- Capacity building for holistic systems
- Long-term (living) history perspectives for comprehensive understanding
- Preservation, protection and reuse of water-related (living) heritage
- Human and non-human stakeholders
- New practices and rituals for water awareness and engagement
- Strategies for inclusive sustainable development, including those drawing on heritage.

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Cover image: View of the sea from Fort San Sebastian, a defense structure built by the Portuguese in the early sixteenth century and later used by the Dutch. The image shows multiple historic layers, including the cross in the sea that memorializes the coastline and advent of Christianity (Source: Carola Hein, 2024).

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Content

Blue Papers
2024 (Vol. 3 No. 1), pp. 1–3
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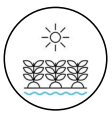
Capturing Water, Culture and Heritage through Icons: A First Attempt

Carola Hein, Matteo D'Agostino, Carlien Donkor, Queenie Lin and Hilde Sennema

Humans have engaged with water in multiple ways, creating physical structures – such as buildings, cities, infrastructures and landscapes – and socio-cultural manifestations – for example, institutions, laws, artistic practices and rituals. They have transformed natural settings in keeping with climate and energy conditions. To understand the diverse conditions of water spaces and heritage, we have created a set of icons to categorize tangible and intangible objects and practices related to water. The icons help us identify different scales, functions and forms of water management-related heritage objects, as well as generic water-related structures. The categories identified are suggestions and not conclusive or mutually exclusive.

Tangible

Drinking
A key function of water management is the provision of freshwater and access to potable water; infrastructures and techniques to store, pump, redistribute and use drinking water.



Agriculture and Irrigation
Numerous strategies and technologies exist to channel and exploit water resources for food production, including the irrigation of agricultural land and livestock watering.

Drainage and Sewage
The removal of excess water and sewage water – e.g., rainwater and excess surface runoff, and wastewater (black and gray water) – requires extensive infrastructure and cleaning systems.

Food from Water Bodies
Natural and artificial water bodies - including seas, rivers, lakes and ponds - are home to plants and animals and are a source of food, obtained through traditional and industrial fishing techniques as well as aquaculture.

Shelter and Defense
Humans have built shelters to protect themselves from harsh climatic elements (rain, snow, etc.), through architectural and urban forms. They have also made structures to defend themselves from and through water, such as dikes, dams, moats and fortification walls.

Health
Clean water is key to human well-being. Water quality is important for individual and public health. The pollution of water bodies through biological and chemical agents has notably influenced the development of spatial planning.

Energy/ Industry
Water is used in industrial processes, e.g., for cooling down machinery, in mining activities and breweries; it is exploited for energy production, such as hydroelectric power. Energy is also key to controlling water and is used to generate energy.

Transport
Water bodies – seas, rivers and canals – are key to transporting people and goods for everyday mobility, tourism and commercial purposes. Specific infrastructures exist to transport people and goods from sea to land and vice versa (e.g., quays, cranes), and for storage (e.g., warehouses).

Places of Leisure
Water bodies, natural or manmade, in cities and landscapes serve leisure practices in multiple ways (e.g., waterfronts, water parks, rivers, swimming pools).

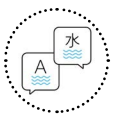
Places of Worship
Humans have created religious spaces for revering water and they may use water to express reverence for or connection with a spirit or deity. Structures such as churches and temples contain elements related to water, or can be part of the management of water resources.

Intangible

Daily Water Practices
Water is part of everyday practices, including drinking, bathing, washing and cooking.

Recreation
Recreational practices use water bodies, natural and artificial. These practices include water sports as well as spending time by the sea.

Rites and Rituals
Water is part of religious and spiritual practices all over the world, including those of major world religions. It is often associated with purification, and in some belief systems, it is revered as a source of all life.



Language/Idioms
Idioms, proverbs and sayings that concern water and water-related societal wisdom and ancestral knowledge.

Laws and Policies
Water management, access, and use have long been regulated through governmental policies and customary laws. Water politics affect and are affected by social, cultural and economic dynamics; they can determine rights and obligations for citizens and community members.

Institutions
Water management laws and policies are often designed and enforced by institutions. These can be political (e.g., a nation-state or a chiefdom), religious or social.

Education
Socialization is key to healthy and sustainable living with water. This can occur through community members, capacity-building programs, schooling, and initiatives to exchange or transmit knowledge and to raise water awareness.

Preservation, Adaptation, Reuse
Diverse traditional and contemporary practices and actions aim at preserving or strategically changing water bodies, related ecosystems and even the social customs connected to them.

Music, Arts and Dance
Ecological knowledge Is contained in local songs and other oral traditions, poems, illustrations, paintings, and artistic performances that connect life stories to water.

Festivals and Ceremonies
Many special events celebrate, commemorate or inaugurate water-related structures, practices and models. This includes fishing and seasonal festivals, events organized to honor or mourn historic water-related events, and ceremonies to establish/launch new water-related objects or structures.

Valuing Rivers

Erik Orsenna
Chairman, Initiatives for the Future of Great Rivers (IFGR)

Rivers are often neglected. They are forgotten in international negotiations, even when they are at the heart of geopolitics. Rivers bear the brunt of climate change – droughts, floods, rising sea levels, cyclones, storms and the disappearance of wetlands. They are often little known by populations that live next to them, who don't understand the services that rivers render to them every day. In general, people are unaware of their responsibility for preserving these common resources of humanity.

The need for a shared vision of rivers in a common sustainable future has led to the establishment of the Initiatives for the Future of Great Rivers (IFGR). With an approach rooted in action and multi-disciplinary collaboration, IFGR has been working to preserve rivers in the face of climate change and to promote them as sources of solutions and levers for development. IFGR brings together a strong network of international experts committed to sharing multi-disciplinary expertise in targeted initiatives, especially concerning international deltas such as those of Bengal, Camargue and the Amazon. A recent trip the IFGR made to Bangladesh demonstrated the importance of physical experiences on a river from source to sea, inspiring philosophical reflections and calls for advocacy and cooperation to strengthen the role of rivers in public policy and to promote projects firmly rooted in local areas. IFGR's interest in sharing and disseminating knowledge and building new networks closely aligns with the work of the UNESCO Chair Water, Ports and Historic Cities and the mission of *Blue Papers*.

Volume 3 no. 1 of *Blue Papers* showcases the importance of rivers in all parts of the world, their physicality as carriers of water and transport, the remnants of rivers and their former uses in the ground and underwater, the covering up of rivers and their contemporary uncovering, historic governance and knowledge systems and the need for a culture of great rivers. We need to harmonize knowledge with emotion, spark imagination, stimulate dialogue, provide testimony and inspire concrete solutions that will reconcile us with rivers and the many values associated with them. People of all ages who use and enjoy rivers, professionals working on rivers, academics researching them, and the guardians of rivers of different countries all have a role to play!

Blue Papers
2024 (Vol. 3 No. 1), pp. 4–5
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Preface

Editorial Issue 1/2024
Rivers as Connectors of Culture and Nature

Carola Hein, Matteo D'Agostino, Carlien Donkor and Zuzanna Sliwinska

Taking an integrated approach to problems involving water, culture, heritage, and sustainable development can be especially complicated depending on the water body at stake. Oceans, lakes, rivers and canals all require specific approaches. This issue of *Blue Papers* takes particular interest in rivers as agents of interaction between water and land, culture and nature, and as carriers and connectors of multiple, often very different challenges.

Rivers have been key to the development of human society and settlements for thousands of years. In many environments they have made human survival possible. They have linked settlements with one another and connected inland areas with major oceans (Hein 2020). The relationship between rivers, cities and surrounding landscapes is multifaceted and has evolved over time. Rivers have always played important roles in freshwater provision, sewage disposal, irrigation, transportation and defense. They have been important in leisure and spirituality. People have often shaped rivers to serve particular needs. The many functions of rivers are reflected in the diversity of values attached to them, the narratives that celebrate them and the conflicts that can arise from river restoration and water management programs. The urgent need for more attention to rivers was highlighted also at the UN Water 2023 conference through calls for transformative, socially and culturally inclusive approaches to rivers (PortCityFutures 2023).

As important arteries connecting the sources of rivers to the sea, rivers also link multiple challenges along their routes. According to the United Nations Environmental Program, 80 per cent of rivers in the Asia-Pacific region are polluted from rapid industrialization and urbanization, affecting water quality and the health of water-dependent communities (Idrica 2023). Pollution caused by human activities moves together with river flows across regions contributing to 95 per cent of the plastic polluting the world's seas and oceans (Asia Geographic 2021). Extreme environmental pollution has inspired river cleanup programs, such as in the Sakubva River and the Nile in Africa (River Cleanup 2024) and the Rhine in Europe. At the same time, nations like New Zealand, India and Canada have been recognizing the legal rights of rivers as political subjects (O'Donnell and Talbot Jones 2018; Berge 2022).

The ecological crisis river ecosystems face today is exacerbated by the effects of climate change. Droughts and floods threaten natural and cultural heritage, urban landscapes and ecosystems. Increased awareness of the relevance of rivers for human survival has prompted riverfront regeneration programs worldwide. Examples of growing interest in riverfront reconstruction include the dismantling of the highway and the opening up of the Cheonggyecheon stream in Seoul, the use

Blue Papers
2024 (Vol. 3 No. 1), pp. 6–9
10.58981/bluepapers.2024.1.ed

of quays in Paris as a city beach in the summer months and the revitalization of the waterfront of the Dutch town of Alblasserdam (Landscape Architecture Foundation n.d.; Geiling 2014; Den Boer 2021). River curves through the landscape are being recreated as part of nature-based solutions to environmental problems and climate change. The Dutch Room for the River program (Rijkswaterstaat n.d.), for example, aims to give the river more room to avoid flooding.

This complex intersection of ecological and climate crises that characterizes many rivers worldwide calls for comprehensive risk assessments and planning approaches that are reflective of the different interests at stake. They need to recognize the values of indigenous knowledge systems and learn from traditional human-nature connections related to sustainable river ecosystems (United Nations n.d.). Careful management of riverscapes and riverfronts can activate different values and interests to re-establish, including often lost societal and cultural connections with nature and water (Wantzen 2023).

Volume 3 Number 1 (2024) of *Blue Papers* engages with many challenges faced by rivers and riverscapes across various contexts and continents. The 18 articles included in this issue address the ingenuity of traditional water management systems, challenges of waterfront development projects in river and coastal areas, the complex institutional systems managing transboundary river basins and natural areas, and the need for new approaches that tackle multiple challenges at once. Together, the contributions emphasize the importance of adopting comprehensive value-based perspectives from the past to the future, especially during ecological and climate crises, in traditional and innovative water and heritage management approaches.

Part I presents value-based concepts by outlining the challenges and opportunities of attending to both water (especially rivers) and heritage to strengthen the safeguarding of environmental functions at the base of Indigenous living systems and contribute to mitigating global climate challenges. Katherine A. Daniell and Bradley Moggridge discuss cultural heritage as a repository of knowledge and inspiration for future innovative solutions, using sustainable water management practices in the Australian Budj Bim Cultural Landscape as an example. Heritage, natural and cultural, tangible and intangible, is threatened by changing water patterns. Vanessa Ziegler, Christa Reicher, Stefan Greiving, Carola Neugebauer and Christoph Klanten delve into this complex relationship, offering guiding principles to strengthen the resilience of built heritage against climate-related risks. Following riverfront developments, Maia Brons explores the multifaceted nature of post-industrial rivers, using the River Lee in East London as a case study to investigate the interplay between regeneration efforts, environmental challenges and the potential for sustainable integration in urban landscapes through the lens of mobilities. Martijn R. Manders takes a similar stance, addressing the challenges and opportunities that climate change and changing water levels have brought to river-related cultural heritage and the potential threat to river-based lifestyles. Yixin Cao offers a potential answer to such threats, proposing a new approach to reintegrating urban rivers as green-blue infrastructure and reviving river culture and river values in contemporary cities. The role of values in finding a better balance among the aims and interests of different actors is at the heart of the contribution by Matteo D'Agostino and Carola Hein, who explore the meaning of diverse values – social, cultural

and ecological – in water resource and heritage management. They propose moving beyond a focus on technological and economic factors toward value-based approaches. Rivers flow into seas and oceans, creating deltaic environments with specific challenges and water values. Simon Richter tackles this discussion by focusing on the latest Dutch spatial planning policy, "Water en Bodem Sturend" (Water and Soil as Governing Principles), which integrates ecological and climate considerations. In his second contribution, Martijn R. Manders touches on the compounding effects of sea level rise on marine processes, emphasizing the need for a multidisciplinary investigation to understand the complex dynamics affecting underwater cultural heritage in coastal areas. The last two contributions of Part I take a broader approach and consider the laws and governance frameworks in force to protect the natural resources of Latin America, with their vast impact on global climate dynamics. Veronica G. Donoso and Christa Reicher emphasize the necessity of expanding protected areas and bolstering law enforcement in the Amazon region to address deforestation, safeguard natural and cultural heritage and mitigate the impacts of climate change. Finally, Emily V. Bell and Bruno P. Puga close this section by discussing the challenges and opportunities of implementing a socio-ecological approach to conservation and resilience in the Pantanal region – a conservation area spanning Brazil, Bolivia and Paraguay – considering its polycentric governance context, lack of clear rules and strategies, and capacity issues across different scales.

Eric Luiten and Lea Kayrouz open Part II with a study of the revitalization of the historic Dutch Waterline, a flood defense system repurposed through a multi-stakeholder effort. The project was taken as an example of the professional education course "Water Systems Design: Learning from the Past for Resilient Water Futures" (TU Delft n.d.). Another participant in the course, Rodrigo Lilla Manzione, used the value case approach to propose the concept and deployment of a "watermark" – a recognizable landmark that can engage the local community, particularly young people, in valuing water resources and developing sustainable solutions for managing the water of Ourinhos, Brazil. The section continues with case studies at the intersection of urban identity and climate resiliency. Nanco Dolman and Johan Verlinde revisit Rotterdam's historical response to water-related challenges, emphasizing its current adaptation efforts through the Weatherwise Program and the development of a blue-green sponge city model to achieve sustainable development goals in the future. Carlien Donkor, Agnese Bavuso Marone and Allegra Aprea present their case on reviving a historic water-based identity amid urbanization and climate change. In their Milanese Navigli project, they propose water-heritage-inclusive urban visions that reintegrate hidden waterways into the city's modern water system to restore Milan's historical identity as a "city of water." Also addressing communal identity loss, Francesca Savoldi examines the impact of coastal changes and large infrastructure projects on community identity and sociability, using the example of Pra', Italy, to illustrate how constructing a port terminal has led to a local maritime community becoming detached from the sea. Similarly, Kristiāna Ustuba investigates the dilemma of protecting a cultural landmark – the military fortification complex in Liepāja, Latvia – from rising sea levels and coastal erosion while preserving its significance as both military and cultural heritage, exploring challenges and possibilities for protection and preservation. The last two contributions of this volume focus on the ingenuity of traditional water systems and the struggle of local communities facing new economic, political and touristic trends. Cristiana Strava illuminates efforts to preserve and revitalize the tra-

ditional khettarat system in Marrakech, Morocco, highlighting its importance for sustainable water management and equitable development in arid regions globally. Sarra Ben Youssef highlights the role of traditional rainwater harvesting systems, such as the majel in Djerba, Tunisia, in addressing acute water stress and promoting sustainable water management practices while questioning the compatibility of heritage-focused tourism with these objectives.

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Policy Recommendations and Key Takeaway Points

Carola Hein, Matteo D'Agostino, Carlien Donkor and Zuzanna Sliwinska

Blue Papers was set up to connect academic and practical analysis of water, culture, heritage and sustainable development and provide concepts, methodologies and case studies to guide policymakers in developing value-based decisions and strategies. The first five issues of the journal brought together over 130 authors from academia, practice, private sector, major public institutions and NGOs. Their insights from multiple sectors and scientific fields – including policymaking, governance, water management, biology, urban planning, heritage and history – shed light on global and local dynamics, challenges and approaches to contemporary urgencies in the water sector and their impact on space, society and culture. The 85 articles so far published in *Blue Papers* have explored examples from 31 countries, highlighting positive and negative aspects of governance, historical processes and socio-cultural practices related to water.

Blue Papers has attracted a growing number of readers, with 7769 views (of the main web page) and over 5500 downloads in 2023. The analysis of featured articles showed that some topics were addressed by many different authors, and some subjects attracted more readers than others. Notably, the articles attracting the most attention focused on Indigenous and traditional water management systems, examples of underwater cultural heritage, and the commercial exploitation of water ecosystems and its effect on non-human actors.

We are convinced that the perspectives presented in *Blue Papers* are crucial to further exploring current connections between sectors focused on water, culture, heritage and sustainable development and establishing new ones. We are grateful that this project has attracted new partners and has welcomed WAMU-NET (Global Network of Water Museums), the UNESCO Chair in Cultural Heritage and Urbanism, and the UNESCO Chair River Culture in supporting its objective. This project is under constant reevaluation, with its format and strategies being refined to expand its global outreach and address more diverse culture-related aspects.

There are three main trends emerging from the first five issues of the journal. The **first thematic line** identifies the need for system analysis and multi-scalar thinking to address the multiple aspects of water and create synergies among different stakeholders. The **second** one recognizes that today's water challenges affect many different sectors of society. Collectively, they show a strong need for solutions that target a variety of problems simultaneously and trigger positive ripple effects from neighborhood to city to territory. This requires a greater emphasis on interdisciplinarity and the need for a deep understanding of local contexts and values to design fully sustainable solutions. The **third thematic line** concerns financing, technology and economic development. There

are many innovative ideas, tools, projects and programs that lack access to adequate funding. New business ideas need to include value-based solutions that are also abreast with newer, better information and communications technologies including artificial intelligence. Contemporary water (heritage) challenges need these answers to test and implement their solutions in circular economies, a sustainable model that creates further value by the continuous use and reuse of materials thereby reducing waste to a minimum.

Starting with the fifth edition of *Blue Papers*, the editorial team has proposed integrating the "Policy Recommendations" section at the end of each contribution to better serve our target audience and collect actionable insights regarding the integration of water-related heritage and its associated values and practices in future management strategies.

The following section outlines policy recommendations that the editorial team of *Blue Papers* extrapolated from the first five issues. Together, these articles propose guidelines to increase **awareness, collaboration, capacity building**, and **innovative policy** and **planning** based on a scientific foundation. In addition, a collection of novel methodologies has been tested in different contexts worldwide.

Summary of Policy Recommendations:

Recognition of Multiple Dimensions of Water

- Raise awareness about all the dimensions of water and water heritage (tangible, intangible, natural, man-made, cultural, spiritual, above and below water). Recognize water as a resource intertwined with history, politics, ecology, the built environment, spiritual and socio-cultural contexts, and a multiplicity of associated values held by various actors across the sites.
- Adopt a holistic approach to policy frameworks, environmental management and conservation that recognizes the intangible relations between cultural and natural landscapes to support sustainable traditional practices and comprehensive, integrated stewardship.
- Leverage human experiences evoked by water - such as hope, fear, ecological grief and historical significance – including spiritual and secular systems of belief – through the creation of museums, interpretive centers and the integration of heritage sites into contemporary water management. The goal is to inspire dialogue, learning, and transformation across conflicting identities and power dynamics.

Adaptation, Preservation and the Re-Use of Water Heritage

- Promote comprehensive analysis of past and current socio-cultural practices associated with water systems, including their political and institutional structures, forms of management and impacts on various social groups, the environment, and non-human entities.
- Repurpose and revitalize obsolete water heritage structures by analyzing their hydrological flows and networks and promoting and implementing "active preservation" strategies that align with the Sustainable Development Agenda.

- Incorporate traditional, sustainable water management practices and environmentally friendly techniques embedded in local communities' ways of life and environmental conditions into future spatial planning and development strategies, leveraging the co-production of knowledge between humans, technology and nature.

Collaboration, Diversity and Empowerment to Promote Sustainable Water Practices

- Incentivize interdisciplinary research projects that holistically examine complex, interconnected relationships between communities, landscapes and environmental phenomena like climate change.
- Enhancing communication and cooperation between various sectors by defining common terminology and concepts, clarifying goals and assigning specific tasks to each stakeholder to improve coordination and effective participation.
- Long-term visions for water and heritage management require investment in and support of diverse coalitions involving communities, institutions, NGOs, scientists, practitioners and international organizations to forge more inclusive governance and planning, monitor environmental quality and heritage sites, and possibly facilitate responses from public institutions.

Capacity Building and Inclusion

- Expand the use of new technologies (e.g., those used in monitoring) and data collection to inform future actions and integrate such technologies with existing sustainable practices rooted in social, ecological and cultural settings. Ensure continuous revision of collected data to respond to dynamic contexts.
- Develop strategies to identify and include actors and community representatives who can effectively communicate local needs to decision-makers.
- Employ skilled facilitators to translate diverse perspectives and align interests for collaborative problem-solving.
- Promote the co-production of knowledge by involving diverse stakeholders from the private and public sectors, including the local community, Indigenous people and youth, in guiding deliberation, design processes and implementation of solutions.

Policy and Planning

- Recognize responsibility and accountability for past activities that continue to impact the present-day physical, social and cultural landscape to promote socio-ecological and spatial water justice and safeguard the future.
- Adopt comprehensive, adaptive and integrated water management solutions and planning that prioritize long-term sustainability over short-term gains and responses while respecting local contexts to improve mediation between different institutional frameworks and stakeholders under a shared long-term vision.
- Strengthen partnerships between government agencies and local communities to implement participatory, culturally appropriate approaches to water conservation; recognize and support customary water tenure by developing legal tools that integrate heritage,

culture and existing technical, financial, social and institutional resources.
- Conduct comprehensive risk assessments that balance economic, environmental and cultural considerations to identify and prioritize the most critical water-related risks facing governmental actors, citizens and ecosystems.
- Establish legal and policy frameworks that recognize water bodies as political subjects with inherent rights and needs and as hydro-social territories co-created and co-inhabited by diverse human and non-human entities to strengthen the protection of vulnerable ecosystems and communities while ensuring the inclusiveness of these policies.
- Establish governance frameworks that foster interdisciplinary collaboration, knowledge exchange and comprehensive approaches integrating traditional and scientific knowledge to manage water resources and cultural heritage within spatial planning across different scales.

Finances and Economy
- Implement funding and support mechanisms that support local efforts to integrate traditional knowledge into regional and national water-management strategies.
- Fund programs aimed at the long-term development of a territory as a whole, which are sensitive to the different values represented rather than solutions focused on single tasks and fast economic gains.
- Allocate resources for knowledge exchange and collaboration for projects, conferences and forums across countries.
- Secure finances for hiring interdisciplinary teams, especially people with local connections and knowledge about the context of intervention and the different values and interests at play.

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PART I Challenges, Concepts and New Approaches

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Indigenous Water Engineering and Aquaculture Systems in Australia: The Budj Bim Cultural Landscape and Baiame's Ngunnhu (the Brewarrina Aboriginal Fish Traps)

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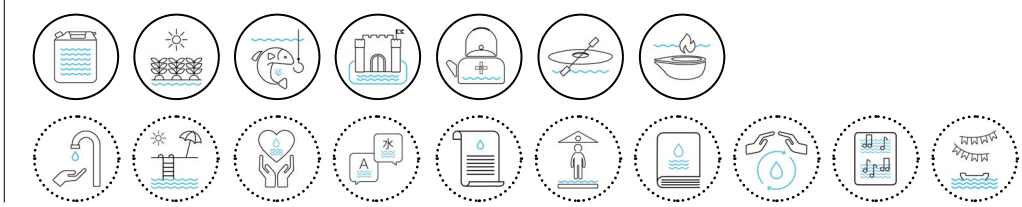
In Australia, First Peoples have practiced sustainable forms of water management for millennia. They have done so by respectfully caring for Country through their use of engineering and maintenance processes, including sophisticated fish and eel trapping structures and weir systems. Some of the largest continuing sites of water engineering and aquaculture in the world are still visible and used by local Aboriginal groups – the Budj Bim in Victoria and Baiame's Ngunnhu (Brewarrina Aboriginal fish traps) in New South Wales (NSW). Recent scholarship and successful heritage listings, including the World Heritage listing of the Budj Bim Cultural Landscape and work by and with traditional custodians in these river systems, are starting to bring into public discourse and knowledge these sophisticated and important places of global cultural significance. The principles used in the design of these systems, and the social and environmental contexts of their maintenance and convening power over millennia, are particularly important as we navigate new technologically mediated forms of water management today and into the future. These management challenges include communities in Australia and globally working on the importance of significant places, values, rights, justice and voice for Indigenous peoples in building sustainable futures, including through innovation and safe, sustainable and responsible cybernetic approaches to water governance and the SDGs.

Keywords: *First People, aquaculture, eel traps, fish traps, Free, Prior, and Informed Consent (FPIC)*

KEY THEMES



< Fig.1 Brewarrina Aboriginal fish traps – Baiame's Ngunnhu – 10 April 2024, view from outside the Brewarrina Aboriginal Cultural Centre on tour with Bradley Hardy (Source: Katherine Daniell, 2024).

Introduction

Fish trapping systems are found all over Australia in both coastal and inland water systems (Martin et al. 2023). Traditional custodians of Country, whether of land, water, sea or sky Country, have continuously kept knowledges and forms of governance of these structures alive through cultural practices, including the maintenance of songlines, ceremonies, oral histories and art (Neale and Kelly 2020). The ingenuity and sophistication of the fish trapping and aquaculture practices of Aboriginal and Torres Strait Islander peoples have always been known by the communities managing and maintaining them; they have also been acknowledged by settler colonists in Australia (see examples in Pascoe 2014; Dargin 1976; Coutts et al. 1978). More recently, specific instances of these systems have been acknowledged as heritage places at the state, federal and international levels. In particular, the Budj Bim Cultural Landscape in South-Eastern Victoria is considered one of the oldest examples of an aquaculture complex in the world. It has been carbon dated to at least 6,600 years, constructed from basalt rocks from a volcanic lava flow, and managed by the Gunditjmara using a variety of practices and technologies, including adding woven traps to the rock structures (UNESCO 2019; Gunditjmara and Wettenhall 2022; Rose et al. 2016). The cultural landscape and effective management of water for the community, including food production, also includes clear evidence of rock-built living structures, supporting the relatively sedentary lifestyles of Aboriginal peoples in the area (Pascoe 2014; ADEE 2017). Another prominent example, Baiame's Ngunnhu at Brewarrina on the Barwon River in the Barka-Darling River basin system and on the edge of the Great Artesian Basin groundwater system in Northern NSW, is also millennia old. Baiame's Ngunnhu is central in the creation stories of the Country and cultural practices and ceremonies of the many Aboriginal groups who have built, maintained and used the large system of rock weirs and fish traps, shaped itself like a large fishing net (DAWE 2005). The Ngunnhu is the "largest system of traditional fish traps recorded in Australia" (NSW Government 2022) and is believed to be over 40,000 years old which would make it one of the oldest surviving human-made structures in the world (Ngemba CWP 2019). It is known as one of the most important meeting places for Aboriginal people in South-East Australia. The Ngunnhu is particularly used during medium and low-flow periods in the river but has been engineered to withstand high flows. Repair and maintenance is possible in low-flow periods (Dargin 1978). Both examples of Indigenous engineering, culture and shaping the Country for community are important in Dispelling the myths of *terra nullius* and *aqua nullius* (Marshall 2017) perpetuated through the colonization of the Australian continent, particularly because they are both sites of important Indigenous resistance, knowledge, values and strength of community (Bell and Johnston 2008; Gunditjmara and Wettenhall 2022; Maclean et al. 2012).

Current Approaches to Preserving and Managing Water Heritage

Heritage preservation and management of fish and eel trapping sites across Australia varies, with traditional custodians and land management corporations working with governments

1. As explained by AIATSIS (2022), "Country is the term often used by Aboriginal peoples to describe the lands, waterways and seas to which they are connected. The term contains complex ideas about law, place, custom, language, spiritual belief, cultural practice, material sustenance, family and identity."

^ Fig. 2 Water flows through the Brewarrina Aboriginal fish traps – Baiame's Ngunnhu – 10 April 2024, view from outside the Brewarrina Aboriginal Cultural Centre on tour with Bradley Hardy (Source: Katherine Daniell, 2024).

and other bodies to develop recognition and support of these sites. Each system and community's journey is different, with much work still ongoing.

Baiame's Ngunnhu was inscribed on the NSW State Heritage Register on 11 August 2000 (NSW Government 2022), and on the National Heritage List on 3 June 2005 (DCCEEW 2021a), with the Ngemba people as traditional custodians, and recognition of the shared importance, maintenance and cultural significance with many neighboring First Peoples. The importance of the site is highlighted in the Brewarrina Aboriginal Cultural Museum constructed in 1988, which now stands in the listed area following an extension in 2015. Significant efforts have been undertaken in engagement and truth-telling to the community through in-person tours and social media, including an active Facebook page, and the system is now highlighted in many education programs, including in cultural, engineering and cybernetics education, at all levels in Australia (e.g., Ruddell and Randell-Moon 2022; Butta 2021; Pascoe 2019). The Ngunnhu has been significantly impacted by colonialization. For example, changes have been made to the system to allow pad-

dle steamers to navigate, and weirs have been constructed for irrigation, which has changed water regimes and blocked the passage of fish. Listings and management plans suggest that both the preservation of values and additional restoration are possible and a number of activities have been undertaken to support this, including some trap wall reconstruction and an engineered fish ladder (MacClean 2012; NSW Government 2022). The ability to restore water in the area (Jackson 2022) and to support traditional custodians in leading restoration efforts and governance will be key to success. Discussions are ongoing regarding the potential for World Heritage listing and an application is in development (Ngemba CWP 2019).

The Budj Bim Cultural Landscape is managed by traditional custodians through the Gunditj Mirring Traditional Owners Aboriginal Corporation and a range of other governance mechanisms (ADEE 2017). Budj Bim was inscribed on the National Heritage List on 20 July 2004, recognized as an Engineering Heritage National Landmark on 20 October 2011 (Peake 2011; Jordan 2011), and inscribed on the UNESCO World Heritage List on 6 July 2019 (DCCEEW 2021b). The Traditional Owners work under a participatory and collaborative framework with the Victorian Government and others, as outlined on the Budj Bim Cultural Landscape website, and have aligned their efforts with future management objectives as outlined in their Masterplan 2022–2030 (Arup 2022); these include the pursuit of economic opportunities through low impact tourism, site development, cultural preservation and ensuring community access. Budj Bim is regularly used in education in a range of domains, including as an applied case study in the University of Melbourne's *Indigenous Engineering and Design* course, where students learn and work with Traditional Owners on Country (Bowra 2020; Prpic and Bell 2022).

The significance of fish trapping structures and technologies across Australia is also given a prominent place in the First Australians gallery in the National Museum of Australia in Canberra.

Current and Future Challenges to these Water Systems

As a Federal nation, throughout the continent there are jurisdictional differences and historical legacies of colonization that impact approaches to the custodianship of fish trapping sites that are significant to Indigenous people. At both national and state levels, reforms related to water policy are underway to improve the management of land, water and extreme events. Increasing variability and shifts in climate due to global warming, along with high water demand and extractions throughout the river basin, are impacting flow regimes, ecological health and fish availability, and hence the ability of traditional custodians to care for the Country and these sacred sites. This is particularly the case in the Barwon and Barka-Darling rivers, part of Australia's famous and over-allocated Murray-Darling River basin, where Indigenous water injustice through a lack of allocations is particularly acute in relation to colonial-settler allocations (Hartwig et al. 2021). Reforms to support justice for Aboriginal and Torres Strait Islanders across Australia are also gaining significant attention following the Statement from the Heart signed in Uluru (PCoA 2018) and the 2023 Constitutional Referendum (not passed) on an Indigenous Voice to Parliament, although this is only one part of the proposed changes required for justice for First People, which include the need for Treaty, Truth and *Makaratta* (reparations and "walking with a limp") (Loughrey 2022; PCoA 2018; Linder and Hobbs 2023). In Victoria, state-level Aboriginal Water Initiatives and processes that recognize and promote

^ Fig. 3 The Brewarrina Aboriginal Cultural Museum – 10 April 2024, on tour with Bradley Hardy (Source: Katherine Daniell, 2024).

Aboriginal-led management of water as part of the Country have gained support through government action, collaborative partnerships, and efforts to raise public awareness. These initiatives are increasingly seen as a source of pride at both the state and national levels, providing momentum for further action following initial steps toward rectifying injustices. These include the foregrounding of Aboriginal engineering ingenuity through the Budj Bim Cultural Landscape with its World Heritage listing and strategic management plan, and the recognition of the Yarra River in Melbourne as a living entity with legal protections through the Yarra River Protection (*Wilip-gin Birrarung murron*) Act 2017 (Wardle 2021). Despite some small federal reforms to include greater provisions for Indigenous values and more Indigenous engagement in formal structures in the Murray-Darling River basin and current discussions on reforms to enhance this component of the National Water Initiative, at the NSW state level, work toward Indigenous recognition, water rights and Aboriginal-led water governance initiatives have had a rockier history. Progress was made during the time of the NSW Government Aboriginal Water Initiative (Taylor et al. 2016), but since the initiative's discontinuation and due to larger political conflicts and media attention on issues such as massive fish kills and alleged

water theft (Jackson 2021), progress has been slower. Potential directions for future water reforms are in dispute; these include increasing investments in water infrastructure, including by installing new dams, higher weirs and irrigation technology upgrades, which local Barka-Darling Indigenous communities say will further impact their ability to care for the Country, including the fish traps. Moving forward on core issues of Indigenous justice in NSW will likely provide traditional custodians of the Country – including the Ngemba custodians of Baiame's Ngunnhu and neighboring First Peoples groups who share it as a significant cultural place – with a greater platform for gaining broad support for Ngunnhu futures in an uncertain and changing world. These futures will include whether greater legislative protections and/or international-level recognition is sought and how these might uphold Indigenous values and rights (Moggridge 2021; Moggridge and Thompson 2021; Hartwig et al. 2021, 2022; SoE 2021), offering cultural, economic, social and environmental benefits to Indigenous and other communities with whom the fish traps are shared.

Conclusion and Future Approaches

The millennia-old Indigenous aquaculture complexes around Australia, of which Budj Bim and Baiame's Ngunnhu are prominent examples, present a range of principles that can support more sensitive and sustainable ways of caring for the Country, kinship networks and community globally. These are engineered systems that work carefully with flow, ecology, climate changes and culture to sustain communities and help them thrive. These examples of water engineering, aquaculture and cultural heritage also extend global knowledge about continuing cultural practices, heritage preservation and evolution into deep time in a way that is not so commonly recognized outside of Australia but is gaining traction (e.g., Iwabuchi 2022). More importantly, these systems are not just part of cultural heritage and the past but are intimately involved in current discussions and practices about building the future (Bell 2021a, b): they are enmeshed in the "everywhen," an Indigenous perspective on circular time (McGrath et al. 2023). These are sophisticated technological systems that show environmental and social sensitivity through their careful design and engineering. Continuous maintenance and renewal rely on complex governance processes focused on respect, meeting, sharing and ceremony. Working with Country – connecting to it, shaping practices and adapting with it rather than working against it to control "resources" that are seen as separate from place and community can be an inspiration when addressing many of today's challenges with technology, environment and society (Butta 2022). Indeed, Country-centered design is supporting the development of culturally appropriate technologies needed to underpin sustainability, including artificial intelligence (Abdilla et al. 2021). Such design is being included in education at all levels. The principles and inspiration from these examples and others across ancient living water systems can facilitate means of creating more effective Country-centered and "two-ways" governance systems, help to bridge knowledges in today's world and offer open space for listening to Indigenous leaders (Bawaka et al. 2015; Daniell and Daniell 2019; RiverOfLife et al. 2021). This is a holistic and cybernetic approach that has more universal application when linked to the implementation of the UN Declaration on the Rights of Indigenous Peoples (UN 2018) and the pursuit of the achievement of the SDGs in safe, responsible and sustainable ways (Daniell et al. 2022).

Policy Recommendations

- Any proposed international, national or local actions related to Baiame's Ngunnhu, Budj Bim and other Indigenous places of value should be led by traditional custodians and/or through free, prior and informed consent (FPIC) to develop proposals (UN General Assembly 2018). Appropriate processes for FPIC should benefit and not burden traditional custodians and be carried out in alignment with the UN Declaration on the Rights of Indigenous Peoples (UNDRIP).
- Translation of FPIC and UNDRIP principles to specific proposals may require significant professional and cultural support to ensure recognition and practice in accordance with the relevant First Peoples' cultural protocols, depending on who seeks to engage in the process.
- Investing in Indigenous leadership and high-quality FPIC processes can build sustainable support and justice for Indigenous peoples.

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Resilience and Cultural Heritage in Urban Development: From Holistic Guidelines to Practical Approaches

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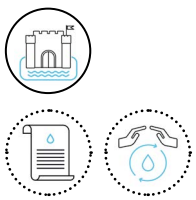
Water plays a dual role in the context of cultural heritage: it can be of great importance, but it can also threaten the existence of built heritage. This article explores the intricate relationship between water and built heritage, focusing on the risks posed by climate change-induced events such as heavy rainfall, which can lead to flooding and surface water run-off. The research project "Resilience and Built Heritage" focused on how built heritage contributes to urban resilience and emphasizes the imperative of integrated risk management, which requires collaboration between heritage professionals and risk managers. The challenges identified include mutual understanding of the disciplines of heritage protection and risk management and a lack of clarity in defining common objectives. Hence, integrated risk management is proposed as a comprehensive concept, encompassing an all-hazards approach and analytical as well as normative steps of risk evaluation and management. Integrated risk management can help develop consistent, holistic, integrative strategies to sustainably protect our built heritage – and thus strengthen its resilience to risk.

Keywords: *built heritage, integrated risk management, urban resilience, heavy rain, climate change*

KEY THEMES



< Fig. 1 Flooding of the Danube River, Stone Bridge, Regensburg, Germany (Source: Stefan Greiving, 2021).

Water as a Threat to Cultural Heritage

Water is, in various ways, part of the cultural heritage of communities. Physical structures as well as institutions, laws, artistic practices and rituals witness human interaction with water and represent its importance for (local) identity as tangible and intangible heritage (Hein et al. 2022). At the same time, water can threaten other forms of built heritage, such as historic ensembles and individual buildings, especially through heavy rainfall which, in turn, can lead to pluvial and fluvial flooding and run-off. Due to climate change, warm air can contain more water, and at the same time, more water evaporates at the sea surface; in addition, the slowing jet stream makes clouds linger above certain areas, so that, overall, the likelihood of heavy rainfall is growing and thus, increasingly threatening cultural heritage (Intergovernmental Panel on Climate Change [IPCC] 2023).

The Need for Integrated Risk Management

Integrated approaches involving heritage professionals and risk managers are therefore needed to protect built heritage effectively. The research project *Resilience and Built Heritage*, funded by the German Federal Ministry for Housing, Urban Development and Building (BMWSB) and the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), investigated existing approaches and how they can be strengthened in European cities. As a result, two papers were published: a guidance paper (BBSR 2023b), including ten guiding principles on general requirements for improving integrated risk management at a higher level; and a handbook (*Arbeitshilfe*; BBSR 2023a), intended especially for German practitioners as a resource for implementing guidance on the local level. The project was part of one of the eleven actions included in the European Union's Urban Agenda.

Until now, such integrated approaches have been unsatisfactory – for three different reasons. First, a systematic neglect of the respective other side is only slowly being overcome; risk management has only recently begun to include heritage as a protection good, while, in turn, heritage management and monument preservation still largely disregard the need to consider risk management.[1] Awareness usually only arises when a disaster strikes and is quickly forgotten after recovery. Second, there is a lack of mutual understanding and no common knowledge base. Both disciplines speak very different languages, using their own technical terms and concepts (such as "diverse risk assessment methods" among those focused on risk, and concepts of "values" and "protection-worthiness" among those concerned with heritage). And third, the definition of common objectives, both disciplinary and interdisciplinary, often lacks clarity. Questions such as "Which cultural assets and sites are we to consider vulnerable, regarding which particular threat?" or "What is an acceptable level of risk?" may not be easy to answer – but they need to be put on the table first, which is not always the case. The setting of such a normative basis is crucial because it includes fundamental political discussions and decisions, and finally leads to the evaluation of risk and the choice of measures for prevention and recovery (BBSR 2023b).

Integrated risk management for built heritage is a comprehensive concept that aims to strength-

1. On an international level in the World Heritage context, risk is starting to be addressed, for example in the elaboration of management plans (UNESCO 2013).

en the connection between both disciplines. The following three key features characterize its comprehensiveness:

First, the pursuit of the "all-hazards approach" is recommended, which means that all kinds of natural and human-made threats (e.g., flooding, storms, droughts, earthquakes, fire, technical collapses, armed conflict), as well as interactions between those, should be considered. This is related to the fact that civil protection in countries such as Germany is always guided by a multi-hazard approach (Greiving 2011), making it, therefore, a compatible concept.

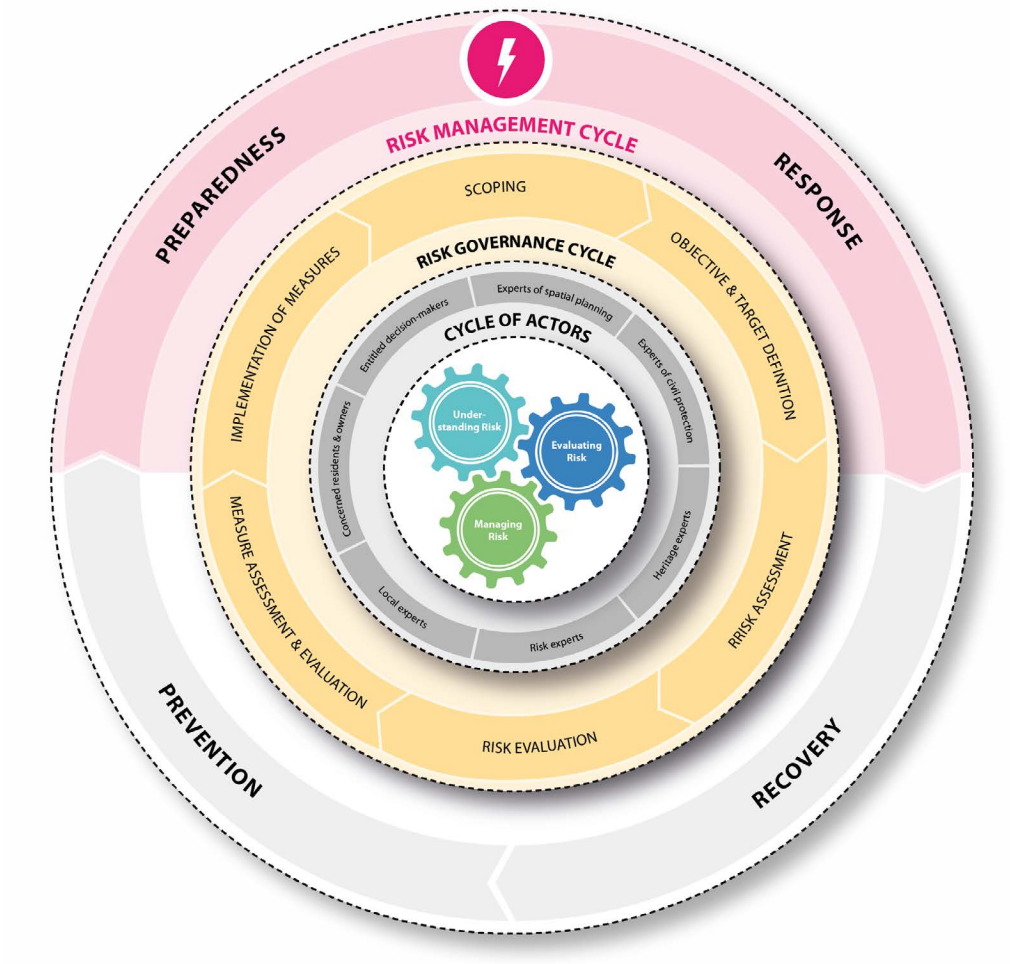
Another feature of integrated risk management for built heritage is that it strives for a systematic approach to cultural heritage. Thus, tangible as well as intangible heritage is addressed, as is the connection between cultural and natural heritage; moreover, it includes state-listed monuments as well as assets and places that are not formally protected but are nonetheless meaningful to local communities (BBSR 2023a; Bierwerth 2014).

Finally, integrated risk management is not limited to the moment of disaster and immediate response but includes all four phases of the risk management cycle: prevention, preparedness, response and recovery. The activities in each stage should refer to and build on each other as much as possible (SHELTER 2019). "Prevention" here refers to the outright avoidance of adverse impacts of hazards and related disasters. "Preparedness" includes the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent and current hazard events and conditions. "Response," during or immediately after a disaster, means the provision of emergency services and public assistance to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of people affected. And finally, "recovery" is defined by the restoration and, where appropriate, improvement of facilities, livelihood and living conditions of disaster-affected communities, including efforts to reduce future disaster risk.

The Risk Governance Framework as a Scientific Basis for Integrated Risk Management

These stages, in turn, are part of the so-called risk governance framework (fig. 2). Beside the four phases of the risk management cycle, this framework depicts various relevant actors in the process, such as experts in the different disciplines and entitled decision-makers. More importantly, a second cycle is included in the framework: the risk governance cycle (International Risk Governance Center [IRGC] 2017) offers another way to capture the overall nature of risk management. Instead of focusing on the different phases, this approach looks behind the scenes, with steps divided into scientific analysis and expert activity on the one hand and normative and political decisions on the other. These risk governance cycle steps take place within the above-mentioned stages of risk management and thus form the basis for each of the risk management cycle steps. The key message here is that risk management is built on both interdisciplinary expertise and political and legal decisions. These factual (analytical) and normative steps are closely interlinked and require careful attention, as the respective interdisciplinary and transdisciplinary dialogues need consistent risk governance.

Finally, three gears are at the heart of this framework, each representing one core topic for integrated risk management: *understanding risk,*

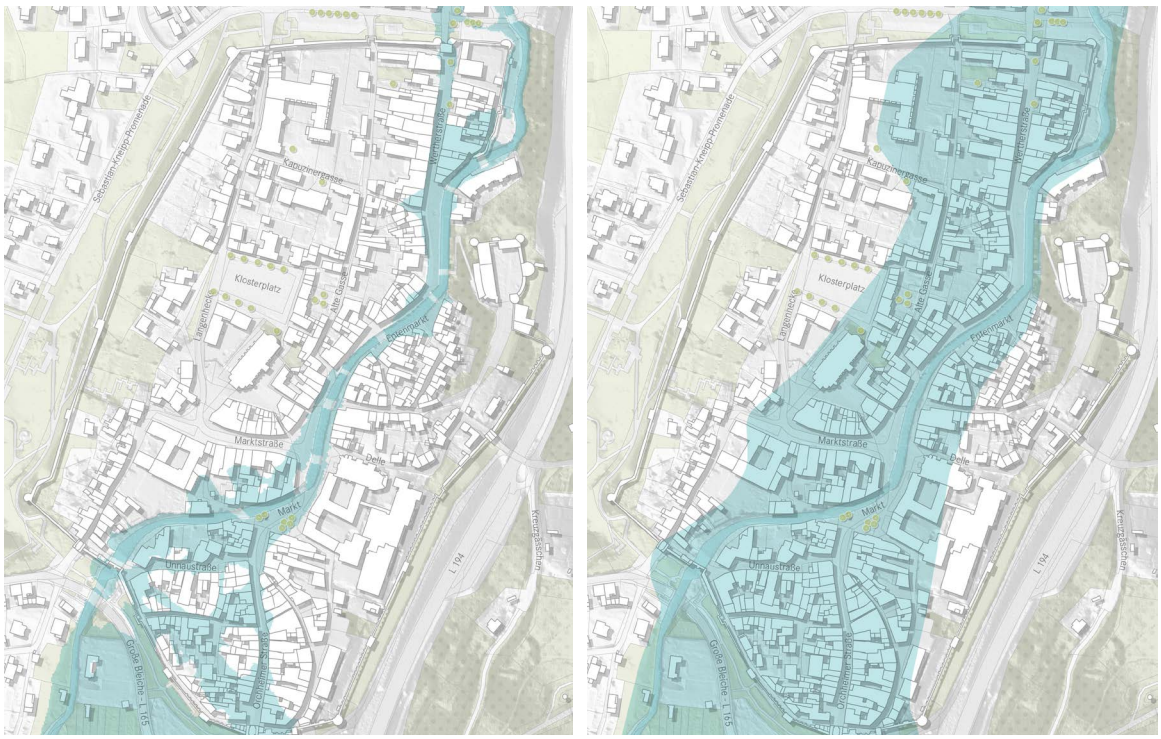


^ Fig. 2 Risk governance framework (Source: Vanessa Ziegler, 2023).

evaluating risk and managing risk. These build on each other and structure the guiding principles for the improvement of integrated risk management for cultural heritage in urban development.

Understanding Risk: Risk is More than a Function

The first step in integrated risk management, and the basis for reducing risk to cultural heritage, is to fully understand risk and all its components. Therefore, understanding risk deals especially with the development of suitable databases and assessment methods. Risk is generally understood as a function of threat or hazard on the one hand and vulnerability on the other. While threats may stem from (external) natural, anthropogenic or socio-natural processes and events (e.g., heavy rains, armed conflicts, environmental destruction or climate change), vulnerability is a result of several (internal) factors of the objects to these threats: susceptibility (e.g., age, state of preservation and building



^ Fig. 3 Comparison of the calculated extreme flood scenario with the actual flood level in July 2021 in the historic old town of Bad Münstereifel (Source: Vanessa Ziegler, 2022).

materials), exposure (e.g., location), and coping capacity (the ability of individuals, organizations and systems to handle adverse circumstances, requiring resources and long-term management). The latter includes infrastructure, knowledge and awareness. For instance, if the involved stakeholders are conscious of the need for risk management and willing to implement respective measures, this contributes to the coping capacity and lowers the vulnerability of a site or asset.

As described above, existing approaches in risk management for cultural heritage are still lacking integration. Likewise, local practitioners in urban development often lack the necessary skills and abilities to fully understand and analyze risk. Assessment methods such as the so-called "risk matrix approach" are not known or not yet systematically integrated. Therefore, the recently published BBSR (2023a) handbook provides a detailed explanation and step-to-step guidance about how to conduct this analysis.

Surely, it is important to have adequate data at hand about threats and hazards and to reduce vulnerability as much as possible to be prepared for potential disasters. But although we need to prepare ourselves, we also need to understand that there is never absolute safety and certainty and that disasters can always strike unexpectedly. Also, the probabilistic data we use in many cases are based on statistics from past events and may no longer accurately represent the present and future due to climate change. The frequency and severity of extreme weather

events can change significantly. We therefore need to update our valuation methods and find new approaches that can take changing circumstances into account. Figure 3 shows, for the case of Bad Münstereifel, how previous estimations of flood levels were exceeded by a great margin during the flood event of summer 2021.

Evaluating Risk: Finding Common Ground, Defining Resilience

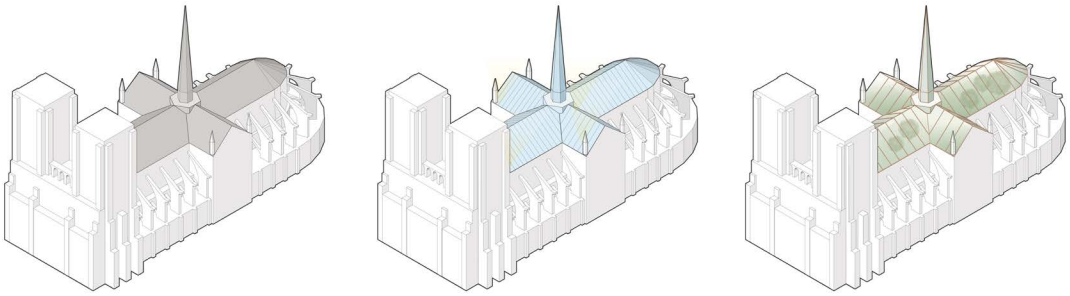
Building on the assessment and interpretation of databases, and before deciding on actual management strategies and measures, objectives and priorities for protection need to be defined. According to the previously mentioned risk governance cycle, several normative steps can be defined which require careful attention and discussion. Although such a clear normative basis for judgments and decisions is considered crucial for successful integrated risk management, in many processes, this important step is either skipped or the (unconsciously) formulated objectives and priorities are not questioned. In several cases, it is evident that sites and buildings shall be reconstructed as before; further exposition to future threats is often not considered.

The definition of objectives should therefore include the designation of both the objects of protection to be considered and the desired level of safety – or, in other words, the acceptable level of residual risk. This requires two major decisions, which should be based on inclusive, democratic discussion and sound evidence.

The first step in defining objections regarding cultural sites and assets should be to identify their architectural, commemorative, symbolic or other values (Meier 2021). Questions that might be asked include these: "Are UNESCO-listed World Heritage Sites more important (and protection-worthy) than listed monuments, which in turn are prioritized higher than non-listed buildings and sites? May some elements not (yet) be formally recognized as cultural heritage but still be important to local communities? Which rules should apply in determining protection levels?"

As a second step, the definition of normative objectives and priorities requires discussion of questions such as "Which state of the (urban) environment should be maintained during a disturbance and restored afterward?" Contributions to this discussion can be very diverse and depend on the underlying understanding of resilience in the context of local integrated risk management. We can generally differentiate between three different resilience concepts:

1. In a narrow and static understanding of resilience, focusing on rapid system restoration after disturbance limits the integrated risk management approach to "bouncing back" — that is, maintaining its status quo. This overlooks adaptive responses and potential improvements in the urban environment (Davidson et al. 2016).
2. Resilience can be considered an adaptation to multiple equilibria, "bouncing forward" while preserving the system's core identity.
3. Another transformative view emphasizes quick system transformation, allowing adaptation beyond past events. Opting for this understanding of resilience in local integrated risk management underlines its potential to achieve greater sustainability (UN-Habitat 2021). Here, "urban resilience" is defined as the "measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming toward sustainability" (UN-Habitat 2021).



^ Fig. 4 Static, adaptive and transformative understanding of resilience (left to right), applied to the Notre Dame cathedral in Paris (Source: Vanessa Ziegler, 2023).

The Notre Dame cathedral restoration debates highlighted contrasting approaches, ultimately favoring "bouncing back." Previous discussions explored alternative solutions, including a "greenhouse roof" and ways of integrating biodiversity and educational spaces in urban planning (Walsh 2019; fig. 4).

Managing Risk: How to Put Integrated Risk Management Down on Paper

The final aim of integrated risk management is to implement concrete strategies and measures to protect built heritage from risk in all phases: prevention, preparedness, response and recovery. While short-term measures involve immediate actions in the sense of "first aid," like installing barriers and stabilizing structures, long-term strategies include spatial planning and structural modifications in land use, such as protecting hazard-prone zones from urban development and reducing vulnerability through building adaptations, dike construction or retention ponds.

Before implementing such strategies and measures, potential conflicts with cultural heritage should be analyzed carefully. The case of Grimma in Germany underlines the necessity of considering possible (visual) impacts: the flood of 2002 devastated the historic town, leading to the idea of a protective wall being constructed around it (fig. 5). Conflicts emerged in relation to the wall's visual impact on the heritage site. Scientific research, as well as a second flood event in 2013 that once again devastated the recently reconstructed city, supported the view that the wall was necessary. This case highlights the importance of resolving visual conflicts preemptively for effective disaster response and the need for efficient conflict to be resolved through informed debate.

To this end, multiple stakeholders, each with their own roles and responsibilities, are to be involved in the process: democratically elected decision-makers, such as the mayor, members of the town council and the public authorities for urban planning, heritage and environment; supervisory authorities, like the disaster control and monument authorities; civil society groups, such as residents, owners, local history associations, and voluntary fire brigades; and finally intermediaries like emergency networks, external engineers and experts.

^ Fig. 5 Flood defense system in Grimma, Germany (Source: Sebastian Bachran, 2022).

Conclusions

The significance of cultural heritage as a fundamental resource for urban resilience is growing in light of recent crises, notably the increasing threat posed by water-related hazards due to climate change. Fading awareness in the aftermath of crises indicates that comprehensive, long-term consciousness and strategies have not yet been sufficiently established. Such crises furthermore underline the vulnerability of our historical buildings and structures and emphasize the urgent need for holistic protection approaches.

This article has focused on integrated risk management, which is of great importance, particularly at the local (urban) level. The local context calls for precise and effective measures involving complex interaction and coordination between different stakeholders. Efforts made by heritage professionals and risk managers must be better integrated. Integrative approaches must, to respond to the complex environments of local heritage and the coupled nature of many hazards, also take into account a multitude of hazards and their interrelation – according to the "all- (or multi-) hazards approach," as explained above. Until now, separate approaches focusing on single hazards (such as inundations) have been most common.

Finally, a comprehensive examination that addresses all the different phases, threats and

types of cultural heritage is crucial for a better understanding and effective management of heritage. It is important to promote substantive discussions and to reach consensus about objectives, especially in terms of priorities and which concept of resilience to apply.

Policy Recommendations

- Intensify communication and cooperation between heritage professionals and risk managers. For instance, establish a staff unit ("task force") at the nexus of both disciplines.
- Elaborate an integrated risk management concept on the local level. Results from the analyses, defined objectives and measures should be formally adopted to guide future administrative actions.
- Establish an iterative learning process. The content of the local integrated risk management should be periodically reviewed – and updated if necessary. For example, due to climate change, prior estimations of flood levels might no longer be accurate.

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The Value of a Mobilities Lens in Studying the Water-Heritage Nexus

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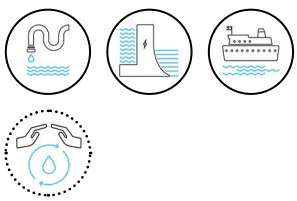
This article explores the value of a mobilities lens in studying the nexus of water and heritage, specifically within the context of post-industrial rivers and the many regenerative and degenerative processes shaping them today. The River Lea (East London) showcases the complex, often conflicting, water-heritage dynamics that manifest across post-industrial riverscapes: efforts to (re)connect communities to rivers and their heritage become entangled with the (pollutive) imprints of industry. Using examples from the River Lea, the article highlights how a mobilities lens, currently underused in water-heritage studies, draws attention to (i) physical accessibility provisions surrounding rivers, (ii) (in)visible streams of fluid materials and (iii) the movements and moorings of more-than-human entities. These human, ecological and more-than-human mobilities can support but also sabotage efforts to regenerate post-industrial rivers, rendering a mobilities lens, with its ability to value and make visible multiple mobilities, indispensable to studying post-industrial rivers as key water-heritage sites.

Keywords: *post-industrial rivers, mobility, environmental degradation, regeneration, River Lea*

KEY THEMES



< Fig. 1 Close-up view: Oil spill in the Lea (Source: Maia Brons, 2023).

Introduction

Rivers in post-industrial landscapes, or post-industrial rivers, constitute key sites in studying the nexus of water and heritage. In Europe especially, many rivers resemble exhibitions of the industrial period, connecting past to present through remnants of historical buildings, technological water systems and industry-induced environmental degradation (Mah 2010). Post-industrial rivers also increasingly undergo extensive regeneration schemes aimed at reviving ecosystems, restoring historical infrastructures and reintegrating riversides into surrounding urban landscapes (Hein 2016). Such interventions cause complex synergies and frictions between heritage- and environment-oriented goals, the stakes of which increase as climate change further intensifies (Corten 2023).

Researchers have made considerable progress in scrutinizing river regeneration initiatives, especially regarding how they engage with the water-heritage nexus, local communities and concerns for justice and sustainability (Goh 2021). Recently, studies of this kind increasingly foreground questions of mobility: how spaces are (differentially) accessed and experienced. Indeed, creating inclusive and sustainable opportunities for people to (re)connect with rivers and their historical and natural heritage implies understanding the parameters of moving to and through those riverscapes (Rhoden and Kaaristo 2020; Usher et al. 2021). Kaaristo and colleagues (2020), for example, use mobilities theory to analyze emerging patterns of co-existence, collaboration and conflict between different canal users (e.g., boaters, pedestrians, cyclists) as Britain's historical canal network becomes gradually reintegrated into urban landscapes. This article further explores the value of a mobilities lens in studying the water-heritage nexus, specifically within the context of post-industrial rivers and their regenerative and degenerative processes. This watery backdrop elicits an approach to mobility that is, from the outset, fluid and flexible: a spectrum ranging from movement to immobility, visible to invisible and human to more-than-human (Boas et al. 2022).

The article uses examples from the River Lea in the Lower Lea Valley (East London). Between the eighteenth and nineteenth centuries, the Lower Lea Valley constituted "the heart of London's industrial economy" (Clifford 2017, 10). Although Britain's industrial period ended, it left its environmental imprint on the River Lea, which became reputed as one of Britain's most polluted rivers and, void of its industrial import, gradually disappeared from public memory. After more than 50 years of neglect, the 2012 Olympic Games brought unprecedented investment to the area, reintroducing the Lea as a "tear in London's urban fabric" that required stitching (Design for London 2013, 7). Since then, the Lower Lea Valley has undergone many regeneration initiatives bearing varying, sometimes conflicting, strategies to unlock its cultural and natural potential and reinstate it as a key water-heritage site. Yet, advancements in making the Lea attractive and accessible are continuously thwarted by political, infrastructural and environmental challenges. It is on this intricate interface of regeneration and degradation, water and heritage, that a mobilities lens may shed some light.

Human Mobility for Social River Connectivity

The first, perhaps most straightforward, value of a mobilities lens lies in its ability to assess basic human mobility to and through riverscapes: the extent to which riversides are physically accessible and attractive. This argument builds on Kondolf and Pinto's (2017) theorization of "social connectivity," which implies the inter-

^ Fig. 2 Volunteers conducting a bird survey along the Lea (Source: Maia Brons, 2022).

actions between rivers, on the one hand, and humans (including cultural and social systems, knowledge and goods) on the other. Social connectivity, Kondolf and Pinto (2017) argue, is mediated by physical infrastructures and conditions along, within and surrounding rivers, also known respectively as longitudinal, vertical and lateral connectivity. Projects aiming to regenerate rivers commonly prioritize ecological objectives, which, critically, results in underdeveloped agendas regarding socio-spatial concerns (Usher et al. 2021). This sustains an underappreciation for basic human mobility needs and the role of spatial infrastructures in influencing how people experience, or are differentially excluded from, post-industrial riverscapes.

The Lower Lea Valley demonstrates how physical mobility provisions can both support and strain social connectivity between humans and rivers and, more broadly, interventions designed to optimize post-industrial rivers' water-heritage offerings. Among the numerous initiatives targeted at regenerating the River Lea is Cody Dock: an organization aiming to reconnect local communities with the river through volunteering and educational activities. Through Cody Dock, hundreds of community members have gained embodied experiences with the Lea, becoming (re)acquainted with its historical and ecological resources, for instance through weekly biodiversity surveys. Here, people move attentively along the river (fig. 2), observing local wildlife and landscape changes and collecting data for a growing citizen-led database (Gasworks Dock Partnership 2022). As illustrated in Dunkley's

^ Fig. 3 Flooded footpath between Abbey Mill Pumping Station and the Lea (Source: Maia Brons, 2023).

(2018) study of woodland- and river-based citizen science projects, such activities have the potential to mobilize people to cultivate physical, social and emotional connections with rivers and their natural heritage, thereby laying the foundation for community-based river custodianship. Furthermore, in the case of the Lower Lea Valley, by engaging with, and rendering visible, local biodiversity – from kingfishers to bat colonies – participants contribute to the wider movement of challenging the longstanding reputation of post-industrial rivers as ecologically depleted (Read 2017).

A mobilities lens draws attention to the Lea's lateral connectivity conditions, specifically the physical accessibility and aesthetic provisions surrounding the Lea that could facilitate or forestall such interactions between people, water and heritage. Indeed, without the clean and cared-for river path, the riverside would remain inaccessible and under-appreciated, leaving the effects of said activities socially and spatially insular. This perspective also emphasizes the contradiction that while mobility alongside the river has improved considerably, mobility toward it has not. The area surrounding the Lea comprises a vast industrial estate with little public transport and even less residential activity. It also constitutes the administrative border between several boroughs, which dilutes environmental responsibility and oversight (Restemeyer et al. 2019). Consequently, the area attracts a great deal of anti-social behavior and remains

a derelict patchwork of "inactive streets, […] disconnected developments and ad hoc industrial sites" (Verdini and Dean 2022, 256–57). These conditions chronically sever the Lea from everyday urban life, resulting in many local residents remaining unaware of its existence.

Other (water-related) physical conditions further obstruct human engagement with the river. For example, because local drainage systems are outdated, parts of the riverside flood during heavy weather. This includes the footpath (fig. 3) between the Lea and the Victorian-era Abbey Mill Pumping Station, which once was a centerpiece in London's wastewater treatment system.

The pumping station represents a principal aspect of the Lea's industrial legacy, namely its designation as a sink and sacrifice zone for London's most undesirable and harmful substances, from industrial pollutants to sewage. Physically engaging with sites like these is essential for people to learn about the Lower Lea Valley's industrial heritage – which underpins many of its contemporary environmental issues – but is undermined by dilapidated walkways and water systems. This signals a paradox between, on the one hand, the professed aspirations of local authorities to restore the Lea's cultural and historical significance (Tower Hamlets n.d.) and, on the other, the protracted negligence of basic mobility provisions.

(In)Visible Currents and Canalization

A second value of a mobilities lens emerges when considering Sodero's (2022) "ecological approach to mobilities," which draws attention to how the mobilities of non-human entities mediate the (mobile) relationships between humans and their surroundings. For example, the movements of weather and water, or the immobility of built infrastructures, can shape the course and condition of rivers and, therewith, the extent to which people can (re)connect with riverine nature and history.

The Lower Lea Valley offers helpful examples. The commendable recent environmental and accessibility improvements along the Lea have occasionally been thwarted by environmental incidents, ranging from chemical leaks to sewage releases (e.g., Laville 2020). An assessment of the causes and costs of these persistent pollution problems remains incomplete without considering the movements, the streams and stagnations, of water itself. Surrounding the Lea is a patchwork of pipes, valves and outfalls which, originating in the Victorian era (roughly 1820–1914), have gradually become saturated with spontaneous, leaky and illegally altered connections. The area's chronic responsibility vacuum further convolutes what is now a largely unmapped and unregulated water network (Bussi et al. 2022). This exposes the river to both "accidental" deposits of harmful sediments, when rainwater washes sediments from surrounding industrial estates and feeds into the Lea, and intentional, illegally dumped toxic substances. Invisible materials, such as tire dust, can have striking and severe impacts on the river's water and ecosystems (Patroncini, Veronesi and Rawson 2014; fig. 4) as can more visible, visceral incidents like mass oil dumps (fig. 5). Either way, (in)visible currents of toxic substances, mobilized by streaming water through unsolicited networks, can mean the difference between a river that is healthy or hazardous for human interaction.

The (im)mobility of the river itself also dictates how people can engage with it and its natural heritage, which remains an underexplored aspect of qualitative urban river research (Kondolf and Pinto 2017). The Lower Lea Valley was originally a marshland in which the Lea moved unrestrainedly with the tides. Its subsequent role as

^ Fig. 4 Algae bloom in the Lea (Source: Maia Brons, 2022).

^ Fig. 5 Oil spill in the Lea (Source: Maia Brons, 2023).

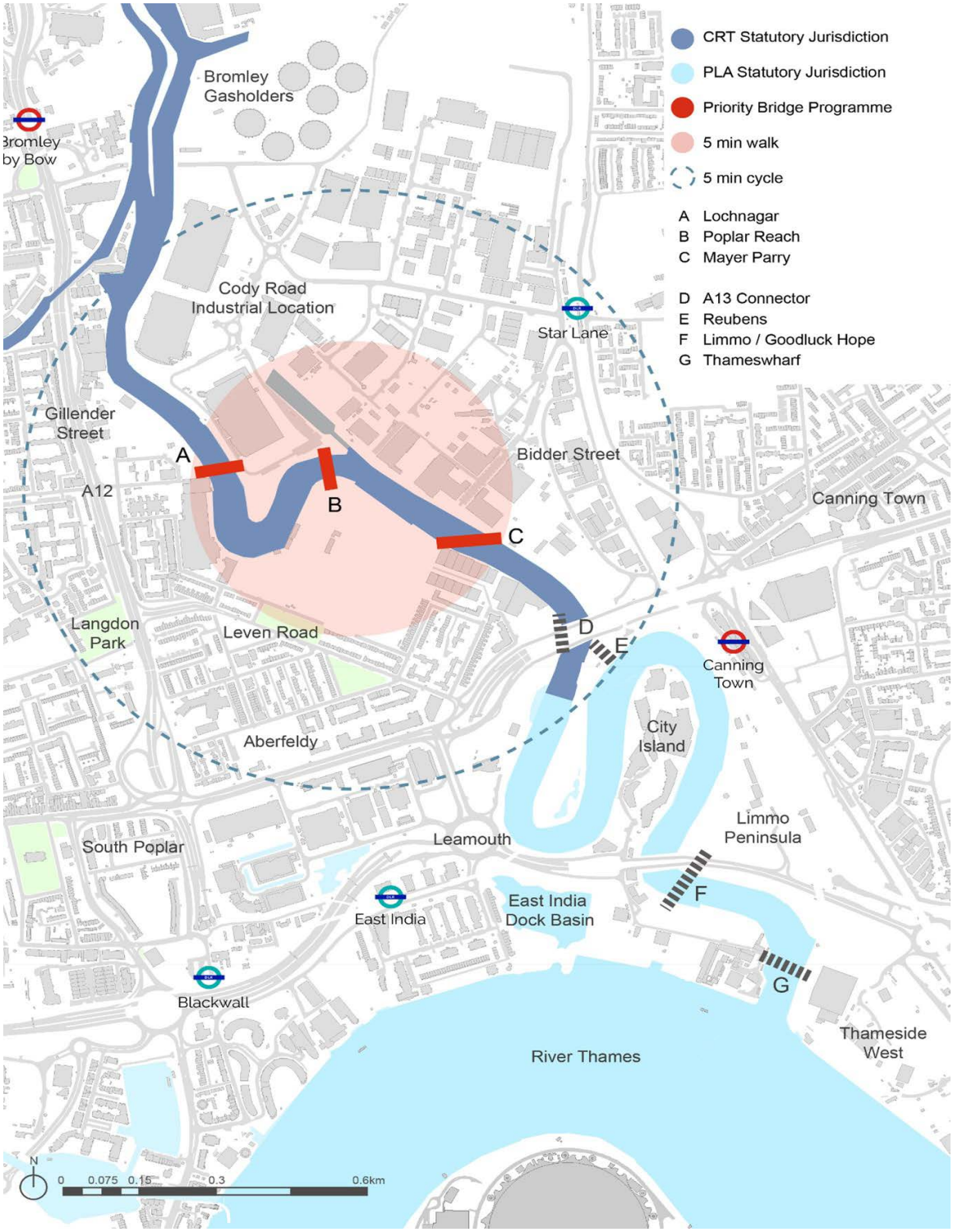
an industrial artery prompted extensive efforts to control, canalize and capitalize on the river (Clifford 2017). An ecological mobilities lens highlights how, a far cry from its original state, today's lower Lea largely remains contained (i.e., immobilized) by its industrial legacy: its banks consist mostly of high impermeable walls; its flow remains dictated by an expansive labyrinth of water-control technologies (Read 2017). On the one hand, these immobilization mechanisms enable human movement around the river and human connectivity with it. The sluices and weirs somewhat stabilize the tidal (highly changeable) river water levels which, together with the hard-surfaced riversides, improve general human accessibility – especially for less mobile people. These human-made provisions also particularly improve conditions for narrow boats to moor along the river. In the Lower Lea Valley this has led to the emergence of several (semi-permanent) boating communities, which, occupying the liminal space between mobility and immobility (Kaaristo et al. 2020), often play important roles in safeguarding local water heritage and strengthening social river connectivity (Read 2017).

Conversely, the Lea's ecological immobilization also imposes mobility (and therewith social and cultural) restrictions on people seeking to (re) connect with the river. As discussed, the water infrastructures surrounding the Lea are undermaintained and unfit-for-purpose, especially considering the increasing volumes of water as urbanization and climate change intensify. The gradual expansion of water-control technologies and impermeable riverbanks has further reduced natural floodplain environments (Gasworks Dock Partnership 2022). As a result, when flood events do occur – when the river "breaks its banks" – the consequences are more extreme, sometimes physically immobilizing communities in neighboring areas and causing considerable spatial (and environmental) damage (Elgueta and Ford 2024). As suggested in Usher and colleagues' (2021) study on mobile community memories of a culverted brook in Manchester, heightened fear of "uncontrollable" water may exacerbate community aversion toward rivers and, thus, damage their social connectivity with them. Furthermore, on an everyday basis, the walls and weirs canalizing the Lea separate passersby from the water surface by several meters. Consequently, the interactions between humans and the river water (including its ecologies) remain somewhat distant and static, resulting in what Kondolf and Pinto (2017) describe as inhibited vertical connectivity.

Safeguarding Scaffolds for Life

The discussion so far has been quite human-centric; highlighting how various infrastructural factors and non-human (im)mobilities may support or suppress human engagements with water-heritage sites. While critically inventorying and improving human mobility is, undeniably, imperative to maximizing the potential of rivers and their natural and historical offerings, so is safeguarding rivers' ecosystems (Houart 2023). A third value of a mobilities lens in studying the water-heritage nexus, then, is its ability to heed the movements and moorings of more-than-human entities. Although ecosystems are indispensable to rivers' natural heritage and sustainability, the mobilities of their occupants are frequently compromised by seemingly progressive accessibility improvements.

The *Lower Lea Bridges* program, co-orchestrated by several borough councils, exemplifies recent regeneration interventions aimed at reintegrating the Lea into East London, specifically by improving riverside accessibility. It involves the construction of three footbridges so the Lea



^ Fig. 6 Map of the *Lower Lea Bridges* program (Source: Tower Hamlets, n.d.).

^ Fig. 7 Coot nesting in an abandoned boat on the Lea (Source: Maia Brons, 2023).

no longer presents a "physical barrier for the local community," but instead starts fulfilling its potential as "one of the most important natural, heritage and cultural assets" in the area (Tower Hamlets n.d.) (fig. 6).

In celebrating the advantages of such initiatives for local residents, their impact on existing ecosystems may be overshadowed – especially when, as has long been the case with the Lea, post-industrial rivers are perceived as having little ecological value, often due to an absence of well-established ecological databases (Gasworks Dock Partnership 2022). However, the image of the Lea as an ecologically derelict "wasteland" (Verdini and Dean 2022, 251) is incomplete. Indeed, partly thanks to its repellent (yet contestable) post-industrial reputation, the Lea saw little human activity for half a century, up until the early 2000s. During this time, animals have been able to construct scaffolds for life without interruption (fig. 7), cultivating a paradoxical post-industrial riverscape that is "murky and rubbish-strewn [but also] ecologically and materially rich" (Wallace and Wright 2022, 188). Demonstratively, through the aforementioned citizen-science data-collection initiatives, the presence of 30 London Priority Species has been reported, alongside that of dozens of threatened and globally declining bird, invertebrate and other species (Gasworks Dock Partnership 2022).

This context throws the plans to reintegrate the Lower Lea Valley into the urban landscape through invasive infrastructural "improvements" into sharp relief: while human mobility may improve, more-than-human mobilities, or entire

habitats, could perish. At the time of writing, the planned construction for bridge A of the *Lower Lea Bridges* program (fig. 6) will likely involve the removal of reedbeds which have grown without disturbance for decades. These reedbeds have essential flood mitigation and water-filtering properties (Verdini and Dean 2022). Moreover, they are indispensable to the mobilities of other more-than-human entities: birds nest in them and fish use them to navigate the tides. Their removal, even to benefit human accessibility, would be detrimental to local ecosystems and the Lea's overall natural heritage. Here, the role of local communities who engage with the river through mobile ecological experiences becomes even more pronounced: they render visible and inscribe social and emotive value to essential, yet often disregarded, river ecologies. This adds weight to the imperative of treating post-industrial rivers as water-heritage sites that should be inclusive not only of a variety of people and abilities, but also a variety of species.

Conclusion

At the junction of rampant urban regeneration and persistent environmental pollution, the task of studying post-industrial rivers and their natural and historical heritage – and optimizing ways to (re)connect communities with them – becomes ever more important, but also more intricate. A mobilities lens, if used critically, can illuminate new ways to understand not only the physical mobility provisions necessary for human accessibility and aesthetic needs, but also the (im)mobilities of infrastructures, ecologies and more-than-human species that shape water-heritage sites and human interactions with them. A mobilities lens can constitute a symbolic bridge between past and present as well as between different stakeholders, spaces and species. Strengthening these connections is a crucial step in mapping the opportunities and challenges of post-industrial rivers as key water-heritage frontiers. Although the conceptual confluence of mobility, water and heritage requires more careful consideration, it holds the potential to inform river regeneration initiatives (including the building of actual bridges) which, rather than trampling valuable ecosystems, can revive relationships between communities and rivers, in spite – or in appreciation – of industrial ruination.

Policy Recommendations

- Policymakers, local authorities and urban planners may benefit from incorporating mobility as a key tenet of (post-industrial) river regeneration schemes. Adopting a holistic approach to mobility, as demonstrated in this paper, may improve the sustainability and inclusivity of projects, both for urban communities and local ecologies.

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Climate Change Threatening Archaeological Heritage in (Former) Riverbeds

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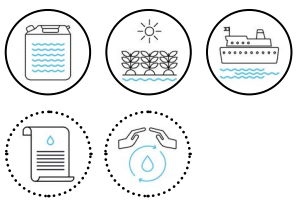
Water has always played an important part in societies. It has created and damaged, also threatened and saved societies throughout their existence. Its absence has done the same. Our rivers and seas contain evidence of this history and contain important parts of our cultural heritage, including underwater cultural heritage. Changing water levels – whether they lead to flooding or drought – challenge people's livelihoods and threaten our heritage in (former) riverbeds, lakes and seas. Hunger stones, drowned villages, waterworks and shipwrecks all provide insight into the long history of human settlement. However, their sudden appearance due to climate change does not always allow for careful exploration. Long-term strategies are needed to assess underwater heritage, investigate and preserve it. This article explores the challenges and opportunities of underwater heritage that arise from climate change, with a focus on Dutch rivers.

Keywords: *rivers, riverbeds, underwater heritage, climate change, flooding, drought*

KEY THEMES



< Fig. 1 Close-up view: The dynamite ship Elisabeth exploded in 1895 in the Rhine River, near Spijk and Tolkamer on the Dutch-German border. Due to extreme low water levels the wreck has surfaced (Source: Vincent Jannink / © ANP).

Underwater Heritage and Rivers

In the summer of 2022 the drought in Europe revealed the vulnerability of human society. Rivers dried up, immediately constraining activities like agriculture and recreation and threatening drinking water supplies and the transport of goods, even the cooling of factories and nuclear installations (fig. 2).

Rivers have been used for shipping, farming, fighting and as a food source for millennia. Now these resources – for many – suddenly seem not so reliable as often thought. However, a temporary absence of water is not completely new. The "hunger stones" discovered in German (fig. 3), Czech and Hungarian rivers have shown us that a low water level has meant disaster and hunger in previous centuries (Henley 2022). We should be warned! The earliest known stones date from the early fifteenth century, like those found in the Elbe River in Děčín, the Czech Republic. Throughout the centuries, whenever the hunger stones have surfaced, people added up the years of low water marks. The name "hunger stone" refers to the famines that coincided with the extreme low water levels. To mark the drought of 2022, the climate action group Extinction Rebellion placed a new hunger stone in the Rhine near Lexkensveer in Wageningen (fig. 4). Will it be a warning that pops up every so many years, decades or centuries, or will this stone soon be visible every year or even the whole year round?

Rivers are important elements in the landscape. They serve an important function by transporting fresh water from the inland to the sea. In doing so they become the lifelines, the arteries, of the landscape and the communities within. Often, the small summer riverbeds are not enough to cope with the large amounts of water that appear in autumn, winter and spring.

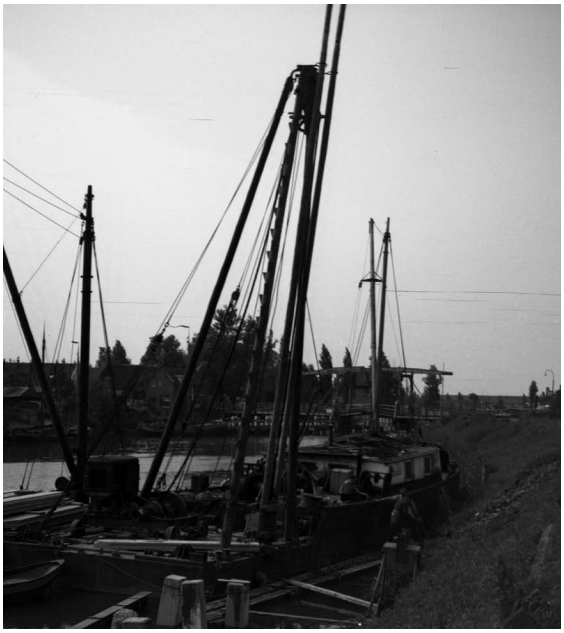
^ Fig. 2 Low water levels in the river Waal in the east of the Netherlands (Source: Martin van Lokven / Rijkswaterstaat).

^ Fig. 3 The Wehlener Hungerstein, City of Wehlen, Germany (Source: Dr. Bernd Gross, CC BY 3.0, via Wikimedia Commons).

^ Fig. 4 The hunger stones that was laid down by Extinction Rebellion in the river Rhine at Lexkesveer, Wageningen, the Netherlands (Source: Extinction Rebellion, CC BY 4.0, via Wikimedia Commons).

The rivers then overflow their banks and occupy a larger stretch of land. This process may cause inconvenience, but in the past was also seen as a way that land could be fertilized. A threat, but also helpful. Dikes were built to restrain the river: lower dikes along the summer riverbed and higher ones along the wider winter riverbed. Still, extreme amounts of water would occasionally cause flooding, destroying houses, sometimes killing thousands of people and animals. Over time, rivers have also been prone to meandering through the soft sediments of large delta areas like those found in the Netherlands, creating floods, demolishing road and railway infrastructure and the quays, bridges and the houses of people living nearby. Entire villages have been swallowed. Although devastating, these water changes have left a wealth of information in the soil about our past. This is the archaeological resource.

The role of rivers as arteries of mobilization and trade is reflected in the many wrecks that can be detected and investigated in existing and former riverbeds (fig. 5). Although most trained underwater archaeologists are focused on research in the sea, important shipwreck finds have been made. Dutch examples of magnificent finds in (former) riverbeds have been discovered in Zwammerdam (fig. 6), Woerden and Vleuten-De Meern concerning the Roman period and Utrecht, Wijk bij Duurstede, Tiel and Deventer for the early Medieval period. Archaeological evidence has been found for earlier and later periods, including prehistoric finds along the Ijssel and World War II wrecks, for example a mini-submarine *biber* (beaver in German) in the Waal near Nijmegen. Most findings were made on dry land, in former riverbeds. They show the potential of former and current riverbeds in the Netherlands to reveal more about the long-term past of river shipping and historic trade networks.



^ Fig. 5 Mid-twentieth century work ships on the river Eem at Eemnes, the Netherlands (Source: Rene Keijzer).

^ Fig. 6 A Roman shipwreck found in a former riverbed in Zwammerdam, the Netherlands (Source: Cultural Heritage Agency of the Netherlands).

Floodplains, Groundwater and Archaeology

The channelling of rivers, the construction of double dikes (dikes for summer and winter), and actions to regulate the flow of water have not only protected people from flooding, but also have created a sense of safety and extra space to develop, to let livestock graze or plant crops. The areas between the dikes are called *uiterwaarden* or floodplains and have been developed from temporary water storage (winter) locations in combination with seasonal areas of use (grazing in the summer), areas for building and for substantial agricultural uses. The construction of settlements requires lower groundwater tables than the original floodplains. This has had important effects: people started to live in areas that were meant as a buffer against disasters and as a result flooding once again became a major challenge and a serious threat. Also, these areas lost their other function, that of storing reserve water. This may have consequences for water storage overall at a time when we need to be resilient against severe drought. Drought may become a huge problem in the (near) future and a challenge to overcome when water levels in the rivers drop dramatically as in the summer of 2022. So far, the Netherlands has experienced only one serious summer of drought, but this experience should provide a foundation for future learning.

While climate change is transforming rivers, these arteries of past and present societies host archaeological heritage in the ground that is in immediate danger of deteriorating or even disappearing – without ever being discovered – at times of drought due to low groundwater tables. Still, these are places that offer the most amazing and well-preserved finds (fig. 6). The low oxygen levels, wet clay and peat environments preserve organic materials very well but river floors are delicate areas that need to be managed carefully.

For decades the banks and floodplains of rivers have been neglected as a possible source of information about our past. Some examples of this neglect are even quite recent. The *Over de Maas* [*Over the Meuse*] project produced an enormous number of finds that were made in an old riverbed that was rated by the government to be of low archaeological value because it was lying in the winter riverbed of the Meuse River. It is said that about 100,000 individual objects were recovered, from the prehistoric period to recent times, from building fragments to complete shipwrecks (*Historiek* 2017). However, new initiatives, such as the "Archeologische verwachtingskaart uiterwaarden rivierengebied" ["River Area Floodplain Forecast Map"] – put more emphasis on prediction, protection and management in these areas, which starts with understanding their characteristic features (Popta and Arnoldussen 2015).

Archaeologists at first may see low water levels as a great opportunity for new discoveries along shores and riverbanks (fig. 7). However, most archaeological sites do not benefit from being exposed to air. Wood dries out and iron corrodes at a fast rate. In fact, low water levels are devastating for the preservation of historic shipwrecks, which are a unique and non-renewable resource. If we add up the length of rivers, canals and ditches, we come to hundreds of thousands of kilometers of inland shores, not including the many lakes and the former river and lake beds. Potentially this fluvial resource and that of other maritime cultural heritage is very rich.

There is, due to the size of area, no way to survey underwater sites in rivers during sudden droughts – like the one in 2022 – let alone to follow up on the surveys made to assess and protect the exposed sites. Citizen science approaches may be a good solution: many eyes

^ Fig. 7 The dynamite ship Elisabeth exploded in 1895 in the Rhine River, near Spijk and Tolkamer on the Dutch-German border. Due to extreme low water levels the wreck has surfaced (Source: Vincent Jannink / © ANP).

and ears may lead to findings and volunteers may lend their hands to excavation work. A professional validation of that work is however always important. As soon as water levels rise again, the sites will be covered with water, but the damage due to their exposure will already be done, irreparable and with much information lost.

As mentioned, floodplain areas have been used for dwelling and agriculture. Consequently, more control of groundwater levels is important. Low groundwater levels may seem ideal for construction and agriculture. For farmers, less water means that they can grow the crop they want and for builders it means that they can build foundations for houses without water issues. Such uses however, are a challenge for other interest groups in the area, including nature conservators, historic house owners, preservationists and archaeologists. For these groups, a change in groundwater levels means less biodiversity and an oxidizing soil, leading to fast deterioration especially in peaty areas, and a huge threat for the invisible archaeological heritage that lies in that soil (Roorda et al. 2020). How many of the traces of our past will disappear before even being discovered? We do not know that precisely. Earlier research in the EU-funded *BACPOLES* project (2002–2005) on changing groundwater levels has clearly shown the devastating effects on wooden foundations of houses and buried archaeological resources (Klaassen 2005).

^ Fig. 8 High water at Ooijpolder at Tiengeboden, the river Waal, the Netherlands (Source: Bart van Eyck / Rijkswaterstaat).

Protected Late-Neolithic sites in the province of Noord Holland have heavily deteriorated as a result of agricultural use and changing groundwater levels.

In the 1990s, many efforts to tame the rivers and to take control of the precious areas alongside them proved to have been made in vain. The severe river flooding in 1993 and 1995 forced the Netherlands to think differently about their strategies and new plans were developed based on the centuries-old way people once lived with the water surrounding them: basically "go with the flow." The project *Room for the River* (2000–2019) was born (Rijke et al. 2012). With respect for the force of nature, the existing floodplains were once again used the way they were intended and additional areas were appointed as overflow areas (fig. 8). Efforts to avert the dangers of uncontrolled flooding may also be part of the solution for the droughts we may be experiencing in coming decades. Too much water in winter, and not enough in summer: the large areas alongside rivers may be used as water storage for the dry months to come. This scenario, however, also means that we have to hold the winter surplus of water longer than we would now. The result may be that some areas cannot be used for anything else. A discussion of different values, priorities and aims needs to take place. We can do one thing, but not always do the other also. Choices must be made. Is this possible? Can we do this? Holding water longer for dry periods to come? Or is this an illusion?

Another issue with rivers and groundwater is access to fresh water. The battle for fresh and

clean water has already started. Many areas in the world have trouble building up reserves for the future. Examples include the Aral Sea in Uzbekistan and Kazakhstan and the Colorado River in the US. Although climate change contributes to the problem, political and personal choices make the situation worse. Large river systems are not being managed as a whole, while each country, each municipality, and each farmer is taking actions independently, often contributing to the problems experienced by those downstream. Water is being measured through the need of individuals or small groups of people, hardly for a whole nation, let alone in relation to what is needed by the natural environment. Whole areas are transforming from swamps to arid areas and from arid areas to deserts. This lack of cooperation and the devastating results can be observed in the Donau-Black Sea Region, where unique swamps are under severe threats due to a lack of water, misuse of water and pollution. Pumping up water, lowering groundwater tables, sea-level rise and extreme drought also cause salinization, mainly in coastal areas. Land becomes unsuitable for agriculture, even as grazing land. We are starting to see these effects in the Netherlands, especially in the lower western parts of the country. What can we do about these problems? Can we only adapt to the changing situations? Or can we also do something to stop them from happening? And how does this relate to maritime and underwater cultural heritage? As shown above, we can learn from our ancestors, from how they used water as an important element in their communities. We can protect against disaster, but also benefit. We can adapt to changes, but also prevent problems or even restore some of what we have lost. There are ways: some innovative, some hundreds of years old. The past can bring us solutions for the future.

Policy Recommendations

- Water management should include the protection and management of (underwater) cultural heritage, which is a rich resource for understanding our past. Policies pertaining to rivers – arteries in the landscape – need to be all-inclusive to overcome the threats triggered by climate change.

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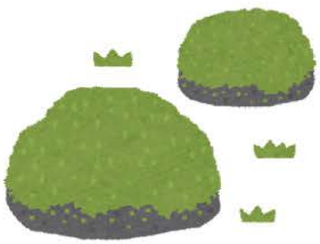
What's your relationship with the river?

Please take a moment to fill out the survey.
Your input will help us better manage our rivers!

Your Voice Matters

We are a research team from the laboratory Citeres - Umr 7324 Cnrs of the University of Tours in France.

This questionnaire is carried out under the auspice of UNESCO Chair River Culture – Fleuves et Patrimoine and coordinated by the Global Network of Water Museums.



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A Global Questionnaire Survey to Understand Human-River Relationships

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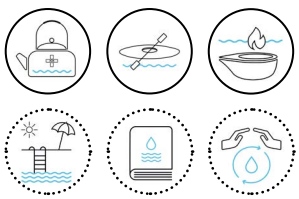
Urbanization has altered natural waterways, leading to a growing disconnection between humans and rivers and the loss of river culture – the co-evolution of biocultural diversities in riverscapes. To combat this trend, efforts to restore rivers are reintegrating them into urban environments as green-blue infrastructure. Recognizing evolving human-river relationships, this article introduces a GIS-based survey aimed at exploring societal perspectives on the roles of urban rivers, particularly to counter the "extinction of experience" with nature. Drawing on previous studies of public interactions, perceptions and evaluations of urban rivers in France and China, this international survey, available in seven languages and in collaboration with a UNESCO-IHP flagship initiative, the Global Network of Water Museums (WAMU-NET), seeks to promote the development of Urban Human-River Encounter Sites (UHRES). Through comparative analysis, the goal is to foster a harmonious coexistence between humans and biota – an eco-social approach to revive river culture in contemporary cities.

Keywords: *river culture, human-river relationship, social science methodology, river management, urban river restoration*

KEY THEMES



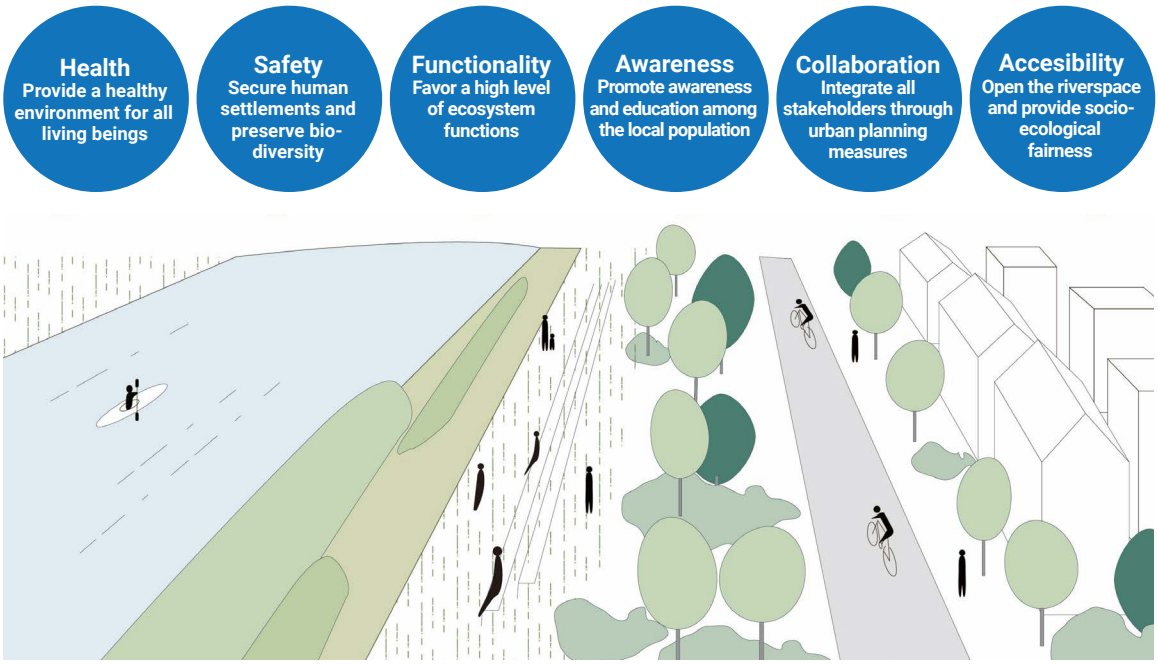
< Fig. 1 Graphical abstract (please scan the QR code to access the questionnaire) (Source: Yixin Cao, 2022).

Introduction: Human-River Relationship

In the Anthropocene, with unprecedented pressures from global warming, industrialization and urbanization, rivers face numerous environmental challenges. These include pollution, devastating flooding, the loss of riparian vegetation and highly engineered morphological structures (Wantzen et al. 2019). Globally, monitored freshwater fauna and flora has declined 83 per cent since 1970 (WWF 2022). Only 37 per cent of rivers longer than 1,000 km remain entirely free-flowing worldwide (Grill et al. 2019). Human-nature experiences associated with rivers are also diminishing, leading to a loss of cultural diversity and practices and adaptation strategies involving river rhythms (Jackson et al. 2022). The decline of cultural heritage in river floodplains affects people's spiritual and cognitive connections to rivers (Hikuroa et al. 2021). Introduced by Wantzen and colleagues (2016), the concept of river culture suggests that rivers' pulsing hydrology nurtures both biological and cultural diversity in riverscapes. River culture is particularly endangered in modern cities where rivers and streams have been straightened, buried and channelized to protect against flooding and to facilitate dense urban living.

In recent decades, river restoration has emerged as a trend to re-establish human-river relationships, particularly in urban settings. The restoration of urban rivers to a state closer to their natural condition often coincides with a city's economic and social development (Brun 2015). Common goals include providing direct sensory (e.g., visual, auditory, olfactory) contact with nature (Soga and Gaston 2020; 2022). However, river restoration projects often make little attempt to understand how people interact with and perceive urban rivers and a disproportionate amount of attention is given to hydrological and ecological aspects (van den Born et al. 2021). The need for socially and culturally sensitive approaches is becoming more evident as river restoration increasingly concerns the wider society (Carré, Haghe and Vall-Casas 2021). Failure to involve the social aspect of river restoration can lead to project failure, as exemplified by the failure of a dam removal project in the Sélune River of France due to a lack of public support (Germaine and Lespez 2017).

Social surveys serve as a tool for investigating the public perspective of the multifaceted values of urban rivers and promoting the integration of societal aspects in river restoration (Le Calvez et al. 2021). The survey "Human-River Relationships" provides a comprehensive understanding of public perceptions and evaluations of the urban river environment, as well as their preferences and suggestions for ongoing or future river restoration projects in cities. This survey is timely, accompanying the rapid development of nature-based solutions while numerous urban rivers are being transformed into public open spaces (Durán Vian, Pons Izquierdo and Serrano Martínez 2021; Prominski et al. 2017), and it aims to simultaneously enhance rivers' ecological functions, improve flood mitigation capacity and provide recreational opportunities for local citizens. The goal of the survey is to help build a Urban Human-River Encounter Site (UHRES) (Zingraff-Hamed et al. 2021) by examining the dynamics of social-ecological interactions related to urban rivers. A UHRES introduces new materialist thinking (Greenway 2023) about human-river relationships that does not prioritize human development (Zingraff-Hamed et al. 2021). Comprising six tenets (fig. 2), the UHRES approach aids in revitalizing river culture in urban areas and shaping a new mindset compatible with a sustainable human-nature relationship. On a practical level, the survey results can help transform UHRES tenets – health, safety, functionality, aware-



^ Fig. 2 The Urban Human-River Encounter Sites (UHRES) framework with its six tenets: health, safety, functionality, awareness, collaboration and accessibility (Source: Yixin Cao, 2022).

ness, collaboration, accessibility – into actionable suggestions for urban planning and aid policymakers in considering local needs. They also assist in guiding future initiatives aimed at raising environmental awareness, enhancing ecological education and promoting river stewardship among the population to reach the UHRES goal of the coexistence of humans and non-human beings within urban river corridors.

Measuring Human-River Relationships – A GIS-Based Public Survey

To understand evolving human-river relationships in various geographical and sociocultural contexts, I have developed a public survey under the auspices of the UNESCO Chair River Culture – Fleuves et Patrimoine[1] and with assistance from the Department of Geography at Hong Kong University (HKU). The questionnaire was initially designed through discussions among researchers from the CITERES - UMR 7324 CNRS[2] laboratory at the University of Tours in France. It was later modified based on similar questionnaires used in a study conducted during the 2021 Science Festival in Tours, France (Cao and Wantzen 2023), as well as in PhD fieldwork in three Chinese cities (Wuhan, Hangzhou, Chongqing) in the summer of 2022. Following consultation with directors of water museums worldwide (WAMU-NET 2022), the survey is now being distributed in partnership with UNESCO's Global Network of Water Mu-

1. https://www.unesco-chair-river-culture.eu/
2. http://citeres.univ-tours.fr/

^ Fig. 3 Urban river restoration scenarios 1-4 (from left to right, up to bottom) made using Adobe Photoshop CC (Source: Yixin Cao, 2022).

seums (WAMU-NET)[3] and is available in English, French, Italian, Spanish, German, Chinese and Croatian. Each language version has been proofread by a native speaker.

The questionnaire, developed from two empirical studies – one in Tours (Cao and Wantzen 2023) and another in three Chinese water museums (Cao, Chen and Wantzen 2024) – has been enhanced with detailed adaptations for international participants. It includes a variety of formats (i.e., single-choice, multiple-choice, five-point Likert scale, open-ended questions) to capture a comprehensive range of responses. It explores six topics: (1) the participant's closeness to the river, (2) recollections of childhood experiences interacting with rivers, (3) valuation and perceptions of the river in the participant's city, (4) expectations of urban river restoration, (5) willingness to participate in river management and (6) the participant's socio-economic characteristics. Using a GIS platform, participants are requested to pinpoint their favorite riverside spot on a street map, which defaults to their GPS location. They are also encouraged to upload images (e.g., from their smartphones) of their favorite river site in their city. Both questions about locations are optional.

To examine topic 4, expectations of river restoration, we created four scenarios based on a simulated image using Adobe Photoshop CC (fig. 3) with added or removed individual restoration elements such as river meandering, concrete bank protection, revegetation, stone placement and recreational amenities – each

3. https://www.watermuseums.net/

Name of the museum	Location	Survey language
Yaku Water Museum Quito	Quito, Ecuador	Spanish
Le Musée de l'Eau et de la Fontaine	Ottignies-Louvain-la-Neuve, Belgium	French
Museum of River Navigation (Museo Civico della Navigazione Fluviale)	Battaglia Terme, Padua, Italy	Italian
National Water Museum of China	Hangzhou, Zhejiang Province, China	Chinese
AQUATICA Freshwater Aquarium	Karlovac, Croatia	Croatian

^ Table 1. The water museums of the WAMU-NET network currently distributing the questionnaire survey (Source: Yixin Cao, 2022).

element depicted in the scenarios is linked to one or more urban river values. The water in each scenario was adjusted to the same shade of blue in all scenarios, signifying an overall enhancement in water quality. The four scenarios aim to address potential conflicts between recreational use and the conservation of natural habitats in restored urban riparian sites, as explored in previous studies (Zingraff-Hamed et al. 2018, 2022; Cao and Wantzen 2023; Cao, Chen and Wantzen 2024). To explore topic 5 about possible participation in river management, an optional open-ended question asked for participants' suggestions regarding future river management in their city. Potentially sensitive socio-demographic questions about education and income level were placed last to avoid any discomfort about those questions discouraging participants from completing the survey.

The questionnaire is expected to be completed online using the ArcGIS Survey123 platform (https://arcg.is/1OHDG00, which can be opened in a browser directly) and executed on-site. A poster, translated into the local language (see example in fig. 4), is displayed in the entrance hall of each participating water museum. The poster features a QR code linking to the questionnaire and provides information about the study while adhering to research ethics. Museum visitors are randomly invited to take part in the survey anonymously by scanning the QR code with their smartphones or tablets. Museum staff can offer instructions if needed. The questionnaire takes approximately 15 minutes to complete, and no incentives are provided for participation. The questionnaire survey is currently being distributed among several water museums within the WAMU-NET network (see table 1). Data collection for the survey is expected to proceed worldwide through the end of 2024. The data analysis phase will begin after all gathered information has been translated from local languages to English. In collaboration with HKU, Iwill employ both quantitative and qualitative analytical approaches. The study will utilize descriptive analysis and inferential statistics to uncover correlations between variables. One key aim is to explore the correlations between people's childhood experiences of rivers, their current perceptions and preferences regarding river restoration scenarios, as well as differences among various demographic groups. Additionally, qualitative coding will be applied

^ Fig. 4 Exemplary poster in Spanish utilized in museums for disseminating the questionnaire (Source: Yixin Cao, 2022).

to the visual content of respondents' submitted photographs of favorite river sites in their cities. This will help identify specific elements related to river systems that are preferred and the underlying cultural reasons for those preferences. Furthermore, an international comparison will be conducted to understand human-river relationships in different geographic, political and sociocultural contexts. For instance, I aim to examine differences between attitudes toward sacred rivers among Indigenous populations in Latin America and urban citizens' perceptions of restored European riverscapes as well as attitudes toward concreted river sites used as flood defenses in densely populated Asian cities. This comprehensive analysis will offer insights regarding how people interact with and perceive river systems in various global settings.

Expected Results and Conclusion

The survey is centered around the concept of river culture and UHRES and the primary objective of the research is to shed light on the long-standing, inseparable connections between humans and rivers that have been forgotten in today's industrialized and urbanized societies. The survey investigates the role of rivers in mitigating the "extinction of experience" (Soga and Gaston 2016), making it possible to analyze the variety and scope of human-nature interactions that rivers facilitate, including potential negative aspects. Specifically, inferential statistics will ascertain whether a river's role during an individual's upbringing influences their current perceptions of urban rivers. This outcome will contribute to ongoing research focused on cultivating biophilia and avoiding biophobia among children and examining their impact on pro-environmental behaviors in adulthood (Cho and Lee 2018; Hughes et al. 2019).
Secondly, understanding public perspectives of urban rivers can contribute to involving stakeholders and the public in the social-ecological restoration of rivers (Germaine et al. 2021). The public survey aims to integrate the "social sphere" with the "biophysical problem-sphere" and identify a "solution sphere" – such as a river's social-ecological restoration – that gains social acceptance and support (Wantzen 2023). The feedback collected through the citizen-science method in the survey will also provide practical recommendations for the successful implementation of UHRES. Specifically, this result will help identify the necessary trade-off between different ecosystem services (Turkelboom et al. 2018) of river systems and help identify strategies to mitigate potential conflicts while transforming urban rivers into multi-functioning nature-based solutions.

Finally, I plan to conduct an international comparative study by analyzing survey results from various geographic locations. This could potentially reveal significant disparities due to localized socio-economic contexts and provide site-specific suggestions for establishing UHRES in different areas. In conclusion, understanding human-river relationships allows us to encourage the harmonious coexistence between humans and biota within urban corridors (Zingraff-Hamed et al. 2021) and in the future contribute to an integrated river management scheme. By establishing sustainable human-river relationships that are grounded in ethical considerations (Strang 2020), we can ensure long-term benefits for future generations.

The use of social science methodology, particularly through a questionnaire targeting the public, represents an innovative approach to studying human-river relationships. This method is at the forefront of understanding rivers' social connectivity and river culture's influence on urban citizens, shifting the focus from the tradi-

tional emphasis on hydrological and ecological aspects to viewing rivers as complex social-ecological systems. Collaborating with WAMU-NET, a UNESCO-IHP flagship initiative (Resolution nº5 – 23rd Session of the Intergovernmental Council of IHP), to study museum visitors' perceptions and backgrounds will help explore the WAMU-NET's international impact and improve environmental education with more interactive initiatives for the public. The results will also be instrumental in reinforcing international communication among water museums. In terms of the results, the study's transnational and transcontinental comparison is unparalleled in its scope, aiming to understand the evolving dynamics of human-river interactions globally. A key objective is to uncover disparities in river restoration practices between the Global North and South, as well as the varied aspects of river culture across different cultures. Additionally, by incorporating transdisciplinary methods and formulating actionable suggestions for establishing UHRES for policymakers, the survey aims to foster a more collaborative approach to river governance by bridging the science-policy-society gap, effectively aligning the SDGs.

Policy Recommendations

- Social science methodology should play a crucial role in studying the evolving relationships between humans and rivers in modern cities.
- Urban river restoration should integrate societal needs and relations, rather than focusing solely on hydrological or ecological aspects.
- International comparison aids in analyzing the evolving human-river relationships across sociocultural contexts.

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The author extends gratitude to the Global Network of Water Museums (http://www.watermuseums.net/) and the UNESCO Chair River Culture - Fleuves et Patrimoine, granted to Professor Karl Matthias Wantzen.

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Design-Based Solutions for Water Challenges: The Value Case Approach

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The concept of values has become increasingly important in many fields, including water management, heritage preservation and design. Politicians, economists, water managers, heritage specialists and designers often consider values as guiding principles for their interventions. While water management has traditionally focused on technological and economic values, in recent decades there has been growing recognition of the significance of socio-cultural aspects. This shift is evident in initiatives like the United Nation's Valuing Water Initiative, which recognized five "Valuing Water Principles" as guidelines for incorporating the values associated with water in decision-making. However, how to define and implement these values in particular contexts has not yet been clearly established, with approaches varying across disciplines and fields. Understanding the complex interdependencies and values characterizing each water system can help develop a strategy for integrated management of water with the goal of sustainable development with a long-term perspective and a design focus.

Keywords: *values, value case approach, water values, ecosystem thinking, long-term perspective*

KEY THEMES

< Fig. 1 Purification rite at the Tirta Empul Temple, Bali, Indonesia (Source: Jorge Láscar 2023, CC BY-2.0, via Wikimedia Commons).

Introduction

Today's water challenges are complex and multifaceted. The way we respond to these challenges depends on the values embraced by various stakeholders, including politicians, economists and citizens, whose needs and expectations do not always align. Over time, different actors have shaped the flows and practices of water systems spatially, institutionally and culturally, bringing forward certain values instead of others, creating path dependencies and affecting the present and future of water systems. Ethical standards, know-how, belief systems and material constraints have shaped responses to past and contemporary water challenges. These responses range from technological and economic interventions to a focus on what seems most socially just and culturally inclusive. Consider an example of competing values: the needs and interests of stakeholders who make a living from river shipping may be opposed to those of people who wish to swim in the river or those of the animals and plants in the ecosystem.

After more than a century of technology- and economy-focused approaches in water management, there is a strong need for solutions that respond to multiple challenges at the same time and trigger positive ripple effects at various spatial scales – from neighborhood to city and territory. The necessity to overcome sectoral approaches is recognized by scholars in diverse fields. Rob Tulder, professor of international business and society management, and his colleague Eveline van Mil have argued that value propositions "of companies need broadening, from short-term 'shareholder value' to one that includes all (present and future) stakeholder interests" (Tulder and van Mil 2023, 419). Such an approach can help in designing more inclusive and sustainable programs, projects and systems to prevent negative side effects and to strategically create direct and indirect positive outcomes for the public and the environment (Tulder and van Mil 2023).

This approach is also relevant for the water sector, as the quality, availability of and access to water directly impact economic development, social justice, health, education and all other areas of sustainable development. Gilbert Houngbo (2023), chair of UN-Water, puts it bluntly: "The lack of progress on water and sanitation is jeopardizing the entire 2030 Agenda for Sustainable Development. [...] Just as negative water-related consequences flow through every major challenge, so too would positive water-related solutions have an impact on every social, economic and environmental challenge." Mono-directional strategies are no longer sufficient and new approaches should consider border ecosystem thinking. In this context, the SDGs can can be a catalyst for addressing "wicked problems," that is, complex and difficult-to-solve issues that have interconnected causes and no clear solution (Tulder and van Mil 2023). As Sandra Pellegrom (2023), the Dutch SDGs coordinator, has pointed out, the SDGs function as a system, and there will have to be a balance among different goals. A careful understanding of which values shape stakeholders' logic and interests can shed light on solutions able to address multiple needs and create positive ripple effects for all parties in the context of intervention.

How to define and assess values, including in the water management field, remains an open question (Hein et al. 2023), even as many international institutions and programs have promoted the idea of valuing water, arguing there is a need to consider water to be more than its economic value. For instance, both the World Bank and the International Water Resource Program (IWRM) propose a method of valuing water in their guidelines (UNEP n.d.; IWRM Action Hub n.d.; World Bank n.d.). The 2018 UN High-Level

Panel on Water defined five "Valuing Water Principles," the first of which highlights a need to "recognize and embrace water's multiple values" (UN-Water 2021). Yet, the suggestions provided by the IWRM and World Bank still treat water as just a resource (Orlove and Caton 2010), an approach that contradicts the UN General Assembly's recognition of water as a human right since 2010. Organizations like UNESCO link values to education as evidenced in slogans like UNESCO's "Change minds, not the climate" that speak to human agency in structural changes (UNESCO 2016). However, there is still little clarity on how to investigate and leverage these values that are recognized as linked to collective and individual interests, to social and cultural practices that change in space and time, and to human rights (Orlove and Caton 2010; Porta and Wolf 2023).

Values beyond the Economic

As a noun or as a verb, the term value has several meanings (Britannica Dictionary n.d.). Yet, the underlying concept is the same. As anthropologist David Graeber has argued, "The fact that we use the same word to describe the benefits and virtues of a commodity for sale on the market [...] and our ideas about what is ultimately important in life [...], is not a coincidence. There is some hidden level where both come down to the same thing" (Graeber 2013, 244). The "hidden level" lies in the conscious or unconscious action of attributing qualities, assessing and estimating. Writing decades before Graeber, Clyde Kluckhohn (1951) provided a comprehensive definition of values as individual or societal conceptions that shape our perspectives and guide our choices according to material constraints and socio-cultural ways in which our spaces and practices are organized. For instance, achieving economic outcomes can be the conception behind our actions and, therefore, the value guiding the choices we make. On the other hand, increasing ecological justice might be the value guiding a project, and the project will then involve actions that might be less financially profitable but in line with what is considered most "desirable" or just for people, plants, animals and the broader environment. Values shape our thinking and decision-making; however, individuals and groups often hold multiple, sometimes conflicting, values. Similarly, objects or systems of objects can embody a diverse range of values. Sometimes values are determined by external factors, like the price of water at a particular time and place; other times, evaluations are intrinsic to our way of understanding and engaging with water and water bodies, which, in Maori culture, would be spiritually, and for tourists, aesthetically.

How we live with water results from technology, lifestyles and values at a specific point in time; heritage, which results from past practices, gives insight into values and value dynamics over time. What we value as a community at large and choose to preserve is captured in institutional definitions of heritage, notably UNESCO's World Heritage Convention of 1972 and subsequent documents. UNESCO distinguishes between natural, cultural and mixed properties of "outstanding universal value" (UNESCO 1972), as well as intangible heritage (under the Convention for the Safeguarding of the Intangible Cultural Heritage 2003). These are deemed worthy of special protection from the dangers that increasingly threaten them. Note that the definition of Outstanding Universal Value assumes there are values that are universally shared. Even though conceptions of what is valuable and desirable change along with societies, the decisions taken and the (infra) structures created remain, creating legacies and path dependencies affecting current practices, built landscapes, and ways to engage with water. In this sense, historical and heritage analysis become extremely important not only to under-

stand what dynamics and driving forces have shaped current situations – and created current challenges – but also what values were handed down to future generations. In the context of water, the combination of tangible structures and intangible practices – ranging from dams to praxis in water management – inherited through time represents the water heritage of societies – even if it is not officially recognized.

To summarize, values are *multiple*; different actors are likely to have different values because values are *situational*; they generate from everyday experiences, ideologies, interests and needs. Furthermore, values are *hierarchical*: people prioritize certain outcomes and actions above others by conceiving something as more right or appropriate than something else (Robbins and Sommerschuh 2016). Thus, values become intrinsically *political*, as certain perspectives will be considered more appropriate than others according to actors' ideologies (DuBois and Salas 2021). Values are also *dynamic*: they evolve as societal preferences, technologies, politics and economic conditions change. Finally, values are *embedded*: they continue to shape us through the built environment, the institutions and the practices established in the past.

Value-Based Design

The values we inherit and the ones we adopt to design solutions and interventions will create the heritage of the future. Values are often tacit and embedded in the design process and the values brought forward with interventions are the ones of decision makers, varying according to personal, professional and socio-cultural preferences and ideologies. For instance, the water meter, an instrument to monitor households' use of water, has been used by South African policymakers to encourage citizens to adopt a more responsible and calculated use of water and to reform the practices of water users and make them the more desirable ones (Von Schnitzler 2008). This particular water infrastructure, the water meter, had both technical and political purposes and ultimately was used to nudge citizens to change their behavior, therefore it also had social values (Larkin 2013).

Architectural researcher Elise Van Dooren (2020) argues that the values driving the logic and design of interventions need to come to the surface in the process of creation and preparation, to be able to discuss them properly. In line with the arguments of David Mosse (2004), expert in policy and development strategy analysis, we propose that relevant stakeholders need to recognize values and interests and they need to translate and broker them in order to implement them in participatory deliberation processes as the foundation of every project. To implement value-based approaches, it is necessary to first identify the values that are embedded in the natural and/or built spaces and in the imaginaries and practices of local people and institutions (Hein et al. 2021). Only then it becomes possible to make these conceptions intelligible for various stakeholders and start processes of co-production to arrive at shared objectives and create added value.

Climate change is transforming water systems and landscapes with an increase in droughts and flooding. Urban areas are sinking, and houses built to provide comfort in arid climates must adapt to heavy rainfalls. We must decide which values will guide future decisions, how to design and adapt our built environment, utilizing already accumulated knowledge and history to develop sustainable practices and equip ourselves with tools to protect shared heritage. If we agree that values are key to designing the future, we need new methodologies to help stakeholders discuss and align their respective

perspectives and develop shared values. We propose to go beyond the traditional business case and develop a value case that acknowledges long-term perspectives, system analysis and ecosystem thinking. We have, therefore, developed and tested a value case approach to leverage the multiple values associated with water and heritage for sustainable development.

Water Systems Design: A Value Case Approach to Solving Water Challenges

Leveraging water values to create sustainable solutions to current challenges and to trigger shared positive externalities in the context of intervention requires analytical tools and a comprehensive framework to guide the exploration of their multiple dimensions. On the one hand, such a framework is based on acknowledging the impacts of long-term developments and path dependencies and the different functions and practices associated with the spaces and institutions composing, surrounding and managing water systems. On the other hand, it calls for the careful analysis of the multi-scalar connections characterizing the network of actors, goods and flows that tie water systems to their localities and broader territories. The value case approach aims to leverage existing and potential connections, creating synergies among the different functions, spaces and actors related to the water system. In this way it is possible to account for different values surrounding water systems, reconcile conflicting ones and open the way to shared governance and collaboration among stakeholders (Sorensen 2015, 2017; Jansen and Hein 2023).

This framework has served as a foundation for the "value case approach" developed by a team from the UNESCO Chair Water, Ports and Historic Cities under the leadership of Carola Hein. This approach aims to apply system analysis and multi-scalar thinking to water systems to create solutions that can foster the creation of added values for local contexts and ecosystems. It is based on careful analysis of the historical developments, spatial configuration, multi-scalar material, and social and cultural connections between actors, institutions, infrastructures and territories.

The UNESCO Chair team tested the value case approach through the professional online course "Water Systems Design: Learning from the Past for Resilient Water Futures." Methods and tools such as the Historic Urban Landscape (HUL) Quick Scan Method, the World Inventory of the Global Network of Water Museums, and the Urban Planning and Development Agency of the Flanders-Dunkirk Region's Canvas (or Toiles) guided the learners' analysis of the water system of their choice, its challenges and multiple values (Damayanti et al. 2022; Eulisse 2023; Vereecke and Deveycx 2022).

Learners explored water challenge(s) embedded in their multi-scalar ecosystem and reflected on the different actors relating to them. Through a series of design steps, learners leveraged these insights into a mission and vision – their value case – to solve their respective water challenges while targeting multiple sectors of society, the economy and the environment. This resulted in value cases that, for example, addressed the lack of water awareness and education, especially in youth, by proposing to transform existing water towers into "watermarks," improving their visibility and the public space surrounding them (Manzione 2024). By applying the value case approach, learners combined long-term thinking with context-sensitive planning to propose interventions able to add value for multiple actors rather than a sectoral solution targeting single water challenges.

Conclusions

The UNESCO Chair Water, Ports and Historic Cities posits that addressing current challenges in the water sector can benefit from a more complex value-based approach. To tackle multifaceted challenges, such as those inherent in water systems, we need to address tacit and implicit knowledge and values. Designing for water values entails strategic spatial and temporal planning, bridging societal principles with specific localities. Values need to be identified and visualized from the onset to be able to suitably involve all stakeholders, and these values have to be evaluated and questioned through multiple feedback loops.

The value case approach provides tools and frameworks to navigate this complexity, analyze water systems and plan value-based solutions based on long-term, multi-scalar and ecosystem thinking. Social science and humanities-based approaches and design methodologies can support these efforts. This approach helps understand legacies and path dependencies in water systems and structure projects to address multiple SDGs generating positive ripple effects across the many societal sectors related to water. The value case goes beyond the immediate task at hand to leverage water planning for the rejuvenation of contexts and ecosystems. It can be applied by public institutions or companies seeking a nexus approach to corporate sustainability aimed at creating shared value. The value case approach can complement and enrich technological and economic approaches by acknowledging the impact of long-term development, multiple stakeholders and fixities and flows at multiple scales.

Policy Recommendations

- Conceptualize and test values; develop methods to activate them.
- Consider water systems as a multilayered ecosystem composed of infrastructures, institutions, practices, people and non-human entities.
- Plan interventions respecting local cultures and social practices, which can be investigated through concepts like values; integrate them into deliberation and design processes.

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Banking on Optimism: Why do Some Dutch Delta Engineers Resist the New Water and Soil System Policy?

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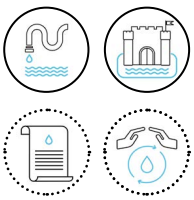
Engineers, long accustomed to finding technological solutions for any vulnerable location regardless of water and soil conditions, fear that a new Dutch spatial planning policy that takes the impacts of climate change into account will place limits on the scope of their activity. The concept of Water en Bodem Sturend (WBS), approximately translated in English as "water and soil as governing principles," is considered a continuation of earlier proposals such as Meebewegen. This ecological and climate-informed policy transition has in fact been in development for at least three decades. Engineers resist the legal anchoring of this policy by downplaying the threat of sea level rise. Anchoring the concept of WBS in law is needed to create a break with technological solutions that are not well adapted and are based on complacency and optimism about sea level rise.

Keywords: *spatial planning and sea level rise, water en bodem sturend, climate adaptation, meebewegen (accommodate), retreat*

KEY THEMES



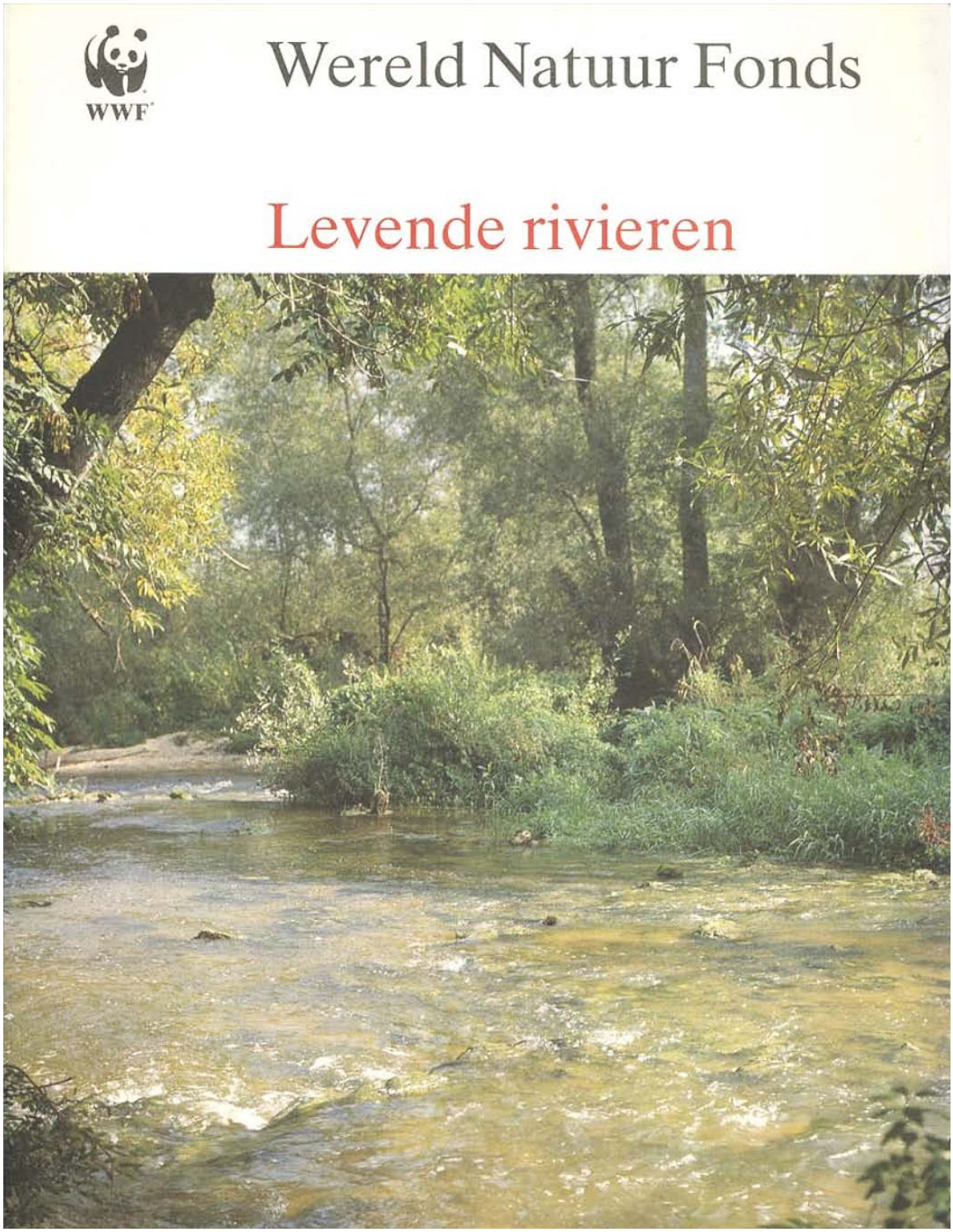
< Fig. 1 Book cover of *Meegroeien met de Zee* (Source: Wouter Helmer et al., 1996).

As the combined impact of a North Sea storm, persistent rain across the Netherlands, and a swollen Rhine River put Dutch flood defense systems to the test, a debate in the water sector spilled into the open, pitting hydraulic engineers from TU Delft against physical geographers from Utrecht University. The dispute concerned a policy adopted by the fourth Rutte coalition – the Dutch government coalition formalized in early 2022 – (KNW 2021) and given substance by the Ministry of Infrastructure and Water in a ministerial letter to parliament (Harbers and Heijnen 2022). Known as Water en Bodem Sturend (WBS), which can be approximated in English as "water and soil as governing principles," the legal enforcement of this aspirational mandate would have direct consequences for spatial planning. The engineers accurately perceived a threat to their identity. A law that determines that some building locations are off limits because of water and soil conditions would be at odds with historical practice and continuing reliance on technological solutions regardless of location. They realized that WBS and the climate adaptation model behind it imply a significant reorientation of engineering in the Dutch delta. Taking a cue from their resistance, this article makes two related arguments: 1) WBS is the current expression of an older and more encompassing ecological approach to climate adaptation now known as meebewegen (often translated as "living with water"), which was forged in urgent response to climate change science; and 2) the resistance manifested by engineers persistently downplays the threat of accelerated sea level rise.

A Long Time Coming

If WBS is an indication that the Netherlands is on the cusp of a significant paradigm shift that recognizes the limits of engineering, this shift has, despite the appearance of a radical break with traditional practice, been a long time coming. Its ecological origins are to be found in the pioneering vision of Plan Ooievaar (Plan Stork), winner in 1986 of the first Eo Wijers Foundation design competition. The plan recommended the removal of secondary dikes, so that riparian forests and marshes could contribute to the regeneration of the river system, while not hindering commercial river transport. Plan Ooievaar became a model for a series of interventions that Willem Overmars, one of its authors, developed with a younger generation of ecologically committed professionals. Throughout the 1990s, their efforts were encouraged by Ed Nijpels, former Minister of Housing, Spatial Planning and Environment. *Levende Rivieren* (1992; Living Rivers) extended and deepened the vision of Plan Ooievaar (fig. 2), while *Meegroeien met de Zee* (1996; Growing with the Sea) applied the same principle to the coast and gave expression to the key idea of collaborating with nature (fig. 1). The authorial team of Meegroeien met de zee included a new name: Pier Vellinga. Vellinga was a member of the Advisory Group on Greenhouse Gases (est. 1986), the forerunner to the Intergovernmental Panel on Climate Change. Adding him to the team strengthened the connection between ecology and climate adaptation and allowed the idea of working with nature to further insinuate itself into policy at higher levels of governance.

The next major station for advancing the idea of collaboration with nature was the report of the Second Delta Commission, which was tasked with advising the government on expected sea level rise and other climate change impacts extending into 2100–2200. The Commission involved national climate experts, prominent among them, Pavel Kabat (current director of research and chief scientist at the World Meteorological Organization) and Vellinga. The result was a visionary report that embraced the



^ Fig. 2 Book cover of *Levende Rivieren* (Source: Wouter et al., 1992).

Meebewegen

^ Fig. 3 The Meebewegen scenario (Source: Carolien Feldbrugge and Ilse van den Broek (© Carof Beeldleveranciers) Deltares, 2017–2019).

principle of collaborating with nature: *Samen werken met water* (Working together with water). The report's chief insight is that "The best strategy for keeping the Netherlands safe and pleasantly habitable in the long run is to develop along with climate change. Moving with and making use of natural processes wherever possible leads to solutions to which man and nature can gradually adapt" (Deltacommissie 2008, 39). Repetitions and variations of the idea of collaborative adaptation proliferate: *meegroeien, mee stijgen, mee ontwikkelen, meegaan,* and *meebewegen* (grow with, rise with, develop with, go with, move with).

One of the more controversial recommendations of the report was to set the upper bound for possible sea level rise at 1.3 m by 2100 and between 2–4 m by 2200 (Deltacommissie 2008). For perspective, the Eastern Scheldt storm surge barrier was predicated on a maximum sea-level rise of 40 cm by 2100. In interviews I conducted with Kabat and Vellinga, they recalled the resistance this recommendation encountered. Policy makers and others were not prepared to go beyond the limits of the current technocratic regime. The recommendation was not adopted and the upper bound was set at 1 m instead.

In March 2017, Deltares published the results of a "policy hackathon" under the title, *Als de zeespiegel sneller stijgt* (If sea level rises rapidly; Haasnoot et al. 2017). The hackathon's goal was to determine if there were limits to the capacity of infrastructural systems to deal with rapid and extreme sea level rise. The effort confronted the national complacency that had settled in when the upper bound was set at 1 meter, instead of 1.3. Although the idea of *meegroeien* or *meebewegen* was not part of the hackathon's remit, the report concluded with three cartoon sketches of possible adaptation strategies, one of which would later come to be known as *meebewegen*. The drawing moved the coastline to the east and showed a set of island cities discernible as Rotterdam, The Hague, and Amsterdam (fig. 3).

The word *meebewegen* is purposefully vague. It signals a willingness to be flexible, to be supple enough to ride out extremes, to accommodate and move with water. It's quintessentially adaptive in ways that other approaches to sea level rise aren't since they involve expensive infrastructural commitments premised on arbitrary projections of SLR (such as 1 meter instead of 1.3) or calculations of probability and risk. These commitments may be overwhelmed by rapid and/or extreme SLR. Coupled with the drawing, however, it was difficult to avoid the suspicion that *meebewegen* also meant retreat. When the Delta Commissioner made meebewegen part of his vocabulary, it was clear that policy was beginning to take hold. In an interview in February 2022, the Delta Commissioner connected *meebewegen* with the pathway that climate change and sea level rise would necessarily impose on the lower Netherlands: "We must prepare step by step for the centuries after 2100. In the long run, the Netherlands will become amphibious. We must move with the flow [*meebewegen*] where water takes us" (Glas 2022, emphasis added, fig. 3).

The question "where" is the relay that connects *meebewegen* to WBS. WBS's basic concern is "where to build." *Meebewegen* also concerns the location of buildings and infrastructure but subdivides this into two further questions: "how to build" and "where to move to." It's in the overlap of "where to build" and "where to move to" that WBS and *meebewegen* converge. When the Ministries of the Interior and Infrastructure and Water asked the Delta Commissioner for advice, he responded in way that put WBS squarely on the national agenda for spatial planning: "In this advisory, I address how the housing task can take into account long-term consequences of climate change with increased likelihood of weather extremes and accelerated sea level rise, and how the water and soil system can give more direction [*meer sturend*]" (Glas 2021, 1; fig. 4).

Much of the Delta Commissioner's response found its way into the ministerial letter on WBS. It claims that "by allowing water and soil to guide spatial planning, we can continue to live, reside and work in the Netherlands now and in the future despite a different and erratic climate" (Harbers and Heijnen 2022, 1). Only one of the Delta Commissioner's recommendations was omitted: "Explore how urbanization and associated long-term investments can be distributed differently across the Netherlands, and initiate movement [*beweging*] to places that are less vulnerable from a climate change perspective" (Glas 2021, 4). Whether the Delta Commissioner knew it or not, recommending that the government shift housing and infrastructure investments to higher elevations in the eastern part of the country amounts to taking the first steps of a future-directed retreat policy. This is the "where" question writ large. As an omission, this is obviously not yet part of WBS. It's only a matter of time.

Based on this analysis of the long path that led

^ Fig. 4 Cartoon of the Delta Commissioner from 'How will the Netherlands defend itself against climate change? (Source: Simon Richter, 2023).

from Plan Ooievaar to the ministerial letter on WBS, we can now offer a summary: WBS is the *current* expression of *meebewegen*. As the virtual successor of Samen *werken met water,* WBS is tantamount to what we could call a "third Delta Commission report." To say so signals its importance. WBS is *on its way to becoming the law of the land*. Although the idea of retreat is latent, measures that should be taken now if WBS were rigorously applied would facilitate or at least not hinder retreat when necessary. Retreat as a component of *meebewegen* is still on the table.

Delta Engineers Keep Watch

WBS may be on the way to becoming the law of the land, but it's not there yet. The integration of its recommendations into planning processes is not a given. The call for WBS to be "juridically anchored" came from many quarters. Under the headline "The Limits of the Dutch Water System have been Reached," Maarten Kleinhans and two other physical geographers from Utrecht University weighed in publicly on how spatial planning would have to change to adapt to climate change impacts. WBS, they concluded, must be durably anchored in law to succeed (Kleinhans, et al. 2023, 2024).

On 1 January 2024, Ties Rijcken and Friso de Zeeuw offered a rebuttal in the same newspaper: "The threat of juridification calls for a strengthened dike watch, as part of the water world seeks to […] achieve absolute priority, which would result in 'Water en Bodem Dicterend' [water and soil as dictatorial principles]" (Rijcken and De Zeeuw 2024). They present themselves as the self-appointed dike watch that protects the Netherlands against the hegemonic ambitions of part of the water sector. Who could be in favor of dictatorial rules that lock up the country when there is such a need for new homes? In the weeks that followed, Ri-

^ Fig. Simon Richter, as Poldergeist, has taken his interpretation of Dutch Water management into the realm of digital humanities, exploring the history and argument of Dutch water management in light of climate change and sea level rise. Poldergeist YouTube channel available at https://www.youtube.com/channel/UCQrvu36tni8MEpLR4ZqFJsQ (Source: Simon Richter, 2023).

jcken and de Zeeuw vied against every sector that endorsed anchoring WBS in the law.

Rijcken is no stranger to journalistic pugilism. In a June 2022 article in *De Correspondent*, he addressed what he considered dangerous trends. Under the provocative title, "Water is Coming, but Don't be Afraid," Rijcken (2022) advocated for the construction of thousands of homes in low-lying and flood prone areas by claiming that they would be protected by the superiority of Dutch hydraulic engineering and water management and by casting doubt on statements to the contrary by the Delta Commissioner, Deltares, and others. Rijcken targeted all those who were arguing for a paradigm shift from a technocratic flood risk management system to what was in the process of being worked out as WBS. The goal of Rijcken's article was to undermine the urgent precautionary work that Deltares, the Delta Commissioner and many others had been doing since the hackathon, and to lull people back into a sense of complacency (figs. 5–7).[1]

Rijcken and De Zeeuw's choice of the metaphor of the dike watch to describe their position vis-à-vis WBS is telling. The threat in their eyes is not the rising sea or climate change, but rather those humans earnestly trying to plan for it. An analysis of all the texts I've considered shows a consistent difference in how the threat of sea level rise and climate change was assessed. If in 2008, the stakes for setting the upper bound of SLR at 1.3 meters were high and the political decision was to go with 1 meter or even as low as 85 cm, in his 2022 article, Rijcken still used old KNMI numbers that predicted SLR of no more than 26–82 cm by 2100, ignoring the fact that the Sixth Assessment of the IPCC stated that SLR of 2 meters in 2100 and of 5 meters in 2150 could not be ruled out. This tendency continues. The engineers consistently downplay the threats, despite news about rising global mean and ocean temperatures, increasing rates of ice melt in Antarctica and Greenland and a weakening AMOC. Rijcken and De Zeeuw are fundamentally not on the same page as experts at Deltares, NIOZ and the University of Utrecht. It's not that they're climate change deniers, but they are sea level rise optimists. This matters because meebewegen and WBS begin from the premise of taking climate change seriously. The goal of WBS is to extend the period of human habitation in the low-lying regions for as long as possible within the limits of the water and soil system. It aims at disarming the threat of river flooding, maximizing the capacity of foreshores to rise with the sea, increasing freshwater storage capacity, and preserving room for dike reinforcement, while not creating impediments to eventual retreat or building "high regret" structures that will be stranded or submerged. There is nothing in principle to prevent engineers from aligning with this position and welcoming the engineering challenges that come with it, but it does require a paradigm shift.

As I was completing this article in March 2024, newspapers proclaimed the results of a study commissioned by the Ministry of Infrastructure and Water and the Delta Commissioner. This was the headline in the NRC: "The Netherlands will remain 'safe and liveable' even with five meters of sea level rise" (Schreuder 2024). "This is good news," said the Minister, "Because the rising sea can obviously have a huge impact on our country. Also good news is that we do not have to choose tomorrow [between protect, advance and *meebewegen*], but that we still have time to do so" (Zoetekouw 2024). Regard-

1. I responded to Rijcken's article in an essay published on LinkedIn, "Het echte monster onder het bed: een retorische analyse van Ties Rijckens 'Het water komt, maar wees niet bang'".

ing new home construction in the Randstad, a contributor to the study added, "There is no conclusion to suggest that we should not want that housing construction now" (Timmer 2024). This is a monumental expression of faith in Dutch ingenuity and a validation of further reliance on engineering solutions and dependence on technology, even for an upper bound of 5 meters of SLR, a number clearly drawn from the 2022 IPCC 6th Assessment. If we recall how the Veerman Commission felt pressure to suppress the recommendation to set the upper bound at 1.3 meters in 2008, we wonder where this newfound confidence comes from. Drilling down into the reports that make up the study, it's clear that the envisioned measures would be disruptive. The PR around the study wraps urgency in a blanket of reassurance and delay. That may be politically astute, but it will probably lead to a renewed feeling of complacency, making the implementation of disruptive solutions more difficult. The internal, climate-science-linked logic of WBS may have suffered a setback, but as its history shows, it's likely to prevail in the long term, one way or the other.

Policy Recommendations

- Anchor WBS in law to avoid maladaptive technological solutions and do not succumb to complacency and sea level rise optimism.

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Changing Sea Conditions as a Threat to Our Underwater Cultural Heritage

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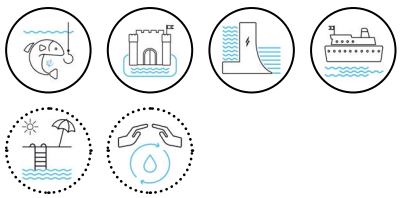
Changing sea conditions due to climate change will have an enormous effect on all sorts of processes in seas, oceans and coastal areas. Current patterns will change, as will sedimentation-erosion processes, acidity and salinity. Invasive species will be able to settle in places they could not before. Each of these changes will trigger other processes that can have a negative effect on underwater cultural heritage. Our need to try to mitigate climate change has us looking for green energy, which has led us to build large wind farms in the North Sea. We want to continue living in areas under threat and therefore we imagine building high walls, to keep the water out. This barrier approach affects current, erosion and sedimentation patterns. Consequently, such actions need to be investigated in a multi-disciplinary way to understand the complexities of changes that may result.

Keywords: *sea, oceans, underwater heritage, sedimentation, erosion, acidity, salinity*

KEY THEMES



< Fig. 1 Close-up view: Previously-strong, hard oak wood from a shipwreck in the Wadden Sea (the Netherlands) has crumbled and almost disappeared due to the attack of the shipworm (*Teredo navalis*) (Source: Cultural Heritage Agency of the Netherlands).

Sea-level Rise and Underwater Heritage

The protection of underwater cultural heritage should be an important theme in the global management of oceans and seas. We are on the verge of drastic changes in our water systems worldwide. As a result of climate change, water levels in the ocean will rise an estimated 5 m by 2150 (European Environmental Agency 2024). This may sound not too bad for underwater heritage, because wet is wet. However, it may be more of a problem than might be imagined. This change in water level will have an effect on many different related processes.

First, it has to be said that the melting of ice – one of the main reasons water level is rising – exposes archaeological sites that have been well-preserved for centuries, like those in northern Norway with Viking finds and on Svalbard with the seventeenth-century graves of Dutch sailors near Smeerenburg. The melting of ice will also affect very well-preserved historic expeditionary huts in Antarctica, like the one from the 1899 expedition led by Anglo-Norwegian explorer Carsten Borchgrevink or captain Robert F. Scott's hut from 1902 (Jacobs 2020; fig. 2). It has even led to the discovery of sites underwater that up until recently had been preserved by an ice shield, like the wrecks HMS Terror and HMS Erebus, which disappeared during the Franklin expedition (1845–1848) in northern Canada and Shackleton's ship Endurance, which was crushed in the ice in Antarctica in 1915 (fig. 3). A discovery not only means that the site is exposed to natural elements, but also often to human interference.

When ice melts, it feeds rivers from far inland that transport the excessive water toward the sea. Some (inner) seas depend heavily on this feeding of fresh water. The Baltic is such a sea. The influx of less fresh water in the future may lead to the influx of more salt water.

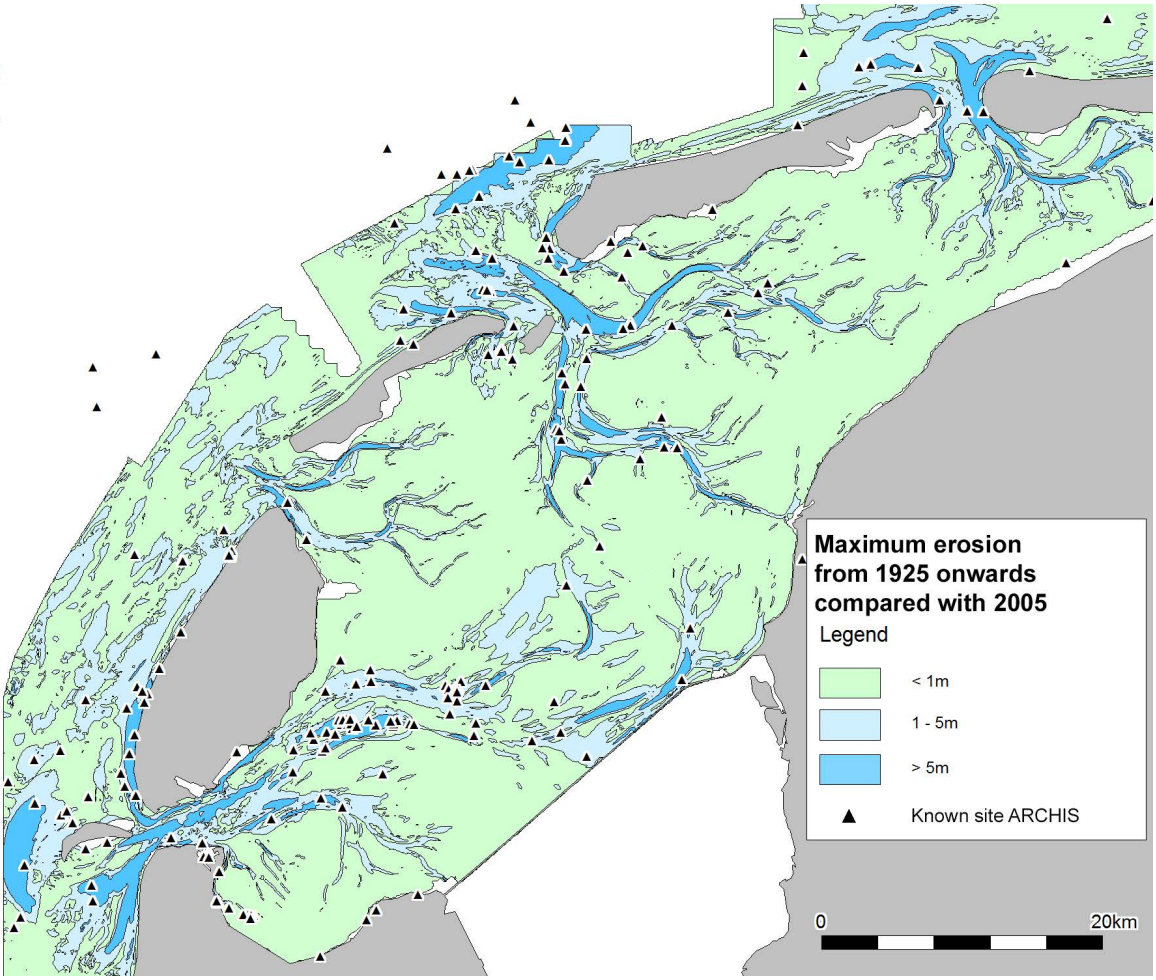
Sea-level rise also means a different water distribution, which usually also means a change in currents. The effect is that water temperatures in the oceans will change, which will eventually lead to a temperature and season change in some parts of the world. The Gulf Stream circulation, for example, flattens out temperature peaks and valleys in Europe. Fortunately, this stream will not suddenly collapse or fail, but a slowdown can be expected and even this will cause an additional sea-level rise and changes in ecosystems and fish populations. A change in current patterns also means a change in distribution of seabed material, like sand and silt. As a result, there will be areas of the seabed that are eroding and others that will receive more sediment. This changing sedimentation-erosion pattern, by the way, we also see on a more local scale – like in the western part of the Wadden Sea (fig. 4) – due to the introduction of hard protective measurements like dikes and (wave) breakers. The construction of these protective elements is also an (indirect) result of climate change. We want to remain safe against any sea-level rise. Temperature changes also result in different weather patterns: more storms, for example. These influence wave action and therefore have a negative effect on maritime and underwater cultural heritage, especially near shorelines. Since maintaining an equilibrium in the environment is always important and change is usually bad, climate change will certainly bring about damage to underwater cultural heritage. Exposure will lead to more deterioration by human, mechanical, chemical and biological processes.

Invasive Species

If seawater temperatures are rising and salini-

^ Fig. 2 This is captain Robert F. Scott's hut that was built on Ross Island in February 1902 for his British Antarctic Expedition of 1901-1904 (Source: Sergey Tarasenko, CC BY 3.0, via Wikimedia Commons).

^ Fig. 3 Shackleton's ship HMS Endurance trapped in Antarctic pack ice, February 1915 (Source: Frank Hurley).



^ Fig. 4 Erosion patterns of gulleys in the Wadden Sea. It shows the comparison between 1925 and 2005. Much of it is caused due to direct and indirect effects of climate change (Source: Cultural Heritage Agency of the Netherlands).

ty levels change as a result, this can affect life in the oceans. Invasive species will be able to survive in places they couldn't before. There are still places, for example, where the shipworm, or *Teredo navalis*, is not present yet. The Baltic Sea is such a place and – not surprisingly – this is where extremely well-preserved shipwrecks from centuries ago are found regularly, still standing with masts up on the seabed (fig. 5). Near the entrance to the North Sea, the shipworm has already shown its destructive capability (fig. 6). Eventually the Baltic Sea may become more saline, which would immediately threaten the shipwrecks in this still brackish, almost freshwater environment (Gregory and Manders 2015).

Recently new shipworm species have been detected in the North Sea. Even more different new species have been discovered in fresh waters of the Philippines, which do not eat wood, but stone. Those shipworm species spreading out over the

^ Fig. 5 The "Ghost ship," an extremely well-preserved shipwreck of a seventeenth century flute ship at 110 m of depth, north of Gotland in Sweden (Source: Cultural Heritage Agency of the Netherlands / MMT).

world may cause enormous environmental and economic problems. What the invasion of these and multiple other new species means for the underwater cultural heritage, we can only imagine. Invasive species like the Zebra mussel and the Quagga mussel in freshwater environments seem to be primarily an environmental disaster, but mussels growing on wooden shipwreck constructions would make them more vulnerable to falling apart due to the weight of the shells and the pressure of the currents. Wood surfaces may become eroded because of the way the molluscs attach to the ship structure.

More Threats to Underwater Cultural Heritage

Climate change may also alter the acidity levels in water (acidification), which may have a strongly negative effect on underwater cultural heritage. Everything containing large amounts of calcium will be threatened and metal will corrode much faster.

The complexity in creating an overview of the effects of climate change on underwater cultural heritage is due not only to the fact that this heritage is often not visible. The combination of multiple processes creates a deteriorating environment: erosion may expose a wooden shipwreck that will be deteriorated by increased currents in the area and species like *Teredo navalis* (Manders and Gregory 2015). The construction will be weakened and when it is colonized by organisms like mussels, oysters or anemones parts of the wreck will become more vulnerable to destruction by currents, leading the structure to fall apart.

Activities to prevent or mitigate climate change

^ Fig. 6 Previously-strong, hard oak wood from a shipwreck in the Wadden Sea (the Netherlands) has crumbled and almost disappeared due to the attack of the shipworm (*Teredo navalis*) (Source: Cultural Heritage Agency of the Netherlands).

threats may also negatively affect underwater cultural heritage. The placement of dikes, as mentioned, have caused huge erosion patterns in the Western Wadden Sea in the Netherlands. The same is happening in other countries. Old types of protection, like the (re)planting of mangrove forests along coasts in the Caribbean countries of Suriname and Jamaica have been shown to have a more positive effect. Sand needed to reinforce the Dutch North Sea coast is removed from areas further from the shore. The presence of many prehistoric objects is a proxy for the effect of sand and pebble abstraction (mining of sand and pebbles from the seabed) on the prehistoric underwater landscape. This hidden landscape is also heavily under threat by the multiple plans for wind farms in the North Sea (Ravilious 2022; fig. 7). These windmills are needed to attain the zero emission the Netherlands has promised to reach by 2050 in the Paris Climate Agreement. The wind farms are being built to mitigate against global warming, but they are threatening underwater cultural heritage. They immediately destroy the submerged landscape below them and in the long run may also cause severe erosion patterns over a much larger area. Sites are being destroyed without ever being investigated. Is this a catch-22? Or can we find solutions to address more than one problem at once? *Can we combine efforts and create an overall picture of the complex effects of climate change and sustainable energy, gaining knowledge about our past and preserving underwater cultural heritage where needed?*

Climate change certainly will have an effect on underwater cultural heritage. In the past, research has recognized some (potential) ef-

^ Fig. 7 A windfarm on the North Sea, photographed during an inspection flight of the coastguard (Source: Joop van Houdt / Rijkswaterstaat).

fects. The biggest problems arise when multiple threats combine. While individual threats have been explored, they have not been systematically researched. To mitigate the impact of climate change, we need to get a picture of what is threatening our underwater cultural heritage that is better than what we have today. Mitigation against the known threats may not be enough. Some threats we do not even envision, others are so complex and related to multiple other threats that we can only adapt. The threats to underwater cultural heritage are often threats that are also important to natural heritage management and environmental protection. It is therefore important to carry out more overarching research, not limiting research to one effect or one heritage field. Only then we can visualize the combined effects of climate change and come to real and effective solutions or adaptations. A common playing field in which joint research could be set up is within the Decade of Ocean Science. We need to address concerns about cultural heritage, in addition to those about the economy and the environment, and increase budgets for both research and protection. Everything is connected in this world. What is expressed in the lyrics of the classic spiritual "Dem Bones" – "Leg bone connected to the knee bone" – is also true regarding the effects of climate change: everything is connected. So, let's make sure we focus a bit more on interdisciplinary integral research on this subject.

Policy Recommendations

- Everything is connected and the individual effects of climate change should be seen in a larger picture of action and reaction. Therefore, it is important to support overarching interdisciplinary research that considers multiple actions and reactions.

- We should not hesitate to include underwater cultural heritage in the discussion of blue growth, green energy and large scientific and policy cooperations and network activities. Cultural heritage matters: it is an important part of our being, our identity. Due to our long relationship with water, the past can teach us about sustainable management. Only by looking back can we see what can be successful to apply and what not. The past is therefore important for our future.

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Strengthening the Legal Framework of Protected Areas in the Amazon to Combat Climate Change

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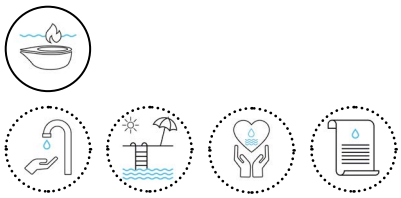
This article discusses the importance of increasing the percentage of protected areas and improving the efficiency of law enforcement in the Amazon rainforest. The Amazon's waters and forests are essential to the global ecosystem, and both global and local climate changes are already having a significant impact on the region, as exemplified in 2023 by reduced precipitation in the region and extremely low levels of rivers like the Rio Negro. Yet, deforestation in the Brazilian Amazon is increasing, especially in those areas not protected by legal environmental legislation. Therefore, expanding legal protection is crucial for both global climate adaptation and the conservation of the natural and cultural heritage of water systems.

Keywords: *Amazon, protected areas, deforestation, climate change, drought*

KEY THEMES



< Fig. 1 Close-up view: Sand along the Rio Negro, exposed by extreme drought in the Anavilhanas region in October 2023 (Source: Reco Nunes, 2023).

Introduction

This article presents Brazil's legal framework for protected areas. Focusing on the Brazilian Amazon, it argues for the need to increase the percentage of protected areas and improve the country's legal framework and law enforcement. Protecting the Amazon, the largest rainforest, river system and freshwater resource on the planet, is key to combating climate change.

This article highlights the role of officially designated Conservation Units and Indigenous Territories, part of the Brazilian National System of Nature Conservation Units (SNUC), in protecting the rainforest. This can be seen in satellite images, which show how the deforestation process has stopped around the polygons of these conservation areas. The satellite imagery also shows which Conservation Units and Indigenous Territories are under the most pressure from land-use change in the Amazon, which is linked to the expansion of agribusiness.

More than 30 per cent of Indigenous Territories in Brazil, most of them in the Amazon region, are waiting to be officially recognized under the SNUC (ISA 2018). It is crucial to speed up the process of creating a legal framework for these territories, which are vulnerable to deforestation.

The greatest threat to these areas is the expansion of large-scale agriculture and cattle ranching. Increased economic activity, combined with a lack of law enforcement and deforestation of the Amazon rainforest, could lead to an increase in the frequency and severity of extreme weather events worldwide (Harris et al. 2021). Climate change is also being felt strongly in the Amazon region, such as in the extreme drought of the Amazon River system in 2023. This article uses the case of the Rio Negro as an example of this process.

Because deforestation is directly linked to unprotected land, it is critical to expand protected areas, including aquatic ecosystems. Increasing the number of protected areas (and supporting their maintenance through law enforcement) will help conserve biodiversity and recognize and value the role of traditional communities, such as Indigenous and Quilombola, in controlling deforestation in their territories.

Legal frameworks are an important way to protect areas from extractive, mining and agribusiness activities. They can also help preserve traditional cultural practices and knowledge. Given the intensification of events related to climate change, protecting the Amazon's natural environment has become a global responsibility, which includes protecting the forest, rivers, cultural heritage and communities that depend on the forest. This will help conserve the natural environment for future generations and alleviate the effects of climate change globally.

We begin this article with an overview of the Amazon rainforest and watershed and present data on deforestation trends between 1985 and 2020. Then, we address the legal framework of the Brazilian system of protected areas, highlighting the crucial role of Conservation Units and Indigenous Territories in combating deforestation and therefore climate change. We use examples of Amazonian areas under the protection of the Brazilian national heritage system. We use UNESCO World Heritage Sites to demonstrate how measures for protecting natural and cultural heritage can help limit deforestation. Finally, we consider the case of the Rio Negro and the Anavilhanas National Park to illustrate the impact of climate change on protected areas. The article concludes with strategies and policy recommendations to support the protection of the Amazon rainforest.

Overview of the Amazon Rainforest and the Deforestation Process

The Amazon covers 944 million ha, occupying 47 per cent of South America, an area shared by nine countries, of which Brazil has the largest area (61.9 per cent, or 521.9 million ha), divided between nine federal states. As world's largest rainforest, the Amazon is responsible for crucial global ecosystem services, including support for biodiversity, carbon storage, regulation of water cycles, and many more. As Brazil's largest biome, it covers 49.3 per cent of the country's territory. It also contains 20 per cent of the world's available water and mineral reserves. The Amazon rainforest is considered the most diverse biological reserve on the planet, possibly containing half of the world's biodiversity (IBGE 2024).

Over the past forty years, the Amazon has experienced massive deforestation, which continues at a rapid pace today. From 1985 to 2020, the Amazon lost 74.6 Mha of native vegetation, of which almost 60 per cent occurred in Brazilian territory (Mapbiomas 2021). Deforestation in the Amazon region is mainly caused by anthropogenic activities, especially cattle ranching and agriculture, which account for 99 per cent of deforestation and put considerable pressure on the remaining forests and their watersheds (Mapbiomas 2022; Figueiredo, Cak and Markewitz 2020; Junior and Dziedzic 2021).

The Amazon River system is the largest watershed in the world, covering 7 million km^2 in Brazil, Bolivia, Colombia, Guyana, French Guiana, Peru, Suriname and Venezuela. About 4 million km^2 are in Brazil (Toda Matéria 2024). It covers the central and eastern areas of South America and is mostly tropical rainforest with great biodiversity (OAS 2005). The Amazon River, which flows approximately 7,100 km from Peru to the Atlantic Coast of Brazil, is the longest, widest and deepest river in the world. The watershed includes ten sub-watersheds, including the Negro, Solimões, Xingú and Madeira.

The Amazon basin holds 73.6 per cent of Brazil's accessible water, and it is strained by the increase in economic activities. Of all water consumed in Brazil, 79 per cent is used in agribusiness (Agência Nacional De Águas 2019). Beef cattle production affects the value of the water footprint, with the impact depending on the specific characteristics of each animal and the management solutions (Palhares, Morelli and Novelli 2021).

In addition to their considerable water use, agriculture and livestock farming use large amounts of fertilizer, which is a source of pollution. This has a major impact on water bodies and on the many communities that live around rivers and/or depend on fishing. Furthermore, mining activities, also responsible for river pollution, have increased by 1000 per cent between 1985 and 2021, impacting riparian communities and Indigenous territories especially (MapBiomas 2022).

For these reasons and many others, water and nature need to be protected (Catalão and Ribeiro 2023; Fantini 2020; Anand 2007). Although the United Nations General Assembly (2010) has recognized the human right to water and sanitation, including water justice and ethics, the effectiveness of these measures is still a matter of debate.

Legal Frameworks in Place for Brazilian Protected Areas

Brazil has a binary legal system for protected areas, with two legal frameworks that are part

of the National Environmental Policy. They sometimes overlap to protect areas. The first is the Federal Forest Code, created in 1934, and updated several times before the enactment of the current legislation (12.651/12) of 2012. The second is the National System of Nature Conservation Units (SNUC), a federal law (9.985/00) created in 2000. Together, they protect the natural landscape, biodiversity, natural environment and bodies of waters under Brazilian jurisdiction, through the creation of protected areas or territories.

The main legal and practical difference between the two legislations is that SNUC areas must be created and regulated by law, whereas Forest Code areas, which exist throughout the country, don't need to be created and regulated because they are defined by geomorphological characteristics. Conservation Units must be created by the government at a particular level, such as municipal, state or federal. They are created when a specific conservation need is identified.

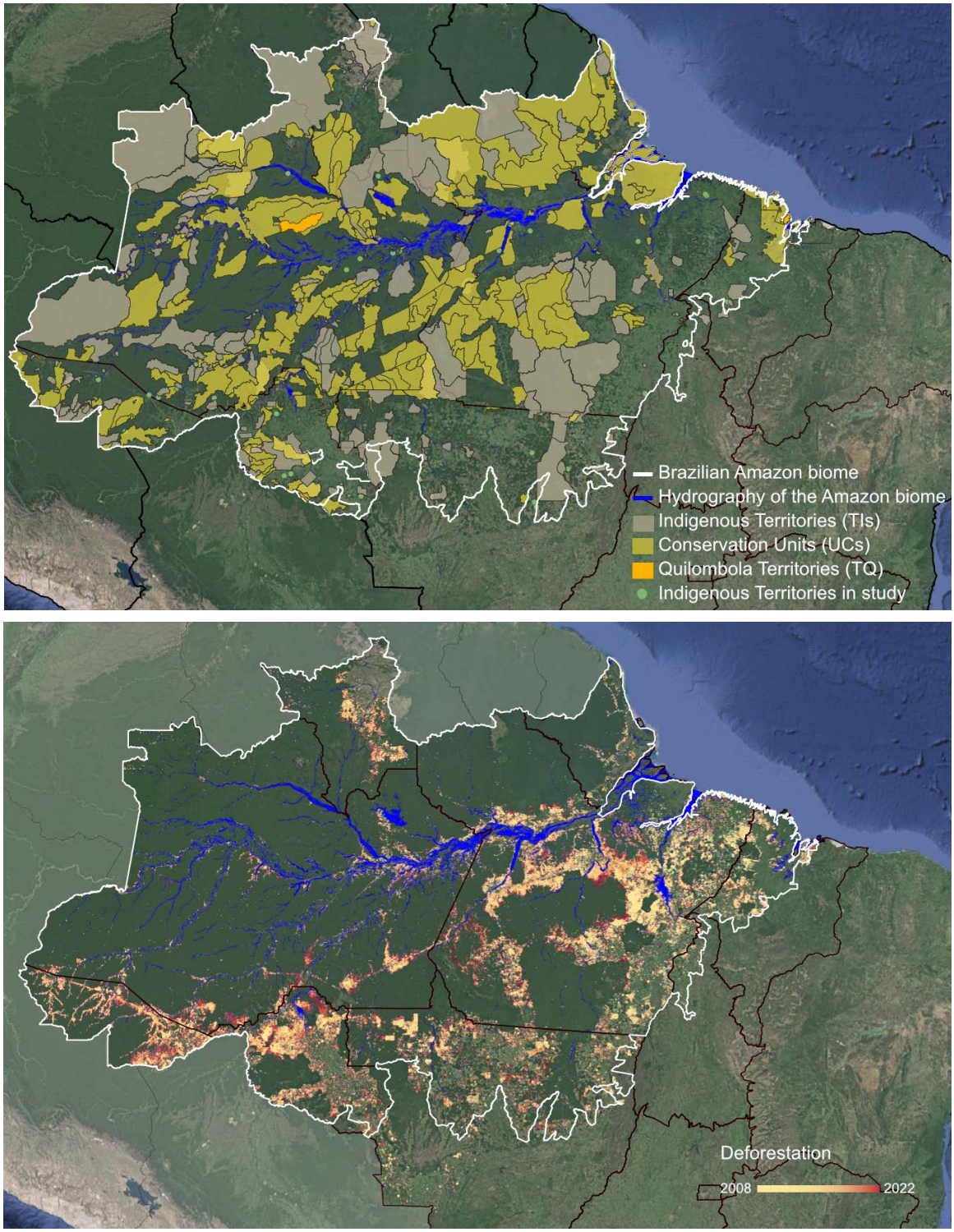
The SNUC defines Conservation Units as an area that includes environmental resources, including jurisdictional bodies of water, with significant natural characteristics. These can have different levels of restrictions on use – they can be integral protected areas or sustainable use areas. In the SNUC legislation, the Indigenous Territories and the Quilombola Territories are identified as Conservation Units that involve local and traditional communities as caretakers of the forest and its resources. On the other hand, the Forestry Code will protect, for example, Permanent Protected Areas (APPs), such as APPs of watercourses or hilltops. This means that in Brazil every river is protected by law as an APP, and some rivers could be covered by a second legal protection framework, for example as part of a SNUC unit.

In terms of area, the SNUC will play an important role in the protection of the Amazon rainforest, as the existing Conservation Units cover a large part of the rainforest. In addition, the Forestry Code provides an extra layer of protection for watercourses throughout the Brazilian territory, including the Amazon rivers. The SNUC also protects and regulates the Indigenous Territories and Quilombola Territories, as mentioned above.

Conservation Units and Indigenous Territories are territorial designations that strongly combat deforestation and support the conservation of biodiversity in Brazil. Both are legally established by public authorities, and include federal, state, district and municipal protected areas. There are more Indigenous Territories than Quilombola Territories in the Amazon rainforest. In the state of Amazonas, for example, there are 8 officially recognized Quilombola Territories and 164 Indigenous Territories (Oliveira and Matta 2022).

In terms of the administration of those areas, the Indigenous Territories are coordinated and protected by FUNAI - the National Indigenous Foundation, which protects Indigenous culture, territories and forest areas. There are also many non-governmental organizations that support the Indigenous Territories. Among the Conservation Units, the federal areas are managed by the Chico Mendes Biodiversity Institute (ICMBio), while the other areas are managed by state and municipal environmental agencies.

However, even with a binary legal framework of protected areas, this system is failing to adequately protect the Amazon rainforest. The primary reasons are a lack of law enforcement and a weak legal framework, which will be discussed in more detail in the next sections of this article.



^ Fig. 2 Indigenous Territories and Conservation Units play a vital role in combating deforestation expansion in the Brazilian Amazon biome area (Source: Donoso, 2024, using data from Mapbiomas, FUNAI, Agência Nacional De Águas and the Brazilian Environmental Ministry).

The Vital Role of the Conservation Units and Indigenous Territories in Combating Deforestation

The Amazon biome is present in nine of Brazil's states: Acre, Amazonas, Amapá, Pará, Roraima, Rondônia, Mato Grosso, Tocantins and Maranhão, with Amazonas having the largest share. Some of the states also contain other biomes, such as the Cerrado and the Pantanal. Rondônia has 99 per cent of its territory covered by the Amazon biome, while Mato Grosso has 54 per cent, Maranhão 34 per cent and Tocantins 9 per cent (IBGE 2004).

Considering deforestation, Rondônia, Mato Grosso and Pará stand out. Rondônia has lost more than 34.3 per cent of its native vegetation area and Mato Grosso has lost 29.4 per cent. Both states also share the highest percentage of vegetation loss within state Conservation Units. This reflects the expansion of agribusiness, which at times has been favored by state policies: In Mato Grosso, one of the national leaders in meat and soy production, only 3.5 per cent of the state is protected under the SNUC legislation. In Rondônia, also a relevant state for meat production, Conservation Unit status protects only 8.6 per cent of the state and the expansion of cattle ranching continually threatens to further reduce the protected areas; the Jaci-Paraná protected area is a notable example (Wenzel, Hofmeister and Papini 2021; Wenzel and Isensee e Sá 2018).

The Indigenous Territories represent 22.5 per cent of the Brazilian Amazon. Of a total of 676 Indigenous territories in Brazil, 67.8 per cent are legally designated as Indigenous Territories. The other 32.2 per cent of the territories are waiting for legal recognition, and this process depends on the political support of the federal government (ISA 2018). In Amazonas, approximately 27 per cent of the state's territory is protected as Conservation Units.

Deforestation rates in the Amazon Conservation Units and Indigenous Territories are lower than those in unprotected areas. However, they still face increasing pressure from agricultural expansion along with an inadequate territorial protection structure and a lack of surveillance (fig. 2).

Amazonian Territories Protected by National Heritage and UNESCO World Heritage Designations

Water and the rainforest in the Amazon region are systemically connected to the global climate. Since the 2000s, watersheds in the Amazon region, like that of the Rio Negro, have been protected by national heritage and UNESCO World Heritage designations. However, these areas are still experiencing the consequences of climate change.

The Central Amazon Conservation Complex is a UNESCO World Heritage site due to its rich biodiversity and natural environment. The protected area includes the Jaú National Park and the Anavilhanas National Park, an archipelago of river islands, both located in the state of Amazonas (UNESCO n.d.), in the watershed of the Rio Negro. This watershed covers an area of approximately 690,000 km2, or 11 per cent of the Amazon basin. The Rio Negro is one of the largest rivers in the world, famous for its natural heritage. The region is characterized by a landscape of rivers and sandy beaches during the dry season and flooded forests during the rainy season. In addition, more than seventeen archaeological sites have been identified along the banks of the Rio Negro. The Brazilian Institute for Historical and Artistic National Heritage (IPHAN) is responsible for the

^ Fig. 3 The Brazilian Rio Negro and the Anavilhanas National Park (Source: Verônica Garcia Donoso, 2024).

protection of Brazil's material and non-material heritage, including that of the Amazon region. The protection effort in the Amazon region has been intensified since 2000 with the expansion of the legal framework for protected areas, taking into account the cultural elements of riparian and Indigenous communities (IPHAN 2007).

River water is sacred to many Indigenous communities in the Amazon. For this reason, some water-related landscapes in the Brazilian Amazon are protected, such as the Lauaretê waterfall, a sacred place for the Indigenous communities of the Uaupés and Papuri Rivers (Federação das Organizações Indígenas do Rio Negro 2013–2015). The confluence of the Negro and Solimões rivers in the city of Manaus was also declared a Cultural and Natural World Heritage Site by IPHAN in 2010. The Rio Negro, with its dark and transparent waters, meets the Solimões River, with its muddy waters, and they run side by side for 10 km before merging to form the Amazon River. The traditional agriculture system of the Rio Negro was designated cultural heritage by IPHAN in 2010.

The waters of the Rio Negro are formed by several rivers, including the Uaupés, Içana, Curicuriari, Marié and Xié. This is a vast region that reaches the borders of Colombia and Venezuela (fig. 3). Currently, 23 million ha of rivers and forests form the socio-environmental territory of the Rio Negro, 65 per cent of which has Conservation Unit status, including nine Indigenous Territories. About half of this area has been declared a Ramsar site, an international convention that recognizes the environmental importance of river areas. This socio-environmental territory has around 33,600 inhabitants, with more than 80 per cent of the total population living in Indigenous Territories. Some Indigenous communities are in riparian areas, while others

are inside the forest. Across this rich territory, connections between people depend heavily on the river (Scolfaro and Dias 2021).

Climate Change, Protected Territories and the Drought of 2023

Alterations in the hydrological cycles of the Amazon are associated with shifts in the global climate, and these alterations are exacerbated by human activities in the Amazon. These activities include the clearing of forested areas.

In the latter half of 2023, the Brazilian Amazon experienced extreme weather events, which hit the state of Amazonas especially hard. These events prolonged and intensified the dry season and raised temperatures in the region, significantly impacting local communities, biodiversity, transportation, energy production and health (Mazzini 2023; Oliveira 2023). The reasons for this extremely dry weather are multiple and interconnected. They include the increase in global temperatures, high temperatures in the North Atlantic, a stronger El Niño event due to increased ocean temperatures, global heating and rainforest degradation due to slash-and-burn agriculture.

On November 30, 2023, the World Meteorological Organization (2023) published a report announcing that the year had been the warmest on record. Temperatures rose approximately 1.40 degrees Celsius above the pre-industrial baseline of 1850–1900. The report also noted the lowest recorded levels of sea ice in the Antarctic, and intense fires in many parts of the world, including Hawaii, Canada and southern Europe, alongside numerous extreme weather and climate events globally.

The extreme dry season experienced in Brazil's Amazon in 2023 served as a stark indicator of the impact of climate change. This was not the first instance of a longer and intensified dry season in the Amazon, a trend that has been escalating annually. The year 2023 saw the Amazon River reaching its lowest water level in 121 years of record-keeping, revealing vast stretches of riverbed sand (fig. 4). This led to higher water temperatures in rivers and lakes, along with an increase in wildfires. The consequences for biodiversity and local communities were profound, resulting in the death of numerous river dolphins and fish and the isolation of forest and riverside communities.

Conclusion

Scientists predicted this extreme drought in the Amazon region, along with many other extreme weather events around the world. The Intergovernmental Panel on Climate Change (IPCC)'s AR6 Synthesis Report (2023), emphasizes that despite progress in climate discussions globally, we are still not implementing changes quickly enough. It is crucial to reduce greenhouse gas emissions to limit global heating before 2030 and to devise effective mitigation and adaptation measures. The report emphasizes the need to combat deforestation, preserve forests, and expand renewable energy sources in Brazil.

The primary causes of deforestation are the expansion of agriculture and ranching, illegal logging, fires, and unregulated mining. Anthropogenic activities, such as pesticide use in agriculture, solid waste dumping, inadequate wastewater treatment in populated areas, and illegal mining activities that release mercury into river water, cause water pollution. A robust legal framework for SNUC is essential to safeguard the rainforest, as it provides legal protection against extractive, mining, and agribusiness activities.

^ Fig. 4 Sand along the Rio Negro, exposed by extreme drought in the Anavilhanas region in October 2023 (Source: Reco Nunes, 2023).

Although the link between deforestation and climate change is well-established, there is a stronger emphasis on theory than on action in combating these issues. Deforestation is often driven by economic interests, resulting in a lack of long-term perspective in resource management. Addressing urgent environmental problems requires global and local action, institutional frameworks, and technical capacity. A shared national and international vision is critical, particularly in the case of the Amazon region.

Strategies to support the protection of Amazonian Conservation Units include involving local communities, supporting the use of remote sensing techniques, strengthening and expanding environmental inspection bodies such as ICMBio, and improving the situation of environmental inspectors through higher salaries and career advancement. Two of the main federal institutions in charge of environmental inspection, Ibama and ICMBio, need additional inspectors working throughout the country (El País 2019; Pajolla 2024).

Enhancing environmental agencies and increasing the number of inspectors in the Amazon are crucial steps to forest protection. Unfortunately, these efforts depend on governmental backing since recruitment typically occurs through pub-

lic competitive exams. Moreover, employing remote sensing technologies, like satellite imagery, is vital for enforcing legal sanctions on products derived from illegal activities, thereby intensifying anti-deforestation efforts. Local communities must also be involved in efforts to tackle deforestation.

Because deforestation happens most often on unprotected land, expanding protected areas in the Amazon is critical. This includes increasing the protection of water-related landscapes. In addition, increasing the number of Conservation Units, Indigenous Territories and Quilombola Territories (and supporting their maintenance through law enforcement) should help conserve biodiversity, while recognizing and valuing the importance of traditional communities in controlling deforestation. Protected areas are key because the legal framework protects territories from extractive, mining and agribusiness activities. It also protects traditional and cultural practices and knowledge.

Policy Recommendations

- Speed up the process of legal recognition of the Indigenous Territories – 30 percent of the Brazilian Indigenous Territories are still waiting to be made official.

- Strengthen law enforcement to avoid the vulnerability of the Indigenous Territories by increasing the number of independent environmental inspectors; expand the use of new technologies like remote sensing for land-use analysis, with the engagement of local communities directly involved in the protection of Indigenous Territories and Quilombola Territories.

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Sustainable Water Governance in the Brazilian Pantanal Biome: Challenges and Lessons

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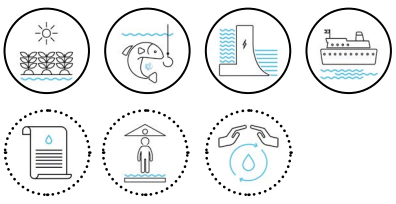
Problems caused by land-use change and climate change transcend territorial boundaries, but often management of natural heritage sites can only influence what happens within the local area. Therefore, we need innovative conservation strategies that also transcend territorial boundaries. Hence, the approach to managing our natural heritage sites may need innovative strategies to ensure their effective conservation. This study examines the conservation approach in the Pantanal biome, which houses multiple centers of decision-making across Brazil, Bolivia, and Paraguay. Despite the region's significant contribution in providing ecosystem services and playing an integral part in local cultural heritage and Native communities, Pantanal has suffered from a lack of clear rules and strategies, challenges in implementation, and, largely, capacity and coordination across different governance scales. This contribution synthesizes key challenges and potential opportunities through co-production and information sharing to ensure a socio-ecological approach to promoting the conservation and resilience of the Pantanal biome.

Keywords: *conservation, integrated water resource management, monitoring, co-production, wetlands*

KEY THEMES



< Fig. 1 Close-up view: Pantaneiro in a typical Pantanal canoe (Source: Ana Raquel S. Hernandes 2011, CC-BY-SA 2.0, via Wikimedia Commons).

Overview of the Pantanal Biome

Spanning Brazil, Bolivia and Paraguay, the Pantanal biome is the world's largest tropical wetland (Schulz et al. 2019). It offers significant ecosystem services, including carbon sequestration, and is abundant in cultural, recreational, and economic resources. It also plays a role in maintaining water quality and supply (Clarkson et al. 2013). However, this region faces critical climate- and land-use change pressures that threaten its sustainability and resilience. Although UNESCO's Pantanal Conservation Area covers a total area of 187,818 ha, it only makes up 1 per cent of the entire biome (UNESCO 2024a; TNC 2024). The interconnected nature of this biome – both relating to its needs and the ecosystem services it provides – makes this geographic area one that UNESCO has declared of Outstanding Universal Value – that is, "cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity" (UNESCO 2024b). Thus, addressing the threats to the Pantanal biome requires attention to social, economic, and ecological interests and needs at the biome level and a concerted international effort to ensure its continued sustainability.

This article begins by discussing how the Pantanal's cultural heritage is integrated with its biophysical composition. It then offers a review of changes and challenges to the sustainability of this socio-ecological system (SES), directing particular attention to the strengths and shortcomings of its governance structure and institutions (i.e, rules, norms and strategies). After reviewing the Pantanal's status, we consider new sustainable strategies that take into account water, culture, and heritage practices. Finally, we offer closing thoughts and recommendations for how academics, professionals and stakeholders from diverse backgrounds can help rethink the relationship between water and heritage.

The Pantanal's ecological diversity and dynamism parallels that of its cultural richness. Seasonal dry and wet periods in this area contribute to its high biodiversity (Wantzen et al. 2008), which is critical for providing ecosystem services integral to the *Pantaneiro* culture (Almeida-Gomes et al. 2022). This culture is rooted in a wide range of ethnicities and histories, including those of Native people, descendants of enslaved Africans and colonizers, all of whom are dependent on the Pantanal's resources for their livelihoods (Ikeda-Castrillon et al. 2023). For the *Pantaneiros* (fig. 2), this biome not only provides critical resources needed for riverine fishing, agriculture, animal husbandry, and traditional pharmaceutical purposes, but it also plays a central role in how the *Pantaneiros* understand themselves and their history, in turn shaping how they engage with the natural environment (Wantzen et al. 2008).

Nonetheless, major land-use changes dating back to the 1970s and 1980s (mainly for soy production and ranching) in Bolivia (Killeen et al. 2008), Paraguay (Caldas et al. 2015) and Brazil (Cardille 2003) marked the beginning of ongoing changes to the Pantanal's hydrological regime, with critical SES impacts. Today, agricultural intensification continues across all three countries, and related deforestation has further degraded the habitat of the Pantanal biome (Guerra et al. 2020). Recent initiatives to alter the Paraguay River for improved ease of barge-transported (fig. 3) agricultural exports through the Pantanal region will further disconnect the river from the floodplain, shrinking the wetland and contributing to major ecological degradation (Wantzen et al. 2024). The preliminary licenses issued for the installation of port

^ Fig. 2 Pantaneiro in a typical Pantanal canoe (Source: Ana Raquel S. Hernandes 2011, CC-BY-SA 2.0, via Wikimedia Commons).

infrastructure in the upper part of the Paraguay River have raised concerns regarding socio-ecological impacts. Simultaneously, the recent construction of dams adjacent to the biome has aggravated shifts in the hydrological regime, contributing to sedimentation and low flows during dry periods (Schulz et al. 2019).

Today climate change is compounding the effects of development in and around the Pantanal. Namely, climatic shifts have driven increased variability in precipitation, rising temperatures, reduced soil moisture and higher evapotranspiration rates (Marques et al. 2021). These factors have further increased sediment loads during the rainy season and have reduced wetland volume (Luo et al. 1997). Between 1985 and 2022, the wetland lost 81.7 percent (789,000 ha) of its water surface, with a more significant reduction in areas where seasonal flooding occurs. Flooded areas have been progressively smaller and less common (Mapbiomas 2023). Lastly, these changes have spurred shifts in flows outside of the regular river channel, posing risks to the land around the Paraguay River that is needed to germinate seedlings (Jurik et al. 1994) for the vegetation that provides both levee stabilization and wildlife habitat (Bergier and Assine 2022).

Governance to Conserve the Ecosystem and *Pantaneiro* Lifestyle

The *Pantaneiro* way of life has historically operated symbiotically with the wetland's cycles of rising and falling water levels, but this may not continue without well-designed and well-implemented institutions (i.e., rules, norms, and strategies) that promote conservation (Wantzen et al. 2024). Maximizing the effectiveness and efficiency of existing institutions in the Pantanal is inherently challenging. Governance of the

^ Fig. 3 Barges transporting commodities on the Paraguay River (Source: Idilio Vieira, 2018).

area is polycentric, a system with many actors operating independently mutually adjusting in accordance with their relationships to one another (Ostrom 1999). Furthermore, unlike other biomes with extensive protected areas, most of the Pantanal is privately owned, requiring extensive coordination (Wantzen et al. 2024). Although the Pantanal has special protection status under Brazil's federal constitution, this biome has historically gained less attention and resources than natural resources in other protected sites, such as the Amazon River basin or the Atlantic Forest. Moving forward, steps to ensure the Pantanal's protection must account for i) historic, multilateral policies and management initiatives, ii) the status of involved institutions, and iii) to meet outstanding social and ecological needs in future implementation of protective policies.

As a polycentric system, the Pantanal's governance has long embraced an Integrated Water Resource Management (IWRM) approach, which "promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (UN 2009). The UN endorsed an IWRM approach in the 1990s to promote coordinated conservation efforts in a polycentric governance context like that of the Pantanal, but similar approaches date several decades earlier. For example, the 1969 La Plata River Treaty set a framework for multilateral decisions that foster equitable use and management of water resources (Gilman et al. 2008). Nevertheless, countries face barriers to coordination due to variation factors such as their respective abilities to monitor others' compliance with collective clean-up efforts, or financial and technical ability to divert–and ultimately–affect water quality and quantity for downstream users (Just and Netanyahu 1998).

Contemporary Challenges

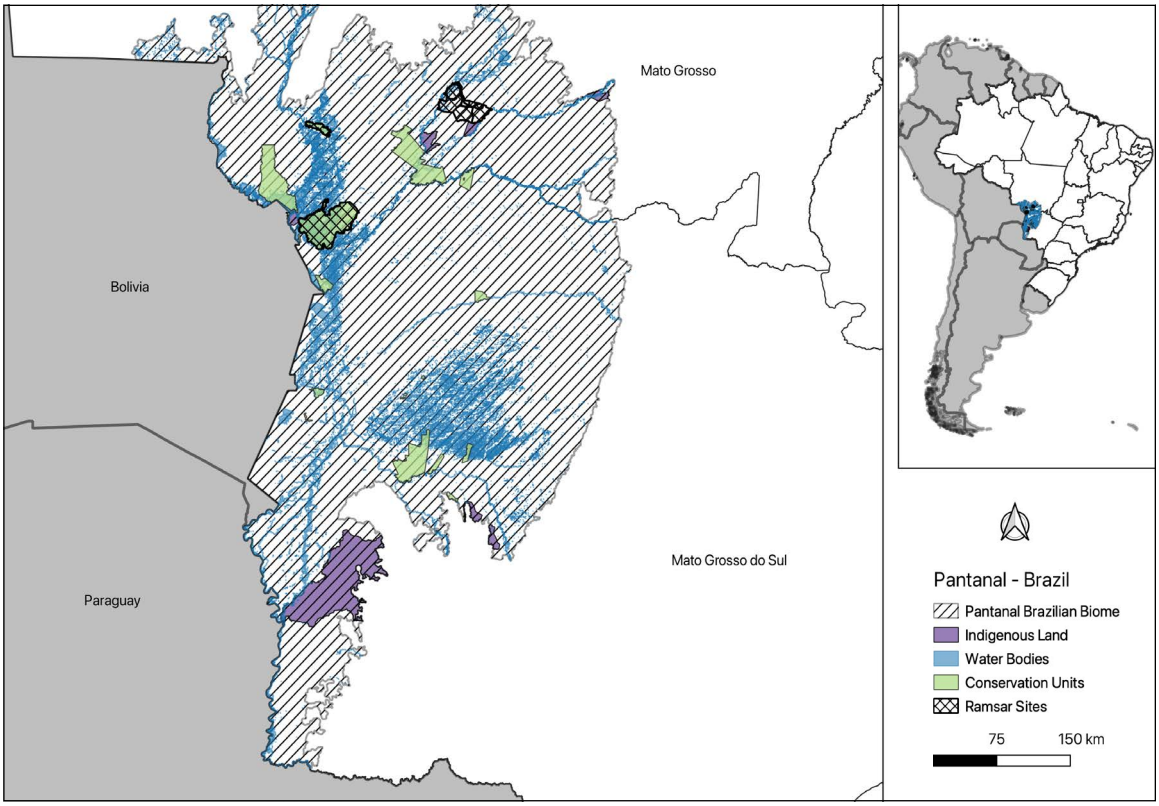
Regulatory frameworks designed to protect the Pantanal against the pressures of development and climate change have served to limit environmental degradation, but they have not addressed modern social, structural, and interpretive challenges. The concurrent emergence of collaborative strategies to advance IWRM bodes well for conservation, but these also face limitations. It is thus imperative to critically evaluate the strengths and challenges of these approaches to inform considerations that may help the governance of this complex SES.

A small proportion of the Pantanal is recognized as a UNESCO World Heritage Site and also has National Heritage status per the 1988 Brazilian Constitution (Supremo Tribunal Federal do Brasil 1988). World Heritage status affords part of the biome legal protection by the parties that sign the World Heritage Convention: they commit to integrate the site's protection into their regional planning, undertake conservation research, and employ staff and services to these ends (UNESCO 2024b). At the national level, Brazil's Constitution states that the Pantanal "shall be used, as provided by law, under conditions which ensure the preservation of the environment, therein included the use of mineral resources" (Const. of Brasil, chap. VI, art. CCXXV).

Heritage protections requirement acknolwedgement, as well as effective programs and policies to ensure sustainability for the ecosystem and the livelihoods of the Pantaneiros (Chiaravalloti et al. 2023). Most of the Pantanal area is in the Brazilian state of Mato Grosso (the third-largest state in Central-West Brazil at 903,357km^2, or 348,788mi^2), shown in Figure 4. Table 1 provides examples of how legislation that may impact riparian areas (i.e., adjacent to rivers or wetlands) is informed by the best available science, but also subjective interpretation.

Collaborative IWRM strategies implemented at different scales have made great strides in improving conservation efforts but face challenges due to limited capacity and coordination (Lemos et al. 2020). These two aspects render communities increasingly vulnerable to rapid and unexpected change. One example involves planning efforts under the Brazilian National Water Resources Policy (no. 9.433/1997, art. 7), which calls for governments to develop long-term water plans at the level of the river basin, state or nation (Brazilian National Water Resources Policy 1997). Under this law and in coordination with the states, the National Water Agency (ANA) developed the 2018 Paraguay Hydrographic Region Water Resources Plan (WRP) to guide the management of the Upper Paraguay River, which falls at the headwaters of the Pantanal (ANA 2018). Challenges have arisen from the WRP's interpretation and implementation. The WRP's language classifies part of the Paraguay River as navigable, but it also proposes areas of restricted use (Wantzen et al. 2023). Furthermore, the absence of a River Basin Committee hampers the implementation of the WRP, as there is no opportunity for civil society to participate in water management decisions for the Paraguay River basin. Many river basin committees are unable to attend to the scale and nature of water governance challenges (Wantzen et al. 2023) and the needs of traditional and Indigenous communities in the Pantanal (Felipe et al. 2021).

A second, larger-scale initiative concurrently emerged with the WRP in 2018, as Paraguay, Bolivia and Brazil signed the Pantanal Declaration, an agreement to develop and coordinate plans for actions that embrace IWRM (Peña 2018). By 2023, the Inter-American Development Bank partnered with the United Nations Environment



^ Fig. 4 The Pantanal Biome and its constituent Indigenous lands, water bodies, conservation units and Ramsar sites. (Source: Bruno P. Puga, 2024. Data sources: Instituto Nacional de Pesquisas Espaciais (INPE) http://terrabrasilis.dpi.inpe.br/downloads/)

Legislation	Scale	Description
Brazilian Forest Code (no. 12.561/2012)	Federal	Wetlands of "social interest" are protected but not guaranteed. Articles 10 and 11 on the removal of native vegetation: subject to the interpretation of technical research recommendations, state environmental agency authorization, and meeting needs of public utility (Brasil 2012).
Amendment: Complementary Bill (no. 17/2020)	State: Mato Grosso	Permits development of the Forest Code's "permanent preservation areas," or riparian areas if the projects are expected to have "low" environmental impact (ICV 2020).
Pantanal Law (no. 6.160/2023)	State: Mato Grosso do Sul	Protects and recovers the Pantanal and its springs, restricting land use and deforestation (Governo de Mato Grosso do Sul 2023).

^ Table 1. Legislation Impacting the Pantanal Biome.

Program to co-finance the Global Environmental Facility (GEF) to strengthen IWRM and the coordination of transboundary water governance (Carreño and Vasquez-Arroyo 2023). The GEF approach is intended to manage endemic species (e.g., jaguar, capybara, riparian forest, or floodable grassland) and tackle root causes of degradation through leading activities, including organizational capacity building and integrating regional concerns into sustainable economic development (GEF 2023). However, the GEF reports continued barriers in addressing threats to the Pantanal (e.g., fire, land-use change, degradation of water resources and poor planning) that stem from the limited technical, managerial and financial capacity of communities – all of which are needed for successful program operations (UNDP and GEF 2021).

Conclusion and Recommendations for IWRM Needs

This evaluation of Pantanal's water resource governance reveals the importance of a) carefully considering the diversity of needs, interests and expertise of those invested in water governance, and b) how these factors align with management at different temporal and spatial scales.

In theory, IWRM is a robust strategy to govern complex socio-ecological systems, given imperfect information and dynamic climatic conditions (Ludwig et al. 2014). One way to fortify IWRM may be through the co-production of knowledge with Pantaneiro and Indigenous communities by collectively identifying problems and solutions based on science and community knowledge and desires (Chambers et al. 2021). Steps toward such a goal may entail establishing a platform (e.g., an in-person initiative and/or digital space to maximize reach and inclusivity) with guidelines and procedural rules that create a safe and equitable space for different groups to express values and understandings, despite tension and asymmetrical power dynamics (Chambers et al. 2021). Finally, large-scale change will require finding well-connected and embedded actors (e.g., the Brazilian Network of River Basin Organizations) to effectively synthesize and broker the latest scientific information, the unique experiences of different Pantanal inhabitants, and co-produced knowledge (e.g., including shared terminology and vision) for decision-makers.

Policy Recommendations

- Drawing on insights from current Pantanal governance arrangements, there are opportunities to speak to the current needs of those impacted by water-governance decisions across different geographic scales over time. This article offers three recommendations that address these accordingly.
- *Diverse needs, interests and expertise:* Promote the co-production of knowledge in existing and new IWRM planning committees to cover spatial, temporal and knowledge-based gaps (for SDGs 6 and 17).
- *Support co-production with science and community knowledge:* Monitor ecological (particularly hydroclimatic) conditions and use citizen science to collect data that inform technical research and budgeting needs for capacity building and that can complement co-productive conversations about innovative adaptations to land-use change and climate change (for SDG 9).
- *Synthesize and broker information:* Develop strategies to identify and include actors that can effectively communicate community-informed needs and experiences to decision-makers responsible for the future of national policy, strategy, and planning (for SDG 13).

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PART II Methodologies and Case Studies

Blue Papers
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The New Dutch Water Defense Line (Nieuwe Waterlinie): Preserving Historical Qualities in a Context of Very High Spatial Pressure

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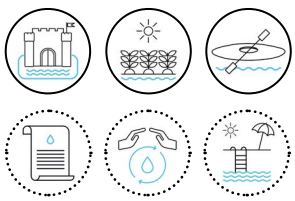
The Dutch Water Defense Line (Hollandse Waterlinie) is a historic defense system in the Netherlands that integrates innovative flood defense mechanisms with the country's lowland topography across a 200 km span. Despite its effectiveness during periods of conflict, technological advancements rendered the defense system obsolete, letting it fall into a state of neglect. The Waterline laid dormant for a few decades until a revitalization effort began in 2001 - a multi-stakeholder endeavor encompassing heritage preservation, nature conservation and spatial development (UNESCO n.d.). In a densely inhabited area, multi-level collaborations were needed to identify new ways to connect water management and heritage preservation. Collaborative efforts among governmental bodies, local communities and private enterprise facilitated the repurposing of historical forts into venues for cultural activities, tourism, farming and hospitality. The successful revitalization of the Dutch Waterline serves as a compelling example of the value case methodology we promote in the course "Water Systems Design: Learning from the Past for Resilient Water Futures." It is an example where heritage preservation is intricately linked with economic development, environmental sustainability and social well-being. As a model for eco- and hydro-systemic thinking, the Dutch Waterline offers valuable lessons for designing resilient water futures and nurturing sustainable landscapes.

Keywords: *value case, ecosystemic thinking, multi-actor, heritage, stakeholders*

KEY THEMES



< Fig. 1 View of the Waterline model at the Waterline Museum at Fort Vechten (Source: Lea Kayrouz, 2023).

Introduction: The Rise, Evolution and Legacy of the Dutch Waterline: Value Case in Becoming

The Dutch Water Defense Lines, or Hollandse Waterlinie, form a defensive system that stretches over 200 km, running partly alongside and partly straight through the core administrative and economic region of the Netherlands (fig. 1). Originally conceived in 1672, structurally improved from 1815 onwards and dismantled in 1963, the network of fortifications to shelter prominent cities against potential French army incursions gradually grew to become a sophisticated lowland defense system. The ingenuity of the Waterline lies in its innovative capability to flood the surrounding areas in case of ground invasion. Over the 150 years following its initial construction, the Waterline underwent significant improvements with military, strategic and architectural innovations, transforming from localized city-level fortifications into an extensive sub-national defense system (fig. 2).

The Waterline as a defense mechanism integrated the water management characteristics of the lowland topography with military defense principles, guaranteeing continued agricultural production. During the nineteenth century, a clever use of the geo-morphological wetland conditions enabled open field dairy farming. Water management devices such as locks, pumps, canals, dikes and inundation polders were collectively administered through the water management authorities (figs. 3–4). This defense feature of the Waterline made possible the neutrality of the Netherlands during World War I. However, technological advancements, especially the use of airplanes in warfare, made the defense system obsolete (Steenbergen et al. 2009).

Spanning 200 km of unoccupied blue-green infrastructure, the Waterline cuts through an area of high population density and of rapid transformation characterized by continued urban, agricultural and water management developments. The ingenuity of the redevelopment plans lies in the ability to combine different developments into a planning strategy able to integrate old forts that are now heritage structures with natural, recreational and economical values. In the professional education course "Water Systems Design: Learning from the Past for Resilient Water Futures"[1] we looked at the Dutch Waterline as a thoughtfully designed ecosystem, a relevant reference to incentivize learners to adopt eco- and hydro-systemic thinking. "Water Systems Design" conceptualizes the Dutch Waterline as a value case in the making, in which contested heritage structures – too expensive to be preserved – acquired new functions connected to the needs and potential of the surrounding territories, from water management to economic development.

From Defense to Heritage: The Transformative Values of the Dutch Waterline

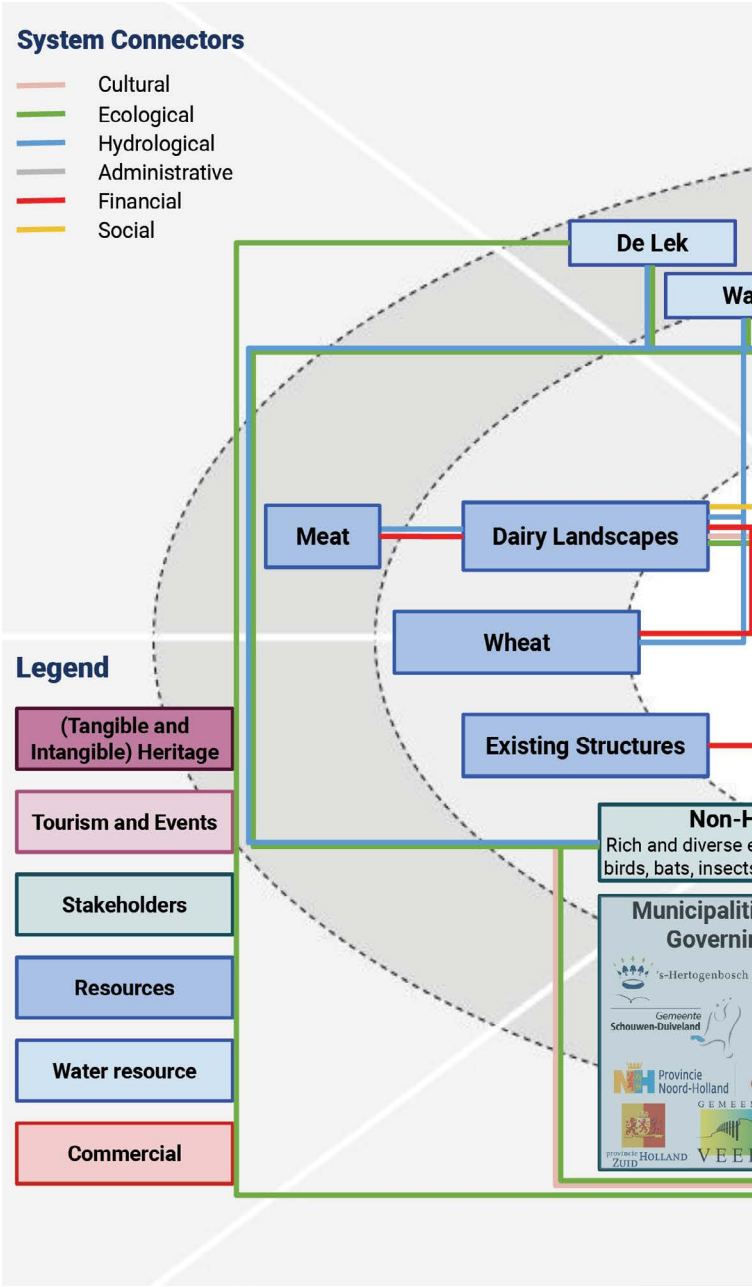
The first version of the Dutch Waterline was operationalized in 1672 as a response to the threat posed by the French army. It continued to be extended and renovated until it became a 200 km network of fortification. In 1815 King William I, leading the newly established Kingdom of the Netherlands, decided to extend, renovate and modernize the whole system. The outbreak of World War I in 1914 saw the Netherlands not participating, allegedly and in part, due to the perceived effectiveness of the Dutch Defense Line. However, during World War

1. "Water Systems Design: Learning from the Past for Resilient Water Futures," https://online-learning.tudelft.nl/courses/water-systems-design-learning-from-the-past-for-resilient-water-futures/.

^ Fig. 2 View of the Waterline model overlooking Utrecht and the surrounding forts (including Fort Vossegat, Fort de Bilt and Fort de Lunetten). The model is featured in the Waterline Museum in Fort Vechten (Source: Lea Kayrouz, 2023).

II in 1940, the Defense Line proved inadequate against airstrikes launched by bomber planes, and some decades later, in 1963, legislative measures regarding fortifications and inundation were rescinded. A turning point for the Waterline came in 2001 when a substantial protection and revitalization initiative was launched by the national government as part of a public investment strategy. By 2009, the entire system and its components were officially designated as a National Monument, and in 2021 the Dutch Waterline extended the Defence Line of Amsterdam, which was already UNESCO World Heritage since 1996.

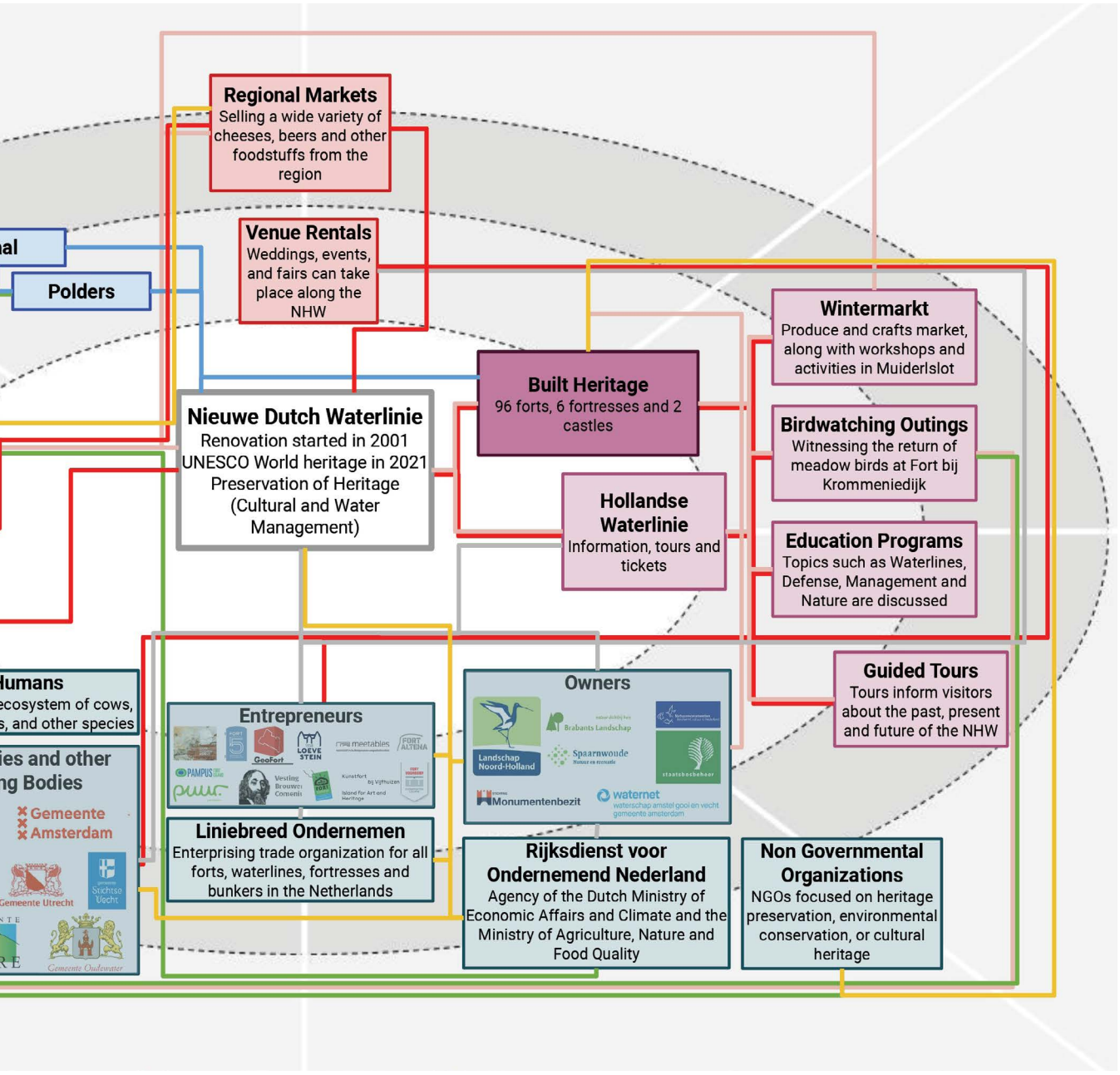
The transformative adaptation of the Waterline, after the loss of its defense function, underscores the evolutive nature of water values. A water-based defense system comprising ninety-six forts, along with the six fortresses and two castles and hundreds of bunkers, was turned into a water management project that allowed for heritage protection and served as a tourist attraction. This paradigm shift was initiated by a robust protection and revitalization program, supported by governmental stakeholders and based on collaboration with local entrepreneurs and institutions. Tangible and intangible water values of shelter and defense,[2] of agriculture and inundation,[3] and laws and policies[4] have been transformed into principles of preservation, adaptation, reuse and recreation. The comprehensive repositioning of the historical megastructure paved the way for an accessible heritage experience, which was facilitated by local NGOs and entrepreneurs, particularly those engaged in the hospitality business.



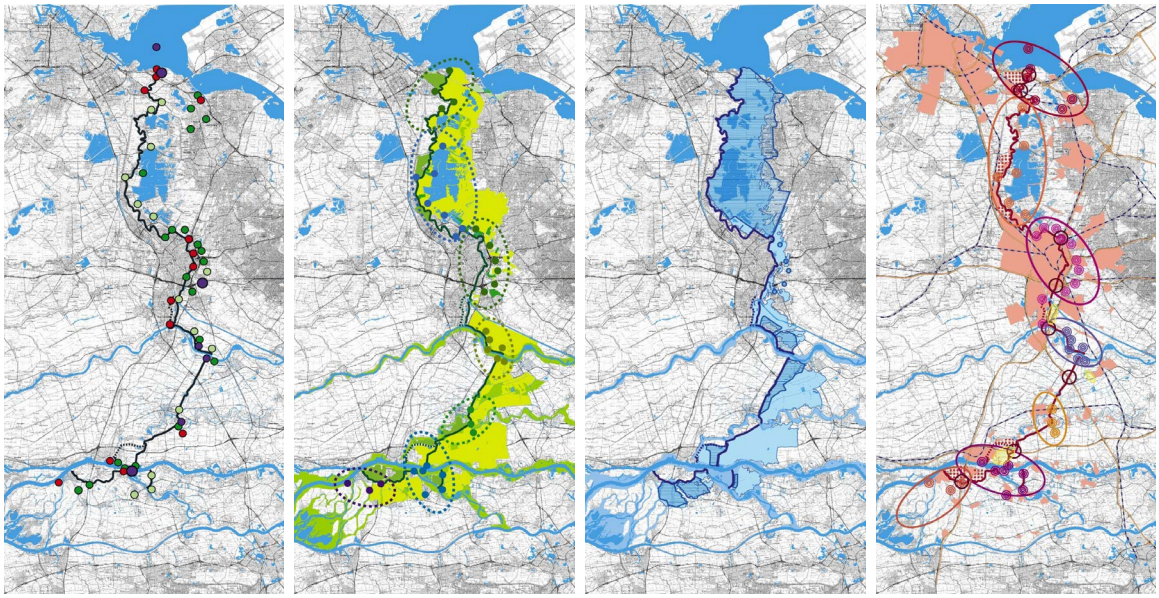
2. Demonstrated through the enhancement and expansion of defense systems, spanning from city to sub-national levels.

3. Exemplified through intelligent utilization of geo-morphological wetland conditions, open-field dairy farming and collective water-management devices.

4. Illustrated by the establishment of legal and financial frameworks for designing, constructing and operating military defense systems, along with funds to compensate farmers in the event of inundation.



^ Fig. 3 Network of flows and stakeholders surrounding the Nieuwe Dutch Waterline, developed by Lea Kayrouz based on literature on the Dutch Waterline and as a model for the course "Water Systems Design" (Source: Lea Kayrouz, 2023).



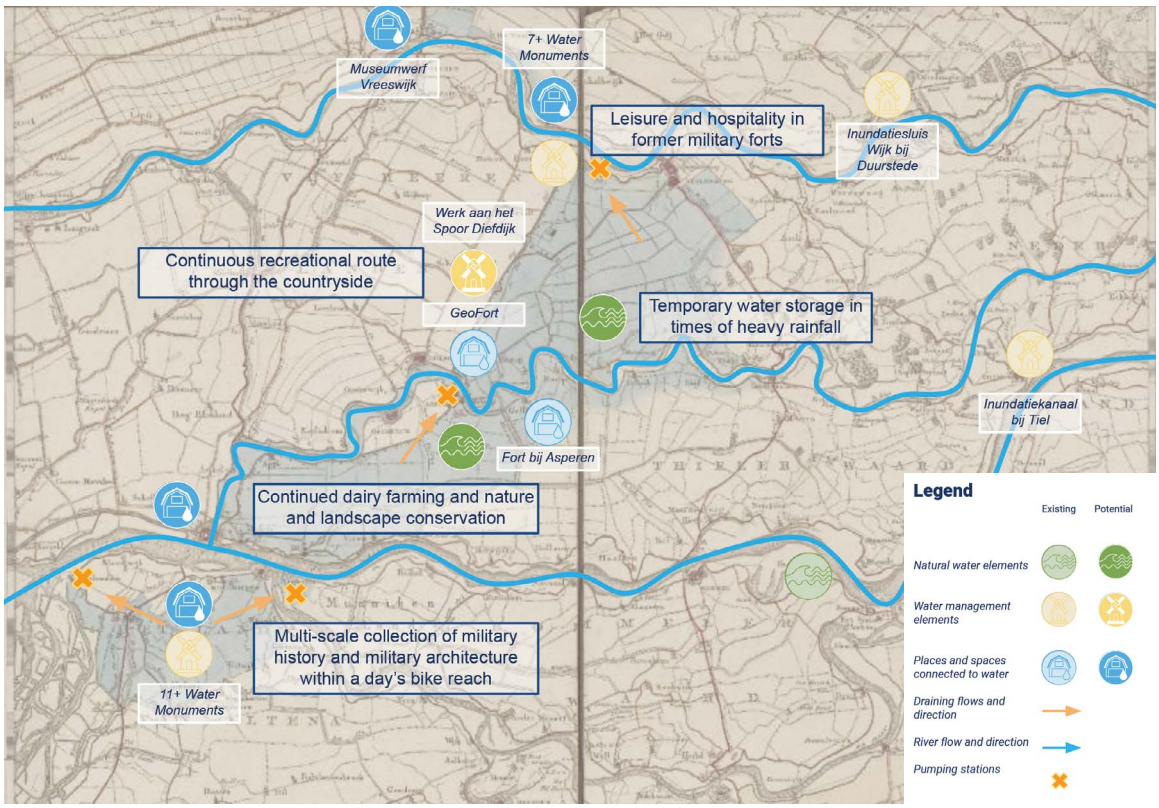
^ Fig. 4 A mapping of the components of the Waterline and the other spatial demands and opportunities in the area. From left to right: Map of the four different ownership and operational scenarios of fortifications of the Waterline; map of the continued agricultural and natural land use of green areas and fort clusters of the Waterline; map indicating the potential significance of inundation for future water retention; map of the clusters of fortifications providing multiple touristic arrangements along the Waterline (Source: Eric Luiten, 2023).

Situated Sustainability: Integrating Heritage, Nature and Spatial Development along the Dutch Waterline

The Dutch Waterline encompasses natural water bodies, water management structures and historical places with a continuous recreational route through the countryside. These elements have been reshaped into operative landscapes as the Waterline has undergone renovation, in a collective effort by a wide spectrum of stakeholders. This includes the Nieuwe Hollandse Waterlinie (NHW) planning office, operated by the Regional West branch of the Rural Area Service, which collaborates with four ministries, five provinces, various municipalities, water management boards and organizations and entrepreneurs specializing in cultural history, recreation and agriculture (fig. 3).

The national government launched the masterplan, which emphasized the importance of guidelines for protection and an invitation to (re)development. The protective approach was based on the definition of the so-called primary defense line that runs through the heart of the Linie and the introduction of three comprehensive spatial regimes that needed elaboration and further definition under the responsibility of provincial and municipal authorities. It provided a foundation for heritage and landscape preservation that made it possible for the Waterline to become a national monument and UNESCO World Heritage Site.

The development standpoint (supported by the four maps in fig. 4) anticipated the ongoing interest in transforming the area of the Waterline because of regional urban extension programs, agricultural development, tourism initiatives, infrastructural investments and quantitative



^ Fig. 5 Mapping of the project envelope around Fort Vuren, Fort Vechten, Fort Nieuwe Steeg and Fort Honswijk (Source: Lea Kayrouz, 2023).

water management and water retention challenges. The idea was to encourage institutional and private institutions to come and invest, but in such a way that the essential historical features of the Waterline would be enhanced. This redevelopment strategy made extensive use of multi-scalar collaboration. Once the masterplan was created, the regional and local governments took the responsibility of supervising the developments of the section of the Waterline under their jurisdiction – each one called a "project envelope." This approach allowed the design of regulations and interventions more in tune with the different contexts and the requests of local actors. At the same time, a quality team responding to the national government monitored the work of each area therefore providing consistency among – and integration within – the different "project envelopes."

Examples for interventions in "project envelopes" include the surrounding area of Fort Vuren, Fort Vechten, Fort Nieuwe Steeg, Fort Honswijk and dedicated efforts focused on nature and landscape conservation. By leasing inundation areas to farmers, financial benefits accrue to the Waterline, fostering economic viability. Furthermore, the advocacy by nature organizations for biodiversity preservation, coupled with the careful integration of old flooding structures with water reservoirs, addresses contemporary challenges like water scarcity, floods

and the salinization of agricultural waste (fig. 5).

Other transformative initiatives include collaborative endeavors with several water management authorities for water storage and treatment, reducing costs and increasing profits; another example is engaging students in the maintenance and restoration of forts (Durville and Boerée 2012) which lowers the costs of preservation for the Nieuwe Hollandse Waterline, while creating an educational experience. The adaptive reuse of former military forts exemplifies another synergy created during the revitalization project, wherein these historical sites are repurposed as wedding and conference venues, museums, offices or accommodations for overnight stays and leisure and cultural activities are sustained and sustain a growing hospitality sector. The Liniebreed Ondernemen Foundation (LOF) provides entrepreneurs with the support and advice necessary to catalyze sustainable futures for the forts and their surroundings (LOF 2023). The LOF has contributed to numerous projects, including but not limited to the publication of route guides, the development of campaigns and festivals, and the setting up of exhibitions pertaining to water heritage. These initiatives were facilitated by governmental stakeholders that provided strategic direction, shaping policies that are attuned to the different regions and their respective needs. In an approach described as "planning by invitation," governments broadly outline areas where spatial changes are desirable, considering long-term forecasts and the preservation of values. However, these outlines are not imposed on the area, as doing so would position the government as an unwelcome guest. Instead, the approach revolves around discerning what the area itself appears to be requesting based on existing values and user inputs; the government can only suggest what is desirable since it is unable to fund said desires. Users, residents and dwellers are responsible for funding the renovation and its economic viability, inviting them to step into the role of policymakers. These diverse strategies showcase the comprehensive and forward-thinking approach employed in the renovation of the Dutch Waterline to integrate historical, natural and economic elements into a sustainable framework, fostering water resilience and adaptability for the future (Bakker et al. 2022; Luiten 2011).

Conclusion: Ecosystemic Revitalization of Heritage and the Value Case Methodology

The renovation of the Dutch Waterline managed to address the interests of heritage management and water security while adding value for the territory. The plan serves as an exemplary instance of a value case, integrating climate-resilient infrastructure, robust partnerships, economic development and innovative water management while preserving historical elements. The renovation initiative aligns with various Sustainable Development Goals (SDGs) generating beneficial effects across the sectors of agriculture and farming, culture and heritage, water management, nature and landscape conservation.

This case not only offers an effective strategy for actively preserving heritage but also demonstrates that the economic viability of preserving the Waterline is contingent upon a comprehensive program involving numerous stakeholders. The New Dutch Waterline was chosen as an example for the "Water Systems Design" course because it epitomizes a cohesive and collaborative approach that safeguards historical attributes and revitalizes heritage structures into dynamic and adaptable spaces that resonate with contemporary needs and values.

Policy Recommendations

- Heritage preservation in areas that are under high spatial pressure is best organized as a twofold initiative: to be straightforward about what should be protected and to be precise under which conditions spatial transformation and modification are invited and appreciated. A policy framework that stands on these two legs will serve as a strong basis for combined preservation and revitalization.
- Make a clear distinction between the different levels of responsibility to achieve a sustainable future for historical material. The experience of the Dutch Waterline program revealed that a jointly edited master plan initiated by the public sector proved to be a binding factor in the distribution of spatial initiative, in the qualitative evaluation of singular projects and in the elaboration of planning guidelines on a local level.
- A variety of instruments can be implemented in a heritage context: ownership and operation, financial or material incentives, legal rules and regulations and supportive communication. Take them all into account when exploring the potential of a larger heritage structure or system.

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From Landmarks to Watermarks: Water Towers as Hidden Signs of Water through the Value Case of Ourinhos, Brazil

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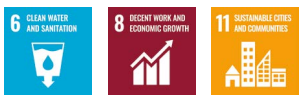
This contribution explores the case of Ourinhos, Brazil, through a value case approach. The findings are based on the author's work in the professional education course "Water System Design: Learning from the Past for Resilient Water Futures," offered by the UNESCO Chair Water, Ports and Historic Cities team based at TU Delft. Following the methodology of the course, the author identified water towers as key elements of transformation and developed the concept of watermarks. Following a brief investigation of history, heritage and context, the article examines the potential of water towers to act as watermarks for educational and professional institutions present in the region. Drawing on pop culture among the city's young people, the article proposes making the Ourinhos Water Tower a recognizable watermark of the city, a place worth visiting and engaging with. The plan includes people from a variety of backgrounds, interests, ages and perceptions who can join forces to develop powerful solutions to valuing water.

Keywords: *water tower, heritage, SDGs, values, watermarks*



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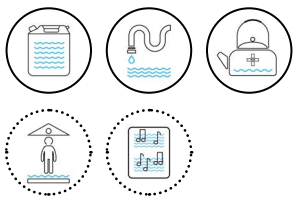


< Fig. 1 The Water Tower of Ourinhos (Source: Monica Clauzet Leite de Souza Manzione, 2023).

Introduction

In response to water challenges related to climate change and population growth, we need new solutions to address complex water problems. Many practitioners and academics are looking to the past to learn from historic water spaces, practices and heritage (Hein 2022). This approach is also the foundation for the course "Water Systems Design: Learning from the Past for Resilient Water Futures,"[1] which provides a value-based approach that catalyzes spatial and infrastructural transformations and includes values associated with material, economic or cultural flows (Robbins and Sommerschuh 2016/2023; D'Agostino and Hein 2024). Learners create a value case following a value-based approach. This article demonstrates how learning in the course can help (re)connect water, culture and heritage and how it advocates for a change in narratives through the Ourinhos case study. The article applies key lessons of the course to an analysis of Ourinhos and offers a plan – the *Watermarks* project – to leverage existing water structures in order to raise water awareness and public engagement in water-related issues.

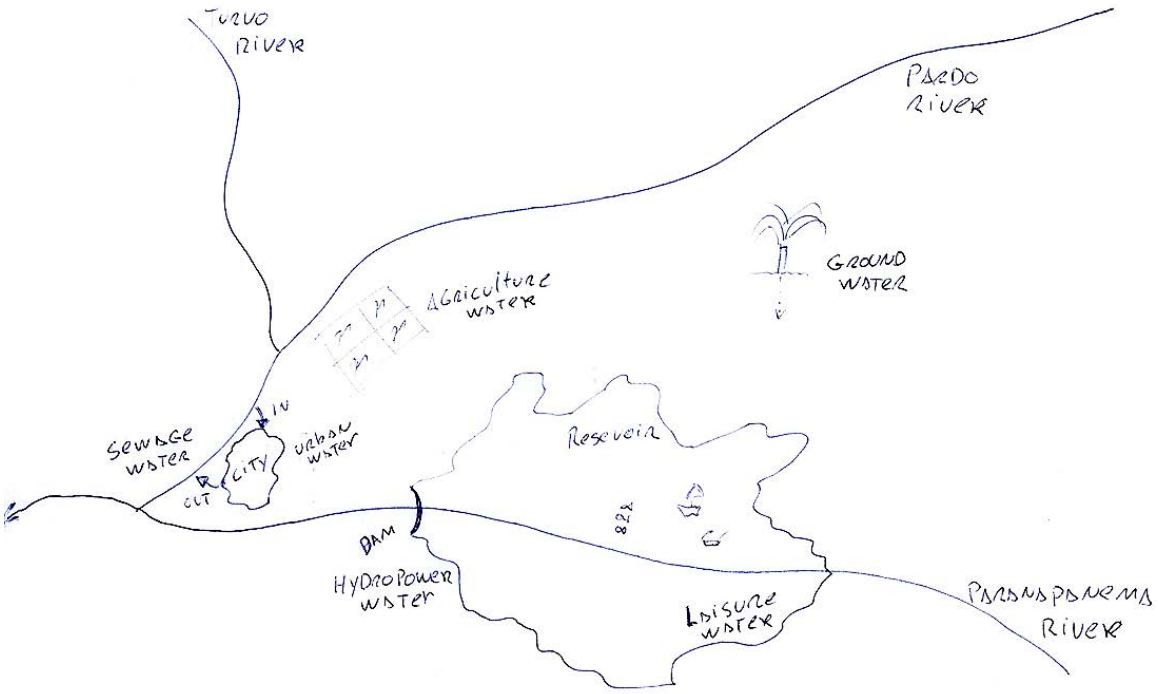
Watermarks and Water Values

In English, a watermark is a design on paper that aids identification or ensures authenticity. A watermark can also be a mark that indicates the height to which water has risen (usually as a result of flooding). In this article and in the project the term "watermark" denotes a landscape feature associated with water. Every city has watermarks, like wells, dams, fountains, cisterns, canals, towers and water tanks. There are also natural formations that permeate cities and their surroundings, such as rivers, lakes, aquifers, wetlands and glaciers. These watermarks have multiple functions related to water systems, communities and identity. They serve diverse groups and therefore embody multiple values, including those that are economic, political, social and cultural. Watermarks erected long time ago continue to affect the built environment and can be considered heritage, even when not officially recognized as such (Hein 2023). Watermarks and their functions directly or indirectly impact the hydrological cycle of a region. It is thus important to consider the geographic space of the water system in which watermarks are embedded to promote restoration – and avoid further disruptions of – the water cycle. Understanding the values associated with watermarks, their formation through time and current impact on practices and space can inspire future practices, activate perceptions of – and relations with – water and heritage and enable context-sensitive water management projects able to preserve heritage while promoting sustainable water uses (Hein et al. 2023).

Rethinking the Water System of Ourinhos: Developing New Strategies

From the establishment of the city of Ourinhos (São Paulo State, Brazil) in 1906 to the present day, values involving the water supply system have been changing. At the city's founding, marked by railroads and coffee production (Dias 2014; Cunha 2020), values such as ambition, leadership, success and working with pride shaped the character of the population and its founders. The creation of the first water system can be considered an achievement - it provided

1. "Water Systems Design: Learning from the Past for Resilient Water Futures," https://online-learning.tudelft.nl/courses/water-systems-design-learning-from-the-past-for-resilient-water-futures/.



^ Fig. 2 Location of Ourinhos, São Paulo (Brazil), its main rivers and water uses (Source: Rodrigo Lilla Manzione, 2024).

water security to the population with a regular supply of quality water, for the common good. But with expansionist policies, the former rulers allowed the city to grow without proper regulation to protect water sources, even when expansions of the water system aimed to create social order and provide water for all. Disease and pollution arising from untreated sewage led to interventions that sought to address issues of health and water quality. However, the government did not maintain this leadership in water health for long. For decades a sewage treatment plan was on the table of the decision makers, without further developments. The population has not demanded change, revealing little awareness of how a region rich in water resources could experience water problems. The main reason is a lack of information and knowledge about water and related systems at all levels. How is it possible to reconnect people with water and its importance in a place where water has not been properly valued?

Place and Context

In terms of water sources, Ourinhos is a privileged city, with three large rivers in its domain, the Pardo-Turvo-Paranapanema Rivers (fig. 2). The region also has many uses for its water supply, including drinking water, sanitation, agriculture, hydropower generation, leisure and recreation. The varied uses come with an equally diverse list of stakeholders. The Pardo River is responsible for 90 per cent of the water used by the city of Ourinhos. As extraction has increased, the Pardo River has reached its limit of providing water to the population and receiving the city's sewage without treatment. To increase water supply, groundwater has been

tapped and instead of solving the sanitation problem, the city government has discussed the possibility of privatizing water services and investing this money into other urban services, such as education, security or health.

Ecosystems, Flows and Networks

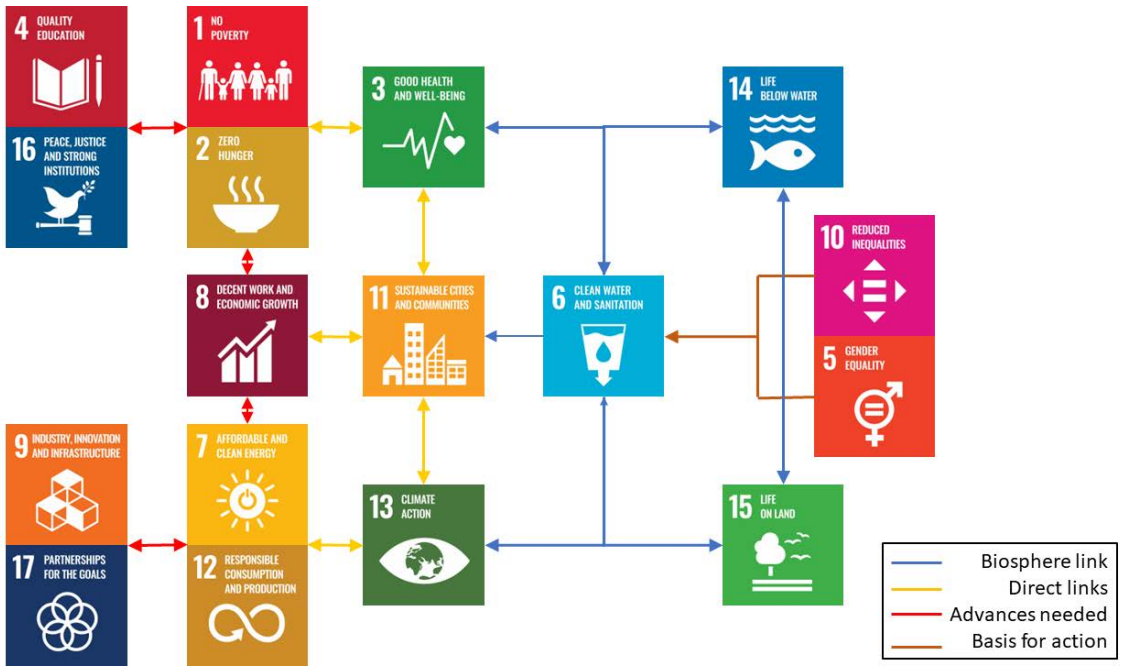
As proposed in the course "Water Systems Design," a large-scale approach to a river system can help develop local solutions that are spatially and institutionally integrated. For Ourinhos, this function is assigned to the Médio Paranapanema Watershed Committee created in 1994 in compliance with state laws to manage water resources, aiming for their recovery, preservation and conservation.

The Paranapanema River forms the border between the states of São Paulo and Paraná. The federal government is responsible for managing water quality and quantity. In December 2010, the National Water Resources Council approved the creation of the Paranapanema River Watershed Committee at an interstate level. There is a close connection between all the watershed committees in the Paranapanema River Basin (PRB). They represent an established channel between water users, stakeholders and public institutions. The presence of the Guarani Aquifer System in the region, one of the world's biggest groundwater reservoirs, supports urban, industrial, and agricultural activities in the watershed. The superficial water and groundwater shared by all the cities along the PRB can help connect the cities that belong to the watershed. This can be part of the work of the watershed committees on state and federal levels. How can the functioning of these committees be improved?

By making the most of scenic places in the area, tourism can be developed in ways that help promote the value of the watershed and stimulate action to fight environmental degradation and increasing water scarcity. However, this development of tourism will require new transportation infrastructures that depend on public investments. The presence of universities, technical schools, non-governmental organizations (NGOs), syndicates and other civic society organizations can offer the support needed for these cities to develop projects to value their watermarks and heritage. Such an intervention would need to be closely related to other large scale interventions such as those related to the energy sector (Zocchi 2002).

Strategy: Contemporary Challenges and the SDGs

To bring back the universalist values characterizing the early days of the Ourinhos water system it is important to reconcile different visions and interests in the PRB region. In particular, there is a need for a comprehensive and multidisciplinary approach able to 1) account for different values placed on water among the population and 2) increase water awareness among Ourinhos citizens by highlighting ways the river is more than a resource for the city. During the "Water Systems Design" course, we used the UN Sustainable Development Goals (SDGs) as a framework to rethink existing water management and balance social, economic and environmental sustainability (UN n.d.). The seventeen SDGs are integrated with each other, and as it happens with water management, the actions taken in one area will affect other sectors of society (Pellegrom 2023). In Ourinhos, water managers and other decision makers at the municipal level (mayors, secretaries, city counselors) may need new tools and methodologies to take a holistic approach to sustainable development, which accounts for local particularities,



^ Fig. 3 Strategy to connect the SDGs to water values in the Ourinhos study case (Source: Rodrigo Lilla Manzione, 2024).

achieves buy-in from society at large and acknowledges historic path dependencies (Hein 2022). In building the value case for Ourinhos, SDG 6 is the central theme, surrounded by SDGs linked to the biosphere and contributing directly to SDG 11, which will lay the foundation for all other subsequent SDGs. Actions to valorize water would involve SDGs 5 and 10 in search of a more fair, equal and inclusive society (fig. 3).

Value Case Proposal

As close as the river is to Ourinhos citizens' hearts, it is far from their eyes. The Watermarks project has proposed considering the river as the central element of the basin and its region. It argues that several cities along the river basin have their own watermarks that connect people's heritage and the historical context of these cities. These watermarks can take several forms, from buildings and manmade structures like towers, pools, dams and channels to natural features like rivers, lakes and aquifers. Sometimes these watermarks are silent and unseen (Burkett 2020) and need to be made visible to people. As addressed throughout the Water System Design course, valuing water is a deeply personal matter, embedded in broader worldviews and often influenced by the cultural and geographical context in which we grew up. Exploring the power of place offers a path to active preservation (Dahme et al. 2022). Developing awareness among the public and arriving at solutions to problems is tricky and challenging, as climate change is demonstrating for humanity. The idea behind the Watermarks Project is to create continuous actions to link people and water in Ourinhos, making the city's watermarks symbols of the presence of water and its importance for human and natural well-being. The plan is to create a new sense of responsibility

^ Fig. 4 The location of the Ourinhos Water Tower (Source: Rodrigo Lilla Manzione, 2024, map modified from Google Earth).

for and awareness of the city's water and an interest in preserving it.

Action Plan

To begin the valorization of local water heritage, one possibility is to make use of a recognizable and popular structure: the water tower of the Ourinhos Fire Department (fig. 4). The water tower has a privileged location in the city. It is in an upscale neighborhood that has several urban elements for leisure, sports and entertainment. On weekends, the place known as Trilha Verde (green trail in Portuguese) takes on the atmosphere of a block party and can be a center for social events. The general idea behind the enhancement of watermarks is to transform the tower surroundings into an "Instagrammable" spot, where people can, for example, take photos and videos to share on their social networks.

The plan proposes that the watershed committee present a project to the São Paulo State water resources state fund to obtain financial resources to make the project viable. The project could develop a cell phone app that would capture the shape of the tower and provide different artistic prints to decorate the tower and consequently the photo. The artwork that would be available on the app would be created by students, youth and the public during art contests. The best works will be available along with other predefined image backgrounds (e.g., plants, animals and traditional elements that refer to the local culture).

This proposal encourages actions to be carried out in municipal and state schools, with lectures on street art and graffiti with artists from local collectives, and on water resources and water values with experts from the universities involved. Teachers of science, arts and

technology will also provide space in their disciplines for the development of activities. São Paulo State University would provide the water experts available in the Department of Geography and Planning of the School of Sciences, Technology and Education of Ourinhos and the Technical School of São Paulo would participate in the development of the cell phone app with the computational systems expertise available in its computing and game theory course. Students from both higher education institutions will be involved to assist teachers in the activities and development of the project in a scholarship modality.

The tower is white, and imagining real paintings and arts in the structure would be a cause for controversy and discussion among the municipalities. Through the creation of the cell phone app, we would seek to connect young people with a language that they understand, encouraging creativity and the development of skills in the school environment. Alongside the Instagrammable point created next to the tower, information would be offered about the structure, highlighting its historical importance, architectural relevance and current features, along with other information that might encourage people to feel a sense of belonging and involvement with water resources. Is there water inside this structure? Where does this water come from? Where does this water go? Key questions that are sparked in visitors' minds when they engage with the watermark can increase people's perception of the importance of a clean and healthy water body near the city – in this case, the Pardo River – and can raise awareness about the entire watershed.

The Ourinhos value case is based on multi-stakeholder engagement and collaboration. The project aims to bring together people who represent different branches of society. Universities, businesses and public institutions can provide technical support, while public engagement and advertisement can be led by local and regional NGOs with the aid of local radio stations, internet channels and social networks as well as schools, neighborhood associations and syndicates. Local artistic collectives will offer artistic and cultural development. Engagement with local or even nationwide influencers could help enlist young people. The realization of the project counts on the financial support available in water resource funds that are part of water legislation, with institutional support of the watershed committees, municipal government and educational, environmental and cultural secretaries. Funds from hydropower companies and water service companies can also boost the project regularly once they are obliged by law to contribute to water resource funds.

In the short term (one–two years) recreation activities, arts expositions and tournaments focusing on water preservation would raise water awareness among local residents and provide education about sustainable daily water practices that in the long term (ten years ahead) would hopefully become part of education and institutional development. The project can be replicated in other cities and regions. Several cities in the state of São Paulo have old water towers and other water elements that could be used to highlight water systems and water resources at local and regional levels.

Conclusion

When exploring the watermarks of a city or region, it is possible to link different actors, from local inhabitants to water experts, along with different scales and practices. Old structures and practices can be adapted to new technologies and social trends. Those familiar with the

interests of young people can help identify and enhance new interventions. The already established water institutions in the region, like the watershed committee, can amplify the impact since several cities are congregated inside the committee framework and they are connected by their shared water source. As proposed in the "Water Systems Design" course, using the correct framework, respecting local particularities and including attractive elements, it is possible to design projects that influence how people perceive, value and connect with water systems.

Policy Recommendations

- Identify, recognize and activate local watermarks for action.
- Enhance effectiveness, consider and respect local particularities.
- Link young people's interests with watermarks.

Acknowledgment

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Achieving a Water-Resilient Rotterdam: Past, Present and Future Perspectives

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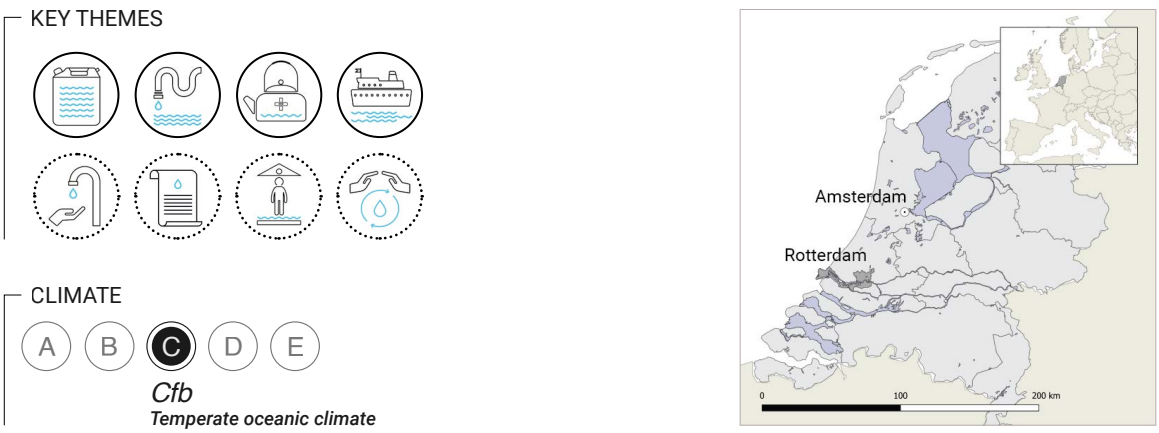
Deltares
Johan Verlinde
Municipality of Rotterdam

Rotterdam has a close and essential connection with water, both as a port city and a delta city. As a low-lying city situated in the estuary of the Rhine and Meuse rivers, most of the city (85 per cent) lies below sea level, and some areas are as low as 7 m beneath sea level. Except for the main port area, the remaining 15 per cent of the city lies in outer dike zones. Since evacuation is nearly impossible, adapting to climate change presents a significant challenge. This vulnerable delta city is continually revisiting its approach to water threats and climate change is demanding a new round of interventions. The historical fight against water is being abandoned in favor of living with water. Water connects and brings leverage. By creating more space for water and promoting blue-green infrastructure in the built environment, Rotterdam is becoming climate-resilient, greener and more livable. Rotterdam's blue-green transformation to a sponge city of the future (2100) aims at achieving SDG 11 ("Sustainable Cities and Communities") and has the potential to fulfill targets regarding climate action (SDG 13), the protection of water quality (SDG 6) and the restoration of biodiversity (SDG 14 and 15).

Keywords: *blue-green infrastructure, climate adaptation, sponge cities, water resilience, water urbanism*



< Fig. 1 Impression of live on the Meuse and the city could look like in 2100 (Source: De Urbanisten 2022).

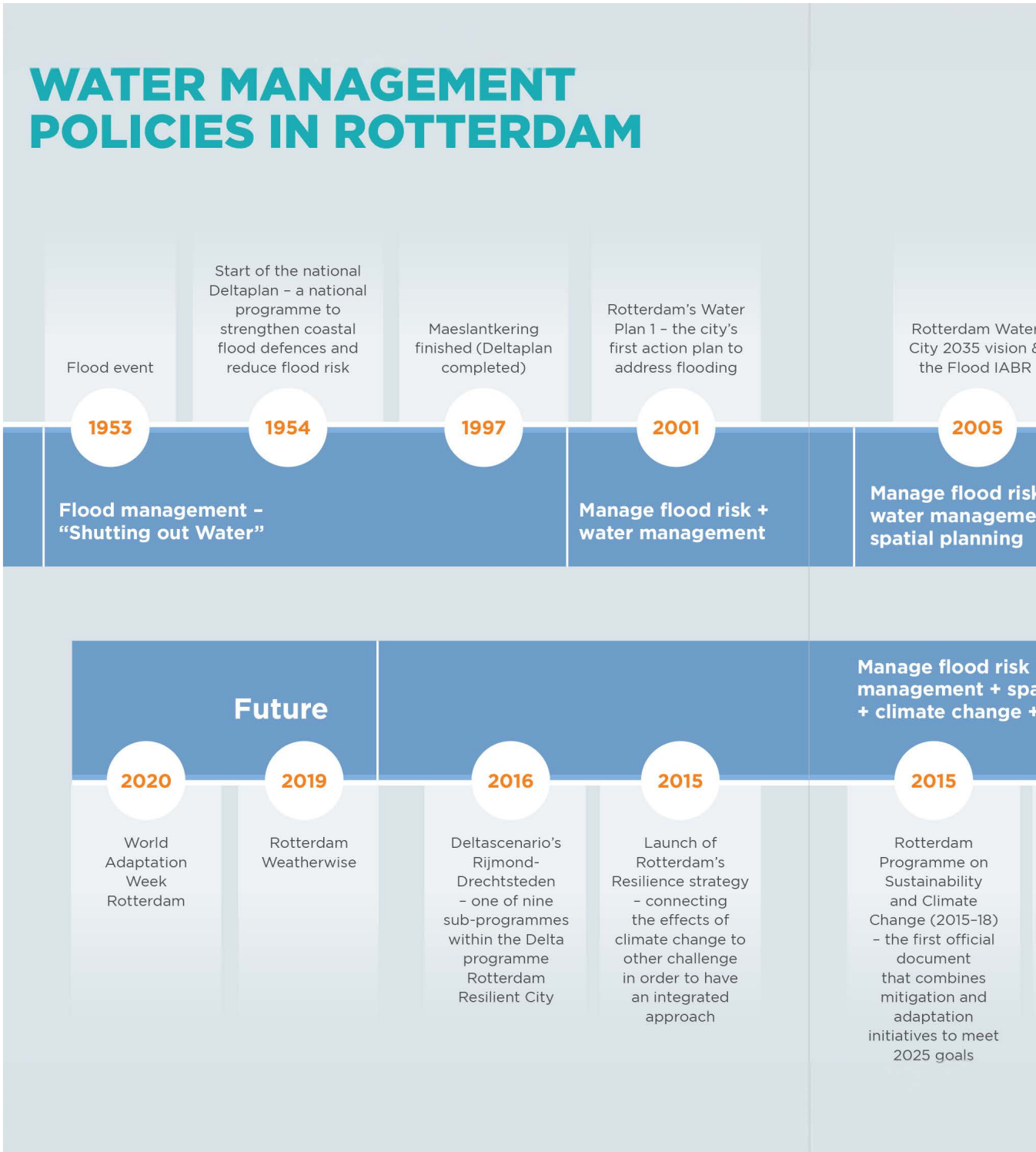
The Past: From Fighting Water to Living with Water

Controlling water has always been a theme in Rotterdam's urban development (Van Vliet and Aerts 2014) and one that is evident in its strategic location along the Nieuwe Maas River, a tributary of the Rhine. Today, Rotterdam faces challenges associated with rising sea levels, high river discharges and extensive polders below sea level (fig. 2), highlighting its vulnerability to water-related hazards. Situated in the Rhine-Meuse estuary of the Netherlands, Rotterdam originated from a dam on the Rotte River in the thirteenth century. Once a small fishing village it is now a prominent international port city and the largest port in Europe.

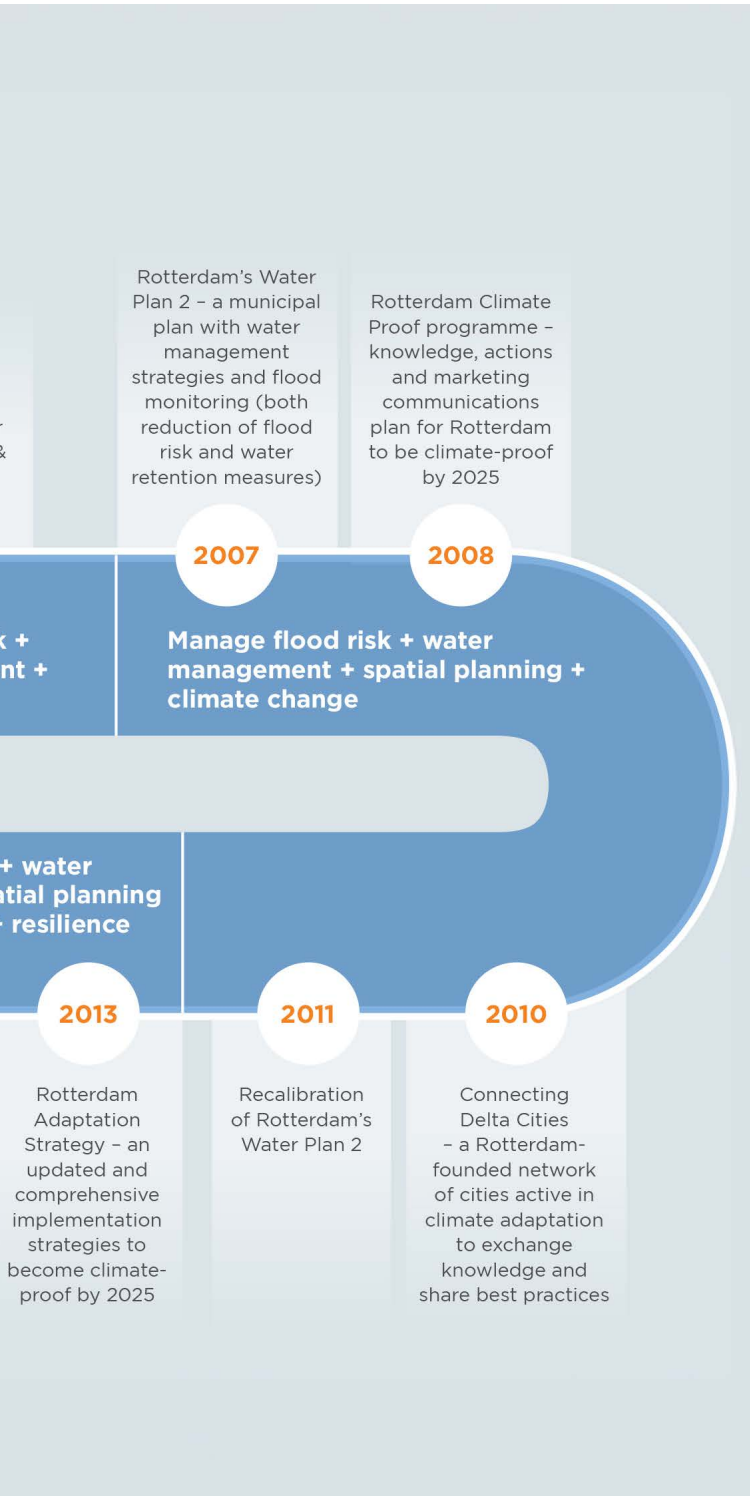
As Rotterdam's port thrived, attracting more residents, urbanization brought new challenges. Densely populated areas saw waste and sewage dumped into ditches, leading in the nineteenth century to sanitation issues and cholera outbreaks. Architect Willem Nicolaas Rose responded with "The Singel Plan," constructing canals to flush the city with fresh river water in 1854. This plan improved citizens' health and made the city more attractive.

During World War II, Rotterdam suffered severe bombing, which devastated the city center and surrounding neighborhoods. During the city's reconstruction, water was pushed back out of the city to facilitate vehicle traffic. Many of the "Singel Plan" canals were turned into roads. The past resonates in current water management policies; with 85 per cent of the city below sea level and lacking surface water, urgent action is needed to address drainage inadequacies and keep the city dry during extreme precipitation events. Over the past two decades, Rotterdam has worked hard to adapt to climate change and to improve the city's water management, spa-

^ Fig. 2 The genesis of Rotterdam: historical parcellation pattern in relation to the current elevation map (Source: Municipality of Rotterdam, 2023).



^ Fig. 3 Timeline of water management policies in Rotterdam 2001–2020 (Source: Municipality of Rotterdam, 2019).



tial planning and resilience (fig. 3). Partly based on an extensive water system analysis, the Rotterdam water partners (municipal and the regional water authorities of Delfland, Schieland en de Krimpenerwaard and Hollandse Delta) formulated their joint vision in the first edition of Rotterdam's "Water Plan" in 2001. Themed "The Flood," the 2005 International Architecture Biennale Rotterdam became the starting point for a Rotterdam Water City 2035 vision. This resulted in "Water Plan 2: Working on Water for an Attractive City" (2007). In addition to addressing sustainable water management and adaptation to climate change, this Water Plan envisioned changing the spatial focus from a city scale to a metropolitan scale. With input from interest groups (e.g., social housing associations) and the engagement with local communities, the recalibration of "Water Plan 2: Water for an Attractive and Climate-Proof City" in 2011 integrates water management, urban planning and climate adaptation solutions. This third edition of Rotterdam's Water Plan comprises thirteen sub-water plans in accordance with the city's urban typologies.

The Rotterdam Weather-Wise Plan (2019) and the Weather-Wise Program Framework 2030 (2023) complete the journey to date and can be considered the fourth edition of Rotterdam's Water Plan. To complement improvements to water safety infrastructure, water safety infrastructure, Rotterdam Weather-Wise aims to create a bottom-up movement to involve both public and private actors in implementing climate change adaptation measures. This transition from fighting water to living with water came about by necessity.

The current strategy is to adopt measures on a small scale that will increase the city's ability to absorb water ("city as a sponge") and, at the same time, improve outdoor public spac-

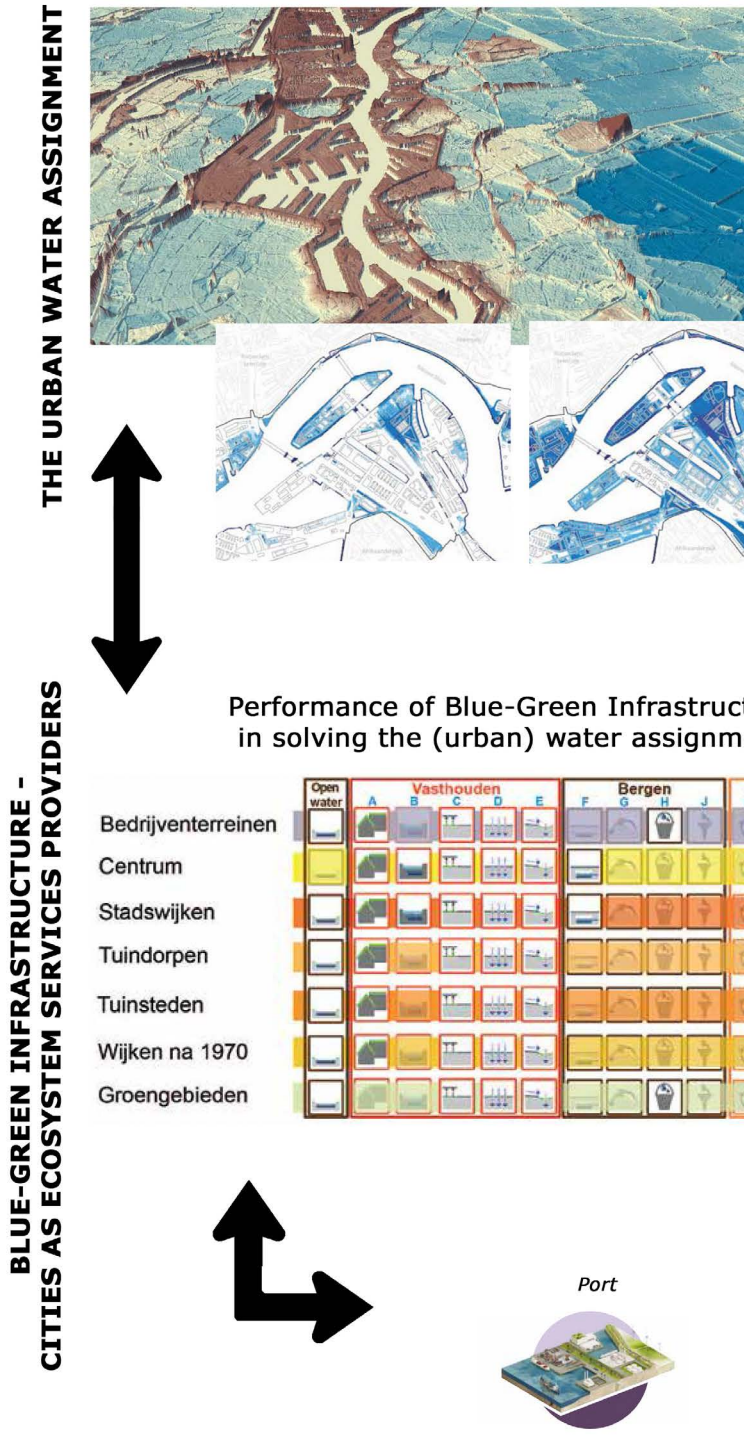
es. This strategy is increasingly visible in the city. Examples include several water squares (multifunctional, floodable public spaces) and alternative forms of water storage (e.g., underground water cisterns and urban water buffers), over 100 ha of green roofs and a rooftop park: an elevated park as a flood defense measure. Citizens' involvement contributed to the city's climate action efforts by turning paved areas into green spaces. In addition, the city council recently approved a plan to add seven major urban parks.

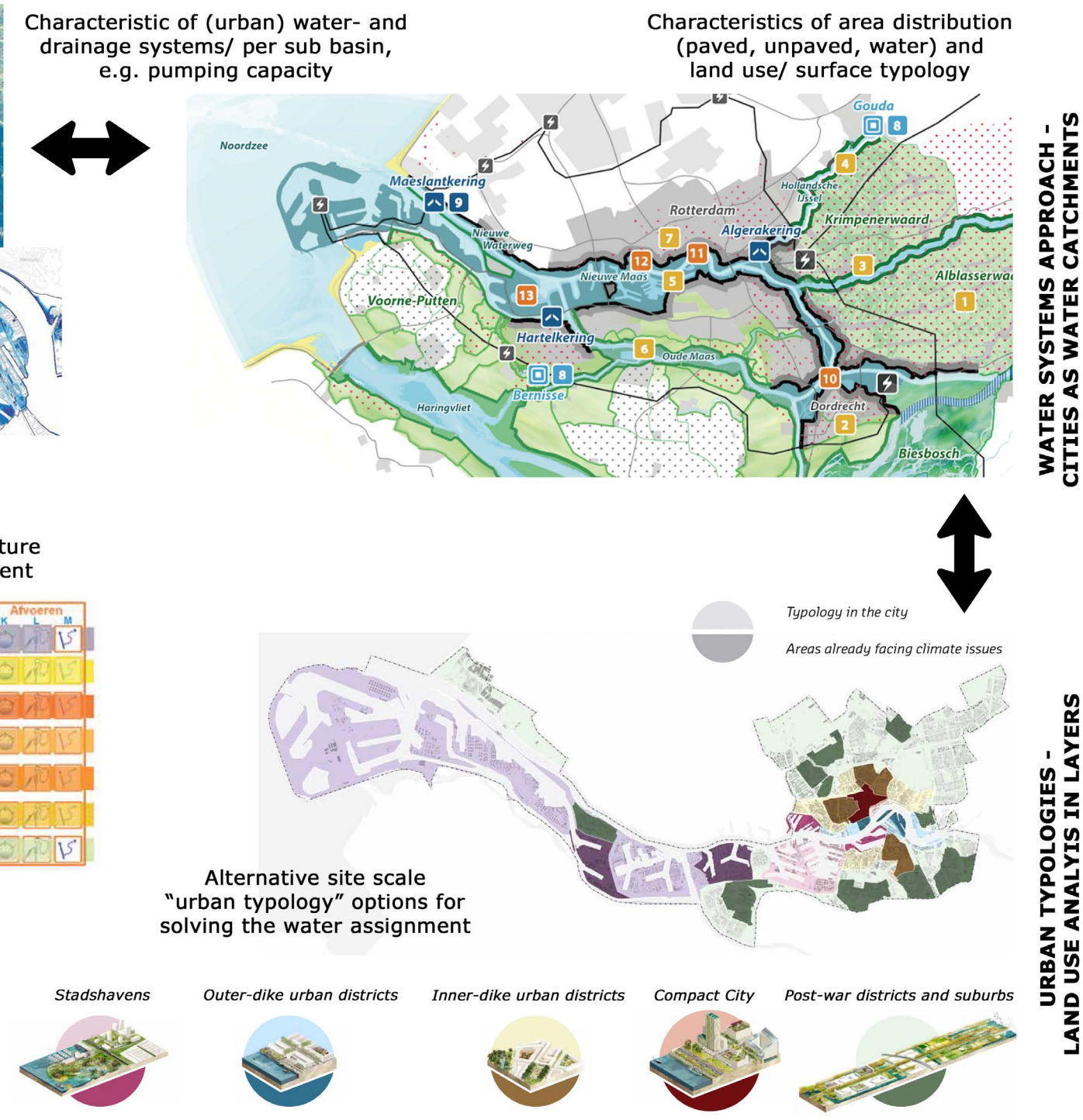
These parks aim to improve the quality of life and increase the attractiveness of the urban environment. Starting in 2024, a shift will be made from car-dominant paved areas to urban parks that will be accessible to pedestrians and cyclists, with a less dominant role for the car. The assumption is that people who live in places that are greener, cleaner and safer are healthier and happier.

The Present: Merging Blue-Green Infrastructure with Urban Design

Solving urban water problems in cities like Rotterdam requires a focus on the "Living with Water" principles of delay, store and drain (Ministry of Transport, Public Works and Water Management 2000). These principles represent a planning challenge for both water engineers and urban designers. Approaches in multifunctional infrastructure (rather than monofunctional or gray infrastructure) must be considered during the design process by linking the urban water problems to blue-green infrastructure metrics (e.g. system and site scale measures). Figure 4 distinguishes the following four quadrants (Dolman 2021):

1. Urban typologies – land use analysis in layers;



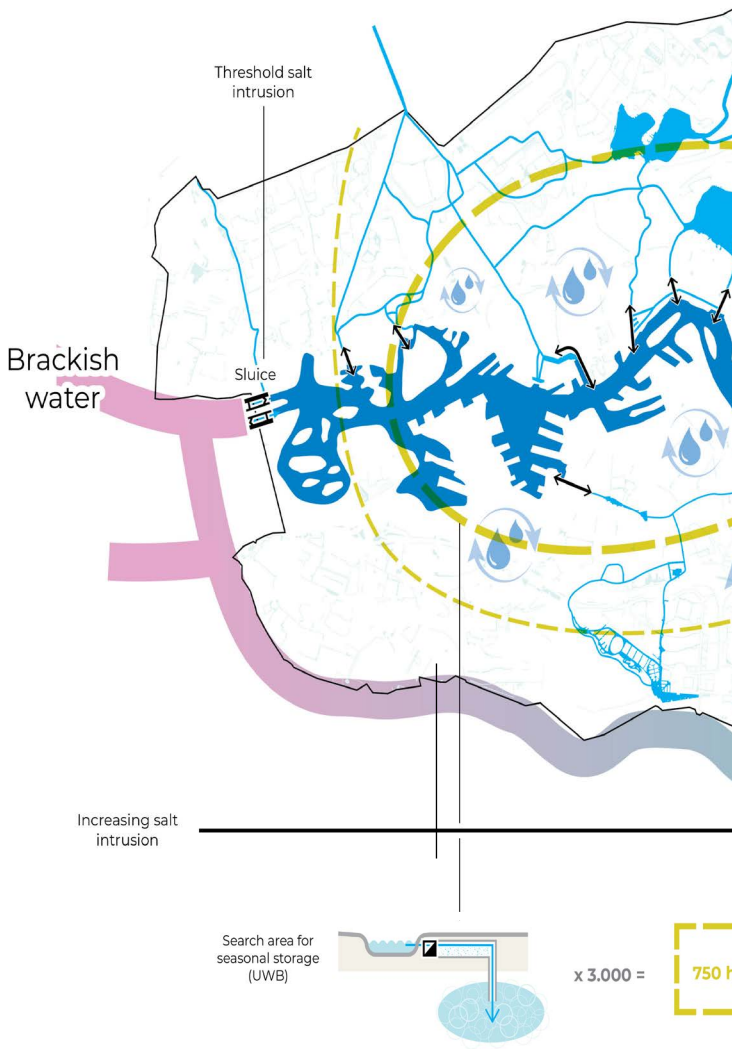


^ Fig. 4 Linking the urban water assignment (i.e. required water storage capacity) to blue-green infrastructure metrics, illustrated for Rotterdam (Source: Dolman, 2021).

2. Water systems approach – cities as water catchments;
3. The urban water assignment (i.e. required water storage capacity);
4. Blue-green infrastructure – cities as ecosystem service providers.

The design solutions to solve the urban water assignment are elaborated in Rotterdam's city planning and urban vision (statement) projects and demonstration (pilot) projects. Some practical measures and optional alternatives, both at system and site scales, include (re)use of water (rainwater harvesting, urban water buffers), surface drainage (delay), retention (water squares, streets, parks), infiltration (swales), green infrastructure, storage of surface water, and adaptive, flood-proof building and floating urbanism (Municipality of Rotterdam 2007).

Rotterdam is transforming into a blue-green city by merging the Weather-Wise Program with the implementation of new green public spaces in seven iconic urban projects. Rotterdam has also moved away from working on projects "for" local communities and is instead focusing on projects "together with" local communities and is even supporting projects "by" local communities. The municipality of Rotterdam explicitly seeks cooperation with various stakeholders such as developers and property owners.



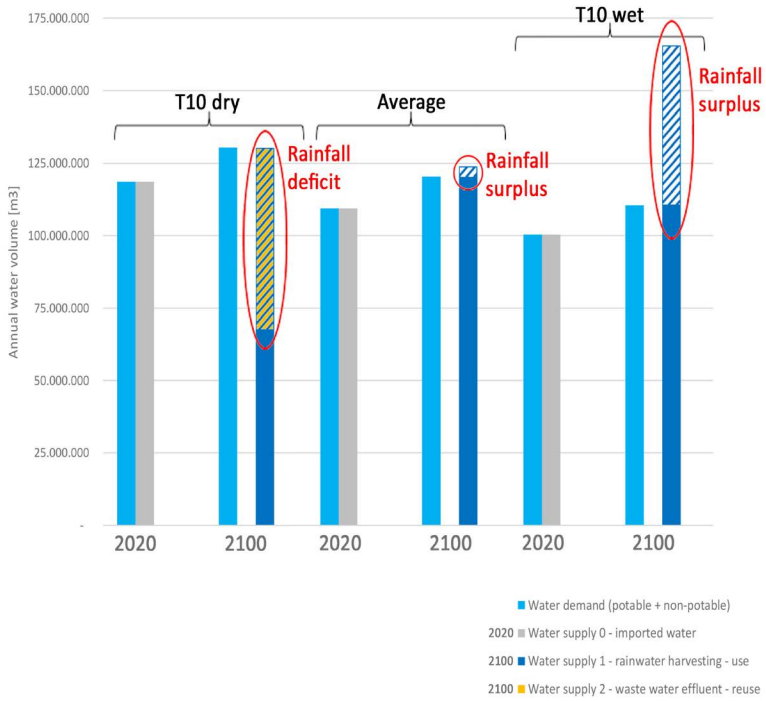
The Future: Rotterdam Water City 2100

Building on the Rotterdam Water City 2035 vision, the municipality of Rotterdam is currently exploring a hopeful vision of a blue-green sponge city of the future: Rotterdam Water City 2100 (De Urbanisten, LOLA and RHDHV, 2022), which is built on three pillars:

1. Flood protection: closing off Rotterdam from the open water;

One UWB holds 20,000 m3. With a depth of 10 m, an area of 2,500 m2 per UWB is required. For 3,000 UWB's this equals a total area of 750 hectares.

Supply (available) = Demand (required) *



Rotterdam Water City can supply its own water by optimal circulation. In a dry year approximately 60 million m3 of water is needed. This will require 3,000 urban water buffers (UWB's) under the city.

* Water balance calculations are based on an estimated total population of 1.1 million in 2100.
In 2020 the area had 880,000 inhabitants - this includes Rotterdam, Schiedam, Barendrecht, Krimpen aan den IJssel and Capelle aan den IJssel.

^ Fig. 5 Water balance of Rotterdam Water City 2100 (Source: De Urbanisten, LOLA and RHDHV, 2022).

2. Flexible integration of land in water: wide, habitable, higher landscapes along the large waters;
3. Sponge City: blue-green infrastructure for long-term water resiliency and the security of the fresh water supply.

Considering the city as a sponge is a strategy built on the "living water principles" of delay, store, drain only when necessary (Waggonner et al. 2014). This approach has been internationally recognized as a best practice through Tokyo's Water Saving City, Singapore's Closing the Water Loop and China's Sponge City Program (Dolman 2024). The aim of making Rotterdam a sponge city is to restore the water balance between urban areas and the surrounding environment. When it comes to optimal use of space, multifunctional water solutions and creating livable cities, the concept of "the city as a sponge" offers a way to address all water and climate challenges through water collection, storage and use. The city as a sponge contributes to the resilience of the landscape in which it lies, enhancing the quality of the living environment and promoting biodiversity.

In this vision, Rotterdam would take transformative measures, including implementing a delta dike protection system and becoming a self-sufficient, circular freshwater sponge city. With the New Meuse River as its central water body, enclosed by two double locks (fig. 5), the city would create a freshwater lake within its water system to facilitate further growth and utilization of this central water body. By closing off the New Meuse, additional housing opportunities would arise in former port areas outside the dikes, such as along canals and on houseboats. Commercial shipping routes currently heading toward the hinterland would be redirected further south. Moreover, waterfront areas would be enhanced with softer, greener designs, while an intelligent urban water system would function as a sponge, supporting the city's sustainability goals. The surrounding polders would be leveraged to more effectively withstand floods and droughts.

To be a sponge city, Rotterdam needs to absorb extreme storm events on all paved surfaces (by means of green polder roofs, wadis, rain gardens, water squares, soil improvement, storage under roads, etc.). The collected rainwater can also be buffered locally in the city using "urban water buffers." In dry periods, the water of these buffers in the aquifers is pumped up again and redistributed through the open water system to the entire city. This was tested in a conceptual water balance considering what 2100 would be like in a very dry year (serious shortage), in an average year (slight shortage), and in a very wet year (surplus). In an average and very wet situation, Rotterdam can supply its water demand with optimal circulation. The city is short 60 million m^3 of water in a dry year. This would be provided by storing the surplus in a wet year and then, in a dry year, transporting that back up into the city.

Conclusion

In the history of Rotterdam, water has mostly had a very positive influence on the city's development. The water that now poses severe threats, like flooding and drought, is the same water that has brought life and economic growth. After the twentieth century, which was all about the fight against water and making way for the car, a radical change took place in water system thinking. By creating more space for water and promoting blue-green infrastructure in the built environment, Rotterdam is becoming climate-resilient, greener and more livable.
For Rotterdam to continue to be livable in 2100, the city must pursue a combination of protec-

tive measures and coping strategies. A key step is to create a closed freshwater cycle that allows Rotterdam to function as its own water supply catchment, working in harmony with a post-fossil port that has undergone a spatial, functional, and infrastructural transition. The aim is to restore the water balance between urban areas and their surrounding environment. By considering the optimal use of space and adopting multifunctional water and "livable city" solutions, Rotterdam can embrace the concept of "the city as a sponge." This approach involves "collection, storage and use of water" to relate all water and climate-related challenges (O'Donnell et al. 2021). Transforming Rotterdam into a Water City 2100 will contribute to the resilience of the landscape, enhancing the quality of the living environment and promoting biodiversity. By implementing these strategies, Rotterdam can continue to thrive safely and sustainably in the face of the challenges posed by climate change.

Policy Recommendations

- The transition toward a water-resilient Rotterdam shows the importance of a radical change in water system thinking, moving from the fight against water (past) to an approach of living with water (present).
- To keep Rotterdam safe and livable in 2100, it is crucial to work with nature. The recommended practices include (i) a good understanding of the urban water cycle and its itegration within urban planning strategies, (ii) a bottom-up movement to involve actors representing both public and private sectors, and (iii) implementing the right combination of gray and blue-green solutions.

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Unveiling Milan's Navigli and Underground Water Heritage through Integrated Urban (Water) Design

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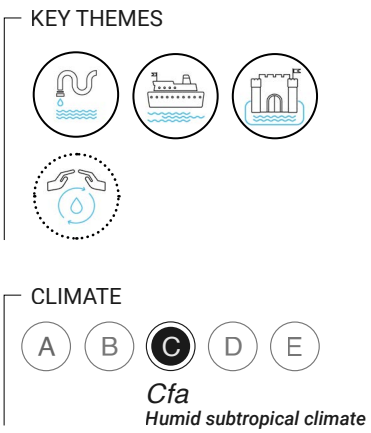
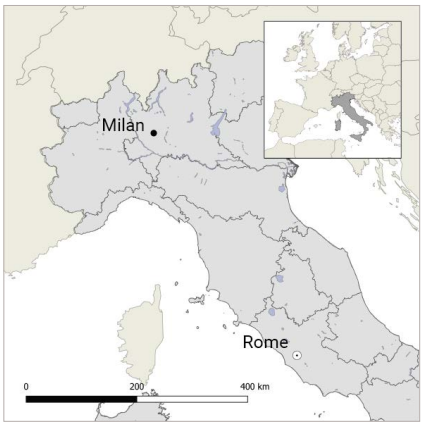
Allegra Aprea
EssilorLuxottica

Historic water systems have become iconic features of cities like Venice and Amsterdam. The Navigli of Milan were constructed to channel groundwater for various purposes and a consequence was the desiccation of the surrounding marshy land. As the city faced new water challenges amid imminent water needs, its water identity was affected by the covering up of the historic water system. Climate change poses new challenges to preservation and planning in this historical water city. This article highlights the importance of history and water heritage for future interventions, by evoking the Navigli vistas that were once the cityscape of Milan. It discusses the current challenges of the hydrographic network, including more frequent and severe floods, and proposes the daylighting of the canals to inspire and adapt modern and future water systems to climate impact. The goal is to reclaim Milan's identity as a "city of water" through a deliberate design methodology informed by the city's history.

Keywords: *Navigli, Milan, urbanization, floods, sustainable drainage systems (SUDs)*





< Fig. 1 *Snowfall in the Navigli, Milan*. Painting: January 1852 (Source: Angelo Inganni, Public domain, via Wikimedia Commons).

Introduction

Cities involve social, economic and cultural features and activities that continually shape their character and identity. Water has played a pivotal role in this process. Its significance in the establishment and governance of ancient civilizations has transcended consumption and livelihood. Control over water supply has long symbolized power and authority (Adeyemi 2023). Historic water infrastructures, such as aqueducts, irrigation systems and canals, have added character to territorial landscapes, creating "uniqueness" through the combination of multiple modular elements. Transformations like those brought about by the automobile have sometimes altered these characters, when they have not erased them completely. As the world is rapidly urbanizing, cities are at the forefront of suffering the impacts of climate change, and thus require mitigating measures (Adeyemi 2023).

The Navigli of Milan are an example of an ancient water system that contributed to the city's original identity as a "city of water" (fig. 1). Although not widely known today, this identity is being remembered in two exhibitions: *The Waterways in Mediolanum* (held from 2023 and still ongoing) and *Milan City of Water* (held in 2015). To add to this "water" identity, the presence of a natural hydrographic network makes the city of Milan particularly vulnerable to floods, especially during periods of intense rainfall (Spano et al. 2021). As a result and as a potential solution to the problem, some citizens and the municipality of Milan have called for daylighting the Navigli (Boatti et al. 2013, 16; Boatti and Prusicki 2019). Yet, in designing and planning for sustainable urban futures, there remains a disconnect between the analysis of physical characteristics of terrains and historical studies of water systems and events (Hein et al. 2023).

This article discusses the water heritage of Milan, natural and cultural, tangible and intangible, manifested in and through the hydrological system of Navigli, which has been long modified, if not forgotten. By proposing an integrated heritage-inclusive urban design for the city, our aim is to use historical interpretation to recover and reestablish the city's intimate connection with water.

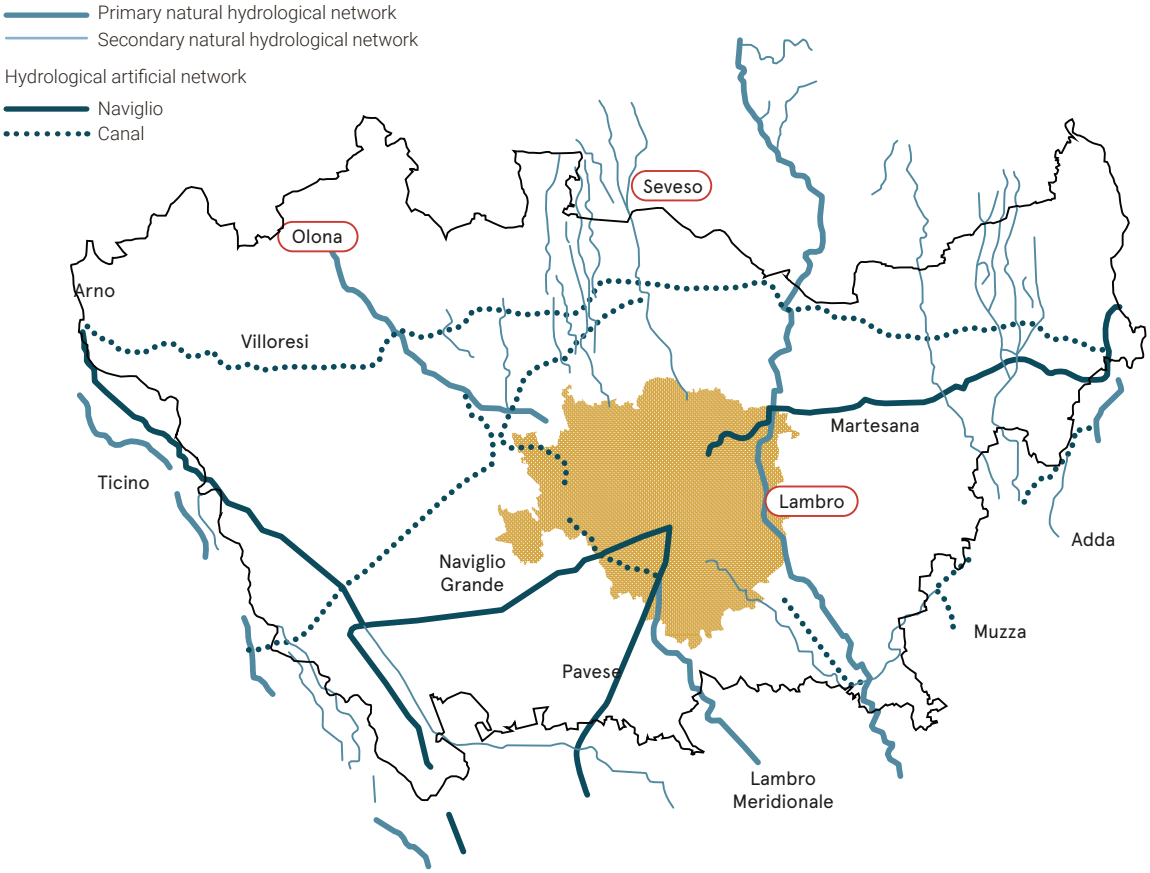
Milan's Water Heritage

Milan, located at the center of Northern Italy depends, like all cities, on the presence of water sources for sustenance and economic activity. Despite its land-locked position, the geography, geology and history of Milan indicate that the city's origins and prosperity are inextricably linked to water (Gattinoni and Scesi 2017), which brought both natural and cultural water heritage. Unlike other ancient cities, Mediolanum (later called Milan) was not built where it was because of proximity to surface water bodies. When the first Roman settlers founded this new fortress, they observed that the soil was particularly marshy, suggesting an underlying groundwater reservoir. The Romans explored the navigational and water supply potential of the area by digging up interconnected channels that were filled by the aquifer, creating through the centuries a water system (Navigli) for the city of Milan (fig. 2). Navigli comprised canals, locks and other water management works to direct and redirect water to various parts of the city. The hydrological net was completed with the creation of the Fossa Interna: a Circular Naviglio connecting all other Navigli and canals and connecting different parts of the city.

^ Fig. 2 Map of Milan's historic water system (Source: Stanqiweb, n.d.).

Natural Water Heritage

The city's name Mediolanum has been interpreted in several different ways, including "medium-lanum" - *medio e (p)lanum*, meaning "in the middle of the plain"; "place between watercourses" and "fertile land" (Ruggini 1990, 17). The city is a confluence of some important rivers (fig. 3): the Olona, the Lambro and the Seveso. The Lombardy region itself, positioned just below the Alps, is a natural collector of waterways and water bodies, one of the most fluvial regions in Italy with the most rivers, lakes and natural water heritage sites. Milan's hydrography, especially underground, reflects this natural condition although some natural waterways have been buried. The covering of these rivers puts certain areas at greater risk of flooding. For example, the Niguardia District, which is also a densely populated residential area, has the Seveso River flowing underneath. Urban development has disregarded the natural variation of the river's flow and failed to provide adequate space for its discharge or drainage (Aprea et al. 2018).



^ Fig. 3 Map of surface hydrography (Source: Aprea et al., 2018, adapted from image by Legambiente).

Cultural Water Heritage

The Navigli were dug as early as 1179 for defensive purposes, as private irrigation channels, and later as lines of trade and business, and became a part of everyday Milanese life (Aprea et al. 2018). In the past, these artificial rivers were the only source of running water for domestic use; for instance there were many old washing houses along the Navigli like the one in Vicolo dei Lavandai (Ministry of Tourism n.d.). They were even used to transport materials to the Duomo (Milan's main cathedral) during construction (Tyson 2021; Global Site Plans n.d.). The Navigli system reached its peak during the Renaissance, when Leonardo da Vinci worked on the improvement and expansion of the canals (Tramonti 2014).

In 1929 most of the canals, especially the Fossa Interna (which is also known as the Cerchia dei Navigli and the Cerchia Interna) were covered up. It was thought that the canals should be turned into roads to develop a more effective transport system so trains and cars replaced boats (fig. 4). Also the canals were perceived as sources of disease and odor, and as health and hygiene needs of the growing city became alarming the initiative to conceal them were desirable (Cesàri n.d.; Global Site Plans n.d.). To-

^ Fig. 4 Via Fatebenefratelli ca. 1930 (left) and 1960 (right) (Source: Civico Archivio fotografico Milano, modified by authors).

day only three sections of the Navigli are visible: Naviglio Grande, Naviglio Pavese and Naviglio Martesana (Tramonti 2014).

The Modern Water System of Milan

The modernist approach to water management, framed as a purely technical endeavor, has disconnected residents' lifestyles from direct interaction with the water system. Despite its historical significance, water is no longer one of Milan's defining features. The city, now renowned as Italy's and the world's fashion capital, has turned away from its water heritage, relegating it to underground infrastructure (Tyson 2021). The remaining Navigli have become almost an aesthetic feature and the area known as the Navigli District in the southwestern part of the city is famous for its nightlife, fine dining and vintage markets (Tyson 2021, Global Site Plans n.d.).

Through the decades, the changes that have occurred have given rise to a different city, where water courses and infrastructures are no longer its most impressive landmarks. This urban reconfiguration also disrupted the operation and efficiency of its water systems, resulting in the occurrence of frequent and extreme floods (Spano et al. 2021). The modern water system and integrated water service (that is the supply and distribution of drinking water and the treatment of wastewater) is managed by Metropolitana Milanese (MM) SpA (2022), the same entity that operates the underground metro lines. The Navigli is currently managed by various entities – public, private and NGOs, such as the Ministry of Tourism, L'Associazione Naviglio Grande and the Institute for the Navigli. However, there is no collaboration among these nor a joint management framework with MM SpA, highlighting the need for integrated water management efforts. In the words of Dr. Stefano Cetti of MM, "The management of the subsoil and its history, in [...] Milan, deserves further study, as heritage [...], and technological innovation, [...], systemic approaches between entities, especially in water management" (Aprea et al. 2018, 205). From 2008 to 2010, Boatti et al. (2013), under the commission of the Municipality of Milan, worked on proposals for a Navigli reopening project, in which the daylighting of the Fossa Interna restores the hydraulic connection between the Naviglio della Martesana and the old dock, Darsena (Cesàri n.d.). It was voted for by 94 per cent of Milan's

residents in 2011 (Aprea et al. 2018) supporting the proposal's claim that it could revive a water heritage element recognized by the older generations as a lost, or original, urban identity. After a public debate (Beltrame et al. 2018), which included a critique of the vision as being confined to the Fossa Interna, excluding what is beyond, and also as irrelevant to the attenuation of the floods of the Seveso River, the project has remained under consideration.

Although Milan is a national icon of excellence in water management and hydraulic works (Ministry of Tourism n.d.) from the historical structures by Leonardo da Vinci to the most modern water collectors, it has experienced more emergency flood situations over the last fifty years (Spano et al. 2021). This has occurred particularly in vulnerable areas such as the Niguardia and Isola districts where the Seveso River overflowed in 1976 and in 2014 respectively (Aprea et al. 2018) and more recently during the rainstorms of 2023 (Ruffino and AP 2023). Most of the metropolitan city's aquifer is less than 10 m below ground level and continues to rise due to a decrease in groundwater consumption – the economic transformation which the city has undergone led to manufacturing industries being increasingly replaced by service industries, as well as the changes of demographic patterns (Gattinoni and Scesi 2017; Aprea et al. 2018). In addition, the groundwater, when going up, was contaminated by chemical compounds discharged in the soil by industrial, artisanal and agricultural activities, rendering much of it unsafe for consumption. Between 1994 and 1999, fifty-one wells were abandoned, as a result of this pollution (Aprea et al. 2018). The water table is predicted to continue rising, leading to setbacks, especially on underground structures and infrastructures. To mitigate these risks effectively, a multifaceted approach tailored to different city areas is necessary (Gattinoni and Scesi 2017).

Waterland Milan

A need for combined research and analysis regarding the history, hydrology, morphology, and other characteristics of specific urban enclaves guided the urban design proposal *Waterland Milan* (Aprea et al. 2018). *Waterland Milan* is an MSc. Architecture graduation project which proposes a heritage-inclusive urban water vision for Milan that not only restores the city's water identity but also manages floods and associated risks. By responding to the critiques of Beltrame et al. (2018) regarding the Navigli reopening project, the project also preemptively responds to Marco Granelli's statement on Milan's flood preparedness (Ruffino and AP 2023). The methodology used, which is informed by history, proposes a water system designed to suit the specific temporal and spatial needs of Milan's various districts.

Historical Interpretation: A Base for Envisioning a Future Water System

According to Hein et al. (2023), "history and heritage can serve as a mirror for water-system thinking, the past has to be recognized as the foundation for future development, and specific spaces and practices can be identified and protected as heritage." By studying the three historical events listed below, we came to understand that they were not only the outcomes of urbanistic responses to past phenomena, but were also temporally and spatially connected, in a cause-effect cycle (see table 1).

The project by Aprea et al. (2018) sought to reconstruct the broken relationship between Milan's residents and water, making it something like it was in Roman times, and to preserve this memory in the long term. By reintegrating the city's hidden historic waterways with a modern

water system, *Waterland* restored Milan's identity as a "city of water" while tackling the hydrological emergency the city experiences annually. Diverse aspects and elements of Milan's hydrological system (aqueduct, potable water supply, sewage system, pumping stations, wells, etc.) and its natural characteristics and historical evolution were explored across the different areas of the city (Aprea et al. 2018). Secondly, it was found that Milan is 59.5 per cent permeable and 40.5 per cent impermeable. While zoning can illuminate Milan's urban evolution, the abandoned railway yards were identified as potential hotspots for the project. An analysis of water conditions and flood risks according to specific areas revealed the eastern riverbanks as well as the already-known northern Niguardia and Isola Districts to be the most vulnerable.

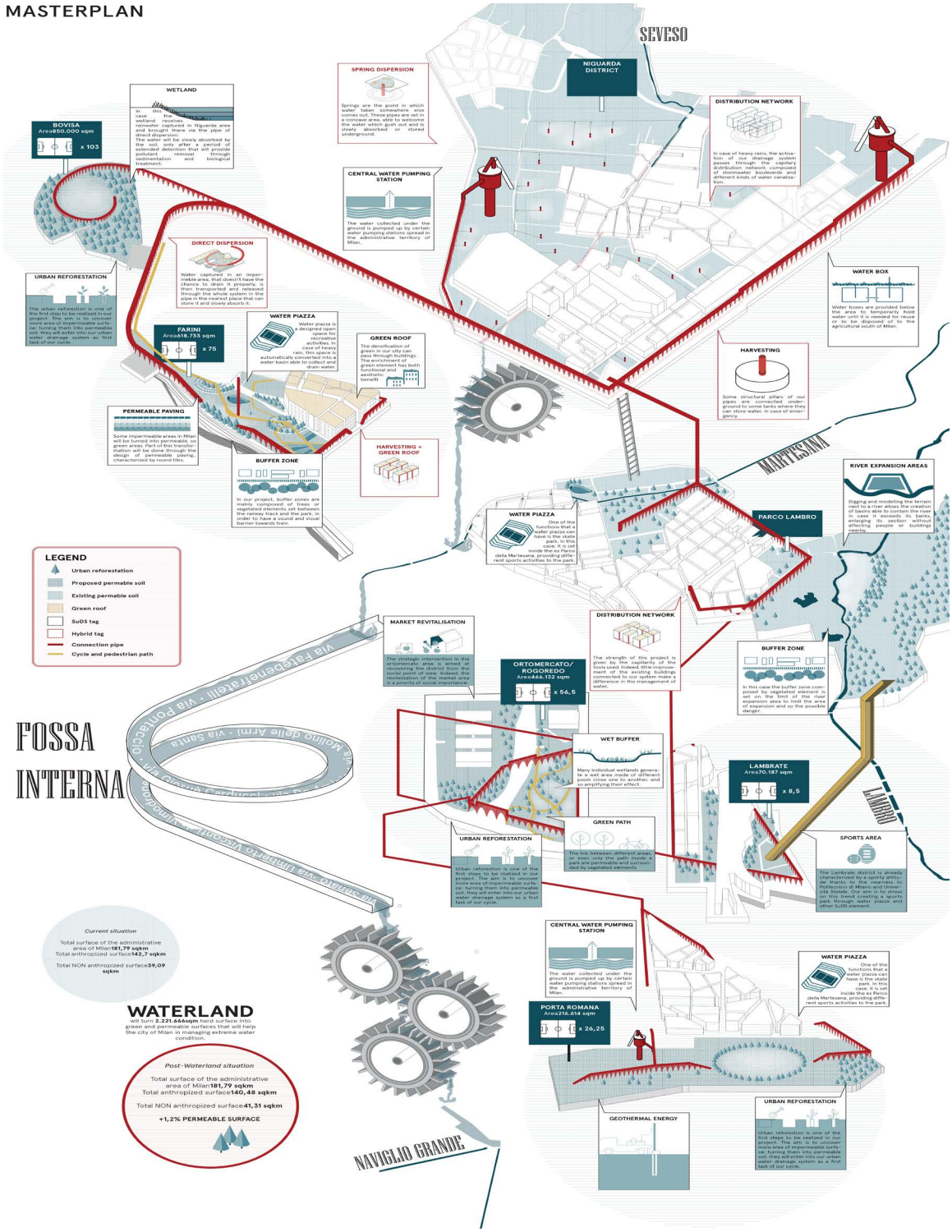
By looking into the past and present water infrastructure, surface and underground, technological solutions for collecting, absorbing, filtering and purifying rainwater, formed part of this landscape project. On one hand, these solutions check the fragmented soil permeability, preventing the risk of flooding and improving the surface water management system with an adaptable and variable program over time. On the other hand, the proposal enhances the architectural and engineering heritage in the Milanese underground, making citizens aware of this richness and showing that historical elements can inspire the future (Aprea et al. 2018, 96). Water could be moved from more vulnerable areas to less vulnerable ones, and abandoned areas could serve new water management and urban functions.

Design Strategy

The primary objective was to enhance current aspects of the Milanese urban morphology, with a critical eye toward the past, by designing for not only technical efficiency but also for the beauty of the city's natural and architectural heritage (Aprea et al. 2018, 29). The priority was to tackle flood risks by monitoring groundwater levels and the functionality of the existing sewage system. By restoring water and ecological continuity through a green-blue system, the city's biodiversity (insects and birds) were

Historical event	Emerging necessity	Immediate consequence	Long-term effect	Resulting analyses
1) New mobility, shift to cars and trains	Urban expansion and asphalt road diffusion	Waterways are buried, urban transformation	Flooding	Urban voids and flood risk analysis
2) Industrialization, higher demand for labor, immigration	Rapid urbanization without a regulation plan	Lack or reduction of green areas	Heat island	Precipitation analysis
		Inability of soil to absorb water	Soil consumption	Permeable and impermeable terrain analysis
3) Indiscriminate environmental pollution, rise of chemical industry and factories	Regulation of industrial waste disposal and pollution levels	Fall of industrialization and closure of water pump factories	Rising level of the aquifer	Aquifer morphology

^ Table 1. Using historical interpretation to understand Milan's hydrological risk (Source: Carlien Donkor, Agnese Bavuso Marone and Allegra Aprea, 2024).



^ Fig. 5 *Waterland* master plan showing the hydraulic continuity of the project to the Fossa Interna as well as the three Navigli (Source: Carlien Donkor, Agnese Bavuso Marone and Allegra Aprea, 2018).

protected. The project also integrated interventions to minimize traffic by promoting soft mobility. Finally, a plan that establishes intervention phases suggested the project would be extended to the metropolitan area by the year 2030.

Project

The outcome of the project was a water system parallel to the existing one which combined soft elements of sustainable drainage systems (SUDs) (Detroit Future City 2012, 411–16) with technical pipes, to manage stormwater, connect new urban features and finally restore the water identity of Milan (fig. 5). The SUDs, since they are mainly landscape elements, were designed as biodiversity hotspots, providing additional ecological benefits. Zero energy principles of gravity, dispersion and suction enabled the project to be cost-effective. Temporality offered relevant responses to different levels of emergency and risks, while also accommodating the possibility of different scenarios: for instance, a skate park in the dry season could function as a collector in the rainy season.

Conclusion

Failure to recognize hydraulic works as national heritage is common around the world. The responsibility is not that of governance alone. Today, water is treated exclusively as a sector of supply and distribution (Ovink 2022) and considered in economic and technical terms without acknowledging past and present cultural significance. As Ovink (2022) argues in his article, "Exploring past practices can and must have positive meaning for today," the water management sector needs to complement their technical expertise with a knowledge of historical hydrological interventions, their successes and shortcomings, and an understanding of the types of water heritage, tangible and intangible, to appreciate what the past means for citizens in terms of fostering and keeping an identity, or simply upholding their values (Hein et al. 2023). This is necessary to be able to predict and design for tomorrow's water systems and cities.

For older Milanese, water in Milan evokes a deep nostalgia for the disappeared aquatic city symbolized by the countless depictions in art of the Navigli. The Navigli brought water to the people and people to the water. In the same way, *Waterland* would do the same. While the call to reopen the canals is good, it should be noted that their water management function is for a different scale of city; this should be translated in a contemporary intervention. At the same time the question of why Milan's Navigli is not among the ten UNESCO sites in the Lombardy region nor an official national heritage landmark remains unanswered.

Policy Recommendations

- Conduct historical analysis of cities to find disused elements that can be integrated into technical hydraulic proposals.

Acknowledgment

The text is adapted from "Waterland. Unveiling the Lost Memoirs of a City through Integrated Urban Water Design. The Case of Milan," by Allegra Aprea, Agnese Bavuso Marone and Carlien Donkor (2018) and does not reflect entirely the extensive work outlined therein. This contribution was peer-reviewed. It was edited by members of the editorial team of the UNESCO Chair Water, Ports and Historic Cities: Carola Hein, Julia Korpacka and Kaiyi Zhu.

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The Shore as a Politicized Space for Community Heritage: The Case of Pra', Genoa

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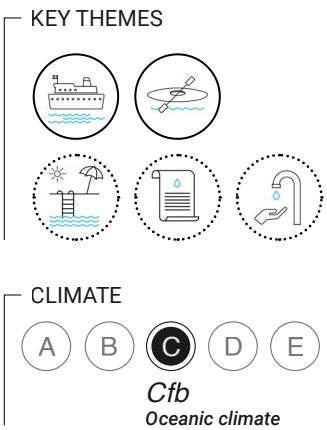
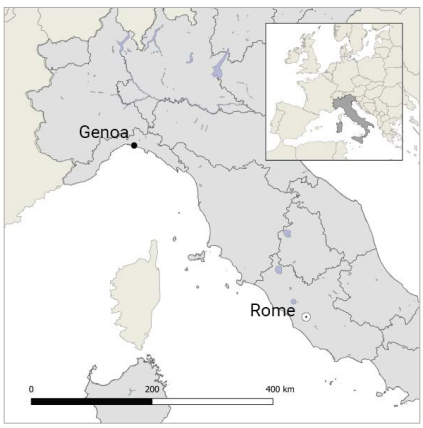
Changes in coastal and maritime environments, increasingly caused by the climate crisis and large infrastructural projects such as global port construction, significantly impact community identity. When a community's terraqueous space – a space that transcends the land-sea binary distinction – suffers a shock, long-term sociability within the community and relationships with nature are altered. This article connects the challenges of coastal community spaces and the community's cultural heritage by articulating a critical ontology of the shore. The connection is illustrated using the example of Pra' in Genoa, where constructing a large port terminal has detached the local maritime community from the sea.

Keywords: *coastal communities, everyday-life, shore, port infrastructure, maritime culture*





< Fig. 1 A plaque with toponomy of collective memory "walking path Beach of Pra" (Source: Francesca Savoldi, 2021, CC BY).

Coastal Space and Cultural Heritage

Between 2010 and 2014, the construction of a port terminal for ultra-large vessels on the beach of Pra' – a coastal quartiere of Genoa, Italy with 20,000 inhabitants – forced the local maritime community to become detached from the sea, triggering social mobilization. This illustrates both the importance of water as a dimension of the socio-cultural identity of the community and the socio-political significance of the shore for its cultural heritage.

Coastal and maritime cultural heritage has been defined as a set of tangible and intangible components linked to human activities and interactions taking place in coastal and marine areas in the past, present and imagined futures (Ounian et al. 2021). UNESCO (2011) categorizes tangible heritage as physical elements, such as buildings, archaeological sites and objects, while intangible heritage refers to practices, knowledge, skills, groups, expressions and cultural spaces. The significance of cultural heritage has been shown through the invocation of memory (Vecco 2010) in communication with a sense of identity or experience (Parkinson et al. 2016). In that sense, the space of community, considered in Lefebvrian terms, is a determinant of cultural heritage across its tangible and intangible components.

According to Lefebvre (1991), space is produced by relations which mold and reproduce its social morphology, with the transformation of space deeply affecting community values. Cultural heritage also relates to everyday lives, communication and the meaning attached to a physical space (Assmann and Czaplicka 1995). Local streets, for instance, are increasingly recognized as reflecting traditions, local stories and beliefs, representing a sense of cultural identity (Yung and Leung 2019). Space should then be considered as a category of cultural heritage.

The shore, as a habitat of maritime communities, is imbued with terraqueous cultural engagement. The everyday lives of these communities involve practices and skills, a particular ethos and social and economic relations that take place between sea and land. The importance of the sea-land continuum, interweaving vital material and immaterial interdependencies between the environment and society, becomes politically visible when communities protest its loss.

Communities on the edge of port cities are contesting the expansion of ports. In the ongoing phase of global infrastructural expansion, ports are demanding more resources from cities, including land for containers, cranes and related infrastructure. Ports are also occupying sea spaces because of naval gigantism and land reclamation. This has triggered civic contestations where the demands of local communities can be framed by the slogan "Right to the City." We can understand this resistance beyond the sea-land division and describe this demand as a "Right to the City and the Sea." Examples of socio-political contestation of terraqueous spaces can be seen worldwide. For instance, a large coalition of citizens and civic organizations, including pier fishers in Durban, South Africa, have been protesting against port expansion, and since 2013 South African courts have recognized fishers' right to access the piers and continue fishing. Other examples include the fishing communities in Makassar, Indonesia, and Negombo, Sri Lanka.[1] In all these cases, the construction of a large port has altered the material and immaterial relationship with the sea, putting livelihoods, culture and heritage at risk.

1. More information on these cases can be found on the platform contestedports.com.

^ Fig. 2 The shore of Pra' in the 1970s (Source: unknown, 1970. Courtesy of PRiMA'vera).

Framing the political significance of space in the definition of the cultural heritage of coastal communities brings up important questions regarding agency: Who decides what can be lost or must be conserved in coastal communities not protected by UNESCO? What are the dominant narratives that define territorial priorities? Who decides which cultural heritage must be preventively preserved and how it should be managed? A critical ontology of the shore demands a reinterpretation of the socio-political significance of such space in its sea-land continuum. This approach emphasizes the centrality of spatial practices in forming cultural heritage. Space isn't an abstract category in material and immaterial cultural practices, however it is the factor that shapes them: "Rather than imagining space as a sort of ether in which all things are immersed, or conceiving it abstractly as a characteristic they would all share, we must think of space as the universal power of their connections" (Merleau-Ponty 2012). Hence, the space of the shore determines the cultural heritage of maritime communities by shaping the connection that forms relationalities between objects and subjects.

The Disappearance of the Shore – A Right to the City and the Sea in Pra'

The process of port construction on the shore of Pra' started in the 1970s and concluded in the 1990s, transforming the landscape of a mar-

^ Fig. 3 A panoramic view of Pra' in 2021 (Source: Francesca Savoldi, 2021, CC BY).

itime community into an industrial one (figs. 2–3). This process has triggered social mobilization that has fostered a collective process for reformulating the space of the community. The community has demanded public spaces with renewed access to the sea, expanding their case for the "Right to the City" to include the sea. Such reformulation has resulted in public participation in which local inhabitants have co-designed a buffer zone between the port and the residential area, producing new interpretations of the shoreline.

In 2021, I conducted ethnographic work in Pra'. Seven in-depth interviews were conducted with residents of different genders, ages and occupations using a snowball sampling. In addition to interviewing and observing residents, I examined relevant institutional documents and publications, including the back catalog of *Il Praino/Supra'tutto*, the local community magazine published monthly between 2009 and 2019. Interviews explored the material and immaterial relationships between the community and the shore before and after the construction of the port terminal, as well as the collective actions and consequences of the social mobilization. Through narrating their experienced realities, interviewees compiled a counter-narrative of port-driven transformations of the shore, distant from the dominant idea that associates port activities with the prosperity of local communities (Savoldi 2024).

Pra' is currently part of Greater Genoa, located 20 km west of the city. From the Middle Ages, it was an autonomous municipality until 1926, when Benito Mussolini's government centralized territorial power by creating the Greater Genoa area. This made Pra' and 18 other suburbs of Genoa, where they succumbed to a top-down culture of disregard toward the urban periphery (Gangale 2019). This peripheralization

made the authoritarian expansion of the port along the western coast of Genoa possible, generating a path dependency of coastal degradation, which eventually reached Pra' in the 1990s.

Pra' has been known in the region as a seaside town since the seventeenth century, with shipbuilders, fishermen and sailors playing a fundamental role in local traditions. In the seventeenth and eighteenth centuries, Genoa's bourgeoisie built villas along the littoral, while the economic and social role of the beach was expanded. Many local inhabitants worked at the shipyards, with local ship-building traditions considered prestigious across the Mediterranean, with particular value attached to the *brigantines*, fast two-masted sailing vessels used by merchants and pirates. Next to the shipyards, the beach was home to both fishing and touristic activities, providing space for fishing boats, resorts, hotels, restaurants and beach clubs. Until the 1970s, the beach remained a central public space for the local community – popular for socializing, resting and playing – especially among children of working mothers. In the 1970s, under pressure from major industrial groups in northern Italy, such as Fiat, the port of Genoa planned its expansion along the shore of Pra'. The terminal was redesigned several times, adapting to the fast changes of containerization, and its construction was finally concluded in 1994. With a severe lack of communication from the port and city institutions, and a lack of public consultation, the entire beach of Pra' disappeared to make space for the new container terminal for ultra-large container vessels. The container terminal was built on the beach, too close to residential buildings, producing strong negative impacts on the community, especially air and noise pollution. These impacts have been accentuated by the morphology of the territory: a narrow terrain squeezed between mountain and sea, an echo chamber where a container dropping resounds greatly, day and night. Poignantly, instead of being called Genoa-Pra' Terminal, the port was named Voltri – after a nearby town, asserting the total disconnection between the port and the local community.

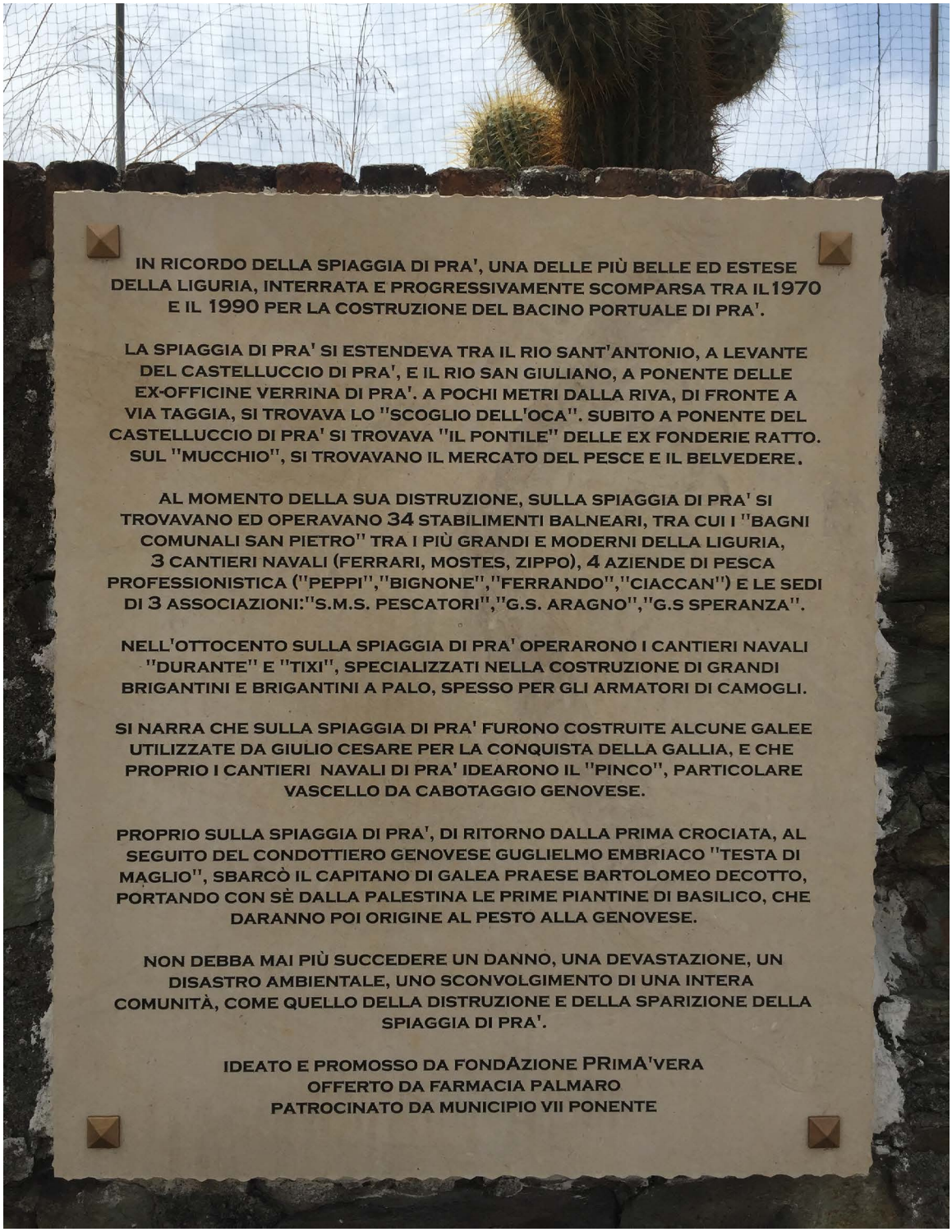
The port's construction entailed demolishing 34 small resorts, including hotels, restaurants, a beach club and fishing spots. Such a transformation produced socio-economic and socio-spatial trauma in terms of lost jobs – never fully replaced by the employment opportunities offered by the new port – and in terms of altered and/or lost identity. The space, as well as residents' sense of place changed. A longtime site of maritime importance and coastal tourism was now overtaken by a neighboring industrial port and community members no longer had access to the sea. This led to the disappearance of traditional practices and a change in locals' everyday lives. Fishers slowly disappeared, with them, the fish market and other traditions, such as anchovy-curing. Residents had to change their lifestyles, reorienting their social life and collective celebrations toward different spaces, and elderly people had to readapt to different uses of public space and to alter their health routines. Maritime knowledge, skills and practices were lost in the place where they had evolved and been maintained. According to the interviewees, the community perceived this transformation as a socio-environmental disaster that changed the community's identity, described by some of them as saddening and gloomy. They felt abandoned by city institutions and rendered passive subjects in their own territory.

In 2010 inhabitants of Pra' – after the loss of the

^ Fig. 4 A plaque with toponomy of collective memory "walking path Beach of Pra' (Source: Francesca Savoldi, 2021, CC BY).

beach and weary of the impacts of the port on their daily lives – began a series of demonstrations, contesting the invasiveness of the port and refusing to be alienated from their terraqueous territory. The collective discourse of the residents framed their city as under "ransom" and demanded that their city, including the shore, be returned to them. After marches in public spaces, road blockages and other disruptive actions, a group of campaigners created the foundation PRimA'vera, a non-party local organization aimed at fostering public participation in local decision-making.

The foundation triggered a participatory process, managing to open a communication channel with institutions and shaping a collective demand for territorial reparations. Ideas proposed by the foundation initially attempted to memorialize the lost maritime cultural heritage of the town. A Museum of the Beach was informally suggested, in which citizens' objects, including photos and clothes, were to be collected and displayed alongside oral and written testimonies. One of the proposals suggested placing a traditional ship along the new waterfront; another was creating a toponomy of collective memory, reflecting the disappeared maritime pasts in the new townscape. These lost sites included Pontile (the pier), Mucchio (the fishers' docks and



^ Fig. 5 Plaque remembering the importance of the beach for the community of Pra'; ending quote: "The destruction of the beach was Pra' was an environmental disaster and devastation, which has perturbed a whole community, and which should not be repeated"(Source: Francesca Savoldi, 2021, CC BY).

^ Fig. 6 A graphic render of the requalification project for the buffer zone between the port and the city (Source: Supratutto, 2021).

the fish market), San Pietro (the former bathing site named after the town's patron saint) and Scoglio dell'oca (a seaside landmark that no longer existed). Slate plaques commemorating the loss of the shore were installed in Pra' "for not forgetting such community suffering" (figs. 4–5). The character of these collective demands is evidence of how memory, identity and culture were embedded in the space of the shore in Pra'.

Besides these requests – only some of which materialized – PRimA'vera carried out a series of public events between 2012 and 2021, including community debates and roundtables with institutional representation. Citizens demanded a space that, on the one hand, could mitigate the effects of the port on people's everyday lives and, on the other, could give back the shore to the community albeit in a different form. The space negotiated between the community, the port and city institutions was a buffer zone, a water lane, and a hilly fringe separating the port from the residential area. PRimA'vera's efforts aimed at "giving back the sea" to Pra', envisioning a new shore that could reinterpret the functionalities of the lost beach and regain public access to the sea. A process of co-design between several students of Pra' and the University of Genoa eventually resulted in a proposal that obtained funding from the European Commission and was incorporated into the port's urban plan. The foundation's president described this evolution as "obtaining respect from institutions and bringing back self-confidence and pride to the citizens of Pra'." The buffer zone, or *fascia di rispetto*, is a 1 km long park with dunes full of trees, a cycling lane

and a central waterway 1.5 m deep connected to the sea (fig. 6). This green area is intended to mitigated the impact of the port on the residential area, providing a new public space that resembles a waterfront.

Conclusion

The case of Pra' shows how important the role of the shore has been in the cultural heritage of its coastal community. As in the case of traditional streets, the shore of Pra' reflected local stories and beliefs, representing a sense of cultural identity. Since the shore is a fundamental space for certain coastal communities to reproduce their tangible and intangible cultural heritage, should it be considered a category of protection that calls for particularly inclusive management and governance?

The vanishing of the shore as a space where the maritime character of the community of Pra' was reproduced generated a discontinuity in its sense of identity; this turned the shore into a subject of socio-political revindication. "The Right to the City and the Sea" described citizens' demands, allowing other related political questions to emerge, such as who has the agency over that space and who should decide what space of cultural heritage is worthy of protection. The disempowerment of citizens of Pra', peripheralized as part of Genoa's territory created by Mussolini's regime, and the unilateral character of decision-making by the port and the city's centralized institutions are at the root of the problem of the shore's contested disappearance.

A critical ontology of the shore highlights how questions of space and power are central to the cultural heritage of maritime communities. If the space of the shore shapes the relations that produce cultural heritage, who should be in charge of its transformation? This question suggests the role of citizen representation. Acknowledging the shore as a terraqueous space of civic revindication has additional implications. If we recognize the inextricability of coastal communities and the sea at a time of multiplying uses, global expansion of port infrastructure and increasing coastal expressions of the climate crisis, what should the role of coastal communities be in coastal zone management and maritime spatial planning, and what role should cultural heritage play in that?

Policy Recommendations

- Design coastal policies that acknowledge the material and immaterial dependencies of coastal communities from the shore.
- Conceive economic policies that acknowledge existent local economies and prioritize them over logistical monoculture.
- Develop governance structures with decentralized mechanisms and new legal systems that enhance participation and authority of local communities in coastal transformation.
- Improve institutional transparency in the management of port infrastructure, providing social, economic and environmental data on the interaction between the port and territory in order to inform the public debate.

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Coastal Erosion and Military Heritage in Latvia

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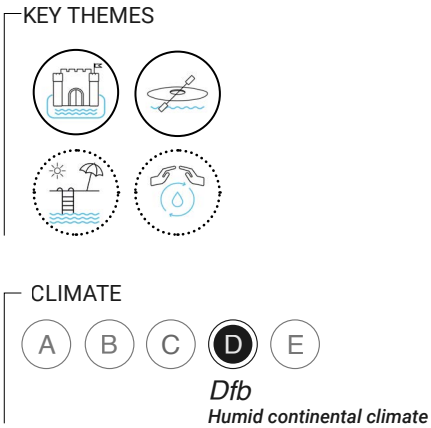
Water often needs protection, but heritage can also require protection from water. The remains of a military fortification complex in the Latvian city of Liepāja are slowly being swallowed by the sea, a case where military heritage meets water heritage. To what extent should these ruins be protected from water and is preservation still possible? Both the coastal defense structures and the sea have been considered symbols of the city, attracting locals and visitors. Yet, over time, the monumental structures have been threatened by environmental challenges triggered by rising sea levels and ongoing coastal erosion. This has led to the deterioration of the structures and the loss of their structural integrity. Although the effects of the natural processes cannot be prevented entirely, they could be delayed. However, the rapidly deteriorating state of the coastal military structures has not resulted in a sense of urgency among local authorities. The article highlights the importance of the military structures in the local context as military, cultural heritage and the water challenges faced by the coastal defense line. It also explores the potential for, and impediments to, the structures' preservation.

Keyword: *military heritage, ruins, identity, coastal erosion, preservation*



< Fig. 1 Artillery Battery 3, showing the relationship between the military heritage structures and the Baltic Sea. As a result of coastal erosion, the forts have deteriorated and have begun to disintegrate (Source: Kristiāna Ustuba, 2023).

Introduction

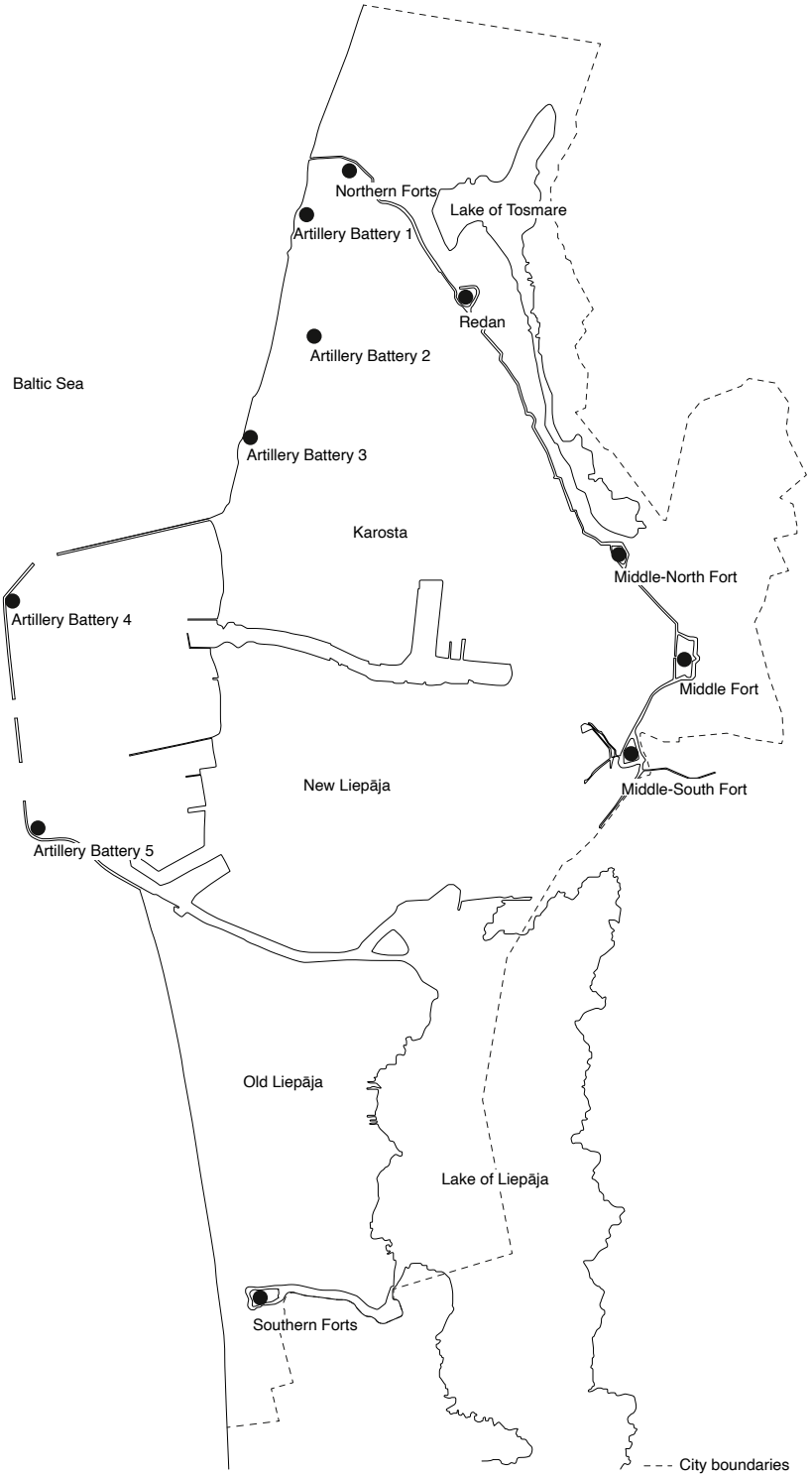
Karosta, "War Port" in Latvian, is a former military naval base, now a neighborhood in northern Liepāja, that was created because of its relationship with water. Situated on the west coast of Latvia, today Karosta stands as a witness of past military activity. In 1890 Liepāja was chosen by the Russian Empire as a suitable city to establish two interrelated systems over the course of the following decade – a military naval base in conjunction with a fortification complex around the city. The construction of new factories, a railway route and most importantly one of the biggest ports in the Russian Empire during the nineteenth century caused Liepāja to become a favorable city for Tsarist Russia's military strategies. In addition to becoming an important industrial center, the city's unique position, framed by three water bodies – the Baltic Sea to the west and the lakes of Tosmare and Liepāja to the northeast and southeast respectively, further encouraged the decision to build a military base in Liepāja. The three water bodies became an integral part of the strategic layout of the fortification complex, consisting of both a terrestrial and coastal defense line (fig. 2). For Tsarist Russia, Liepāja represented the edge of what nowadays is considered as Eastern Europe.

Yet, the force that brought the structures into existence during the rule of the Russian Empire is now causing their gradual disappearance and erasure. When it ceased performing its military role with the dissolution of the Soviet Union in 1994, Liepāja was left with an abundance of coastal and terrestrial defense structures rendering it the largest military territory not only in Latvia but the Baltics as a whole (Zeltiņa 2008). Ever since, part of the infrastructure has been left abandoned to deteriorate in the landscape. Located on the edge of the Baltic Sea, the coastal military structures particularly at Artillery Battery 1, also (incorrectly) referred to as the Northern Forts, and Battery 3, are directly being impacted by dynamic coastal conditions. Coastal erosion is the main challenge faced by these military heritage structures. Consequently, the fortification complex in Liepāja presents a unique intersection between water and heritage.

Despite being in a state of decay, the former fortification elements in Karosta, especially the ones on the coast, are more than just concrete formations that were imposed on the landscape because the city offered a strategically favorable military location. Now that they no longer serve any military purpose, the structures continue to embody national history and local identity, simultaneously addressing and challenging notions of heritage, monuments and ruins. The forts on the coast are what many people across Latvia associate most with Liepāja and Karosta. They have become an unofficial symbol of the place, attracting both locals and tourists. In her essay on symbols of Liepāja, Ilze Balcere (2008) emphasized that Karosta in recent years has successfully managed to promote itself by engaging with its history through the remaining military structures. However, no efforts have been made to maintain the heritage that is at risk of disappearing.

Military Ruins as Heritage

Only in recent years have military structures been discussed as architectural heritage. Questions remain about how to consider such remnants. In "Remembering Ruins, Ruins Remembering," Marc Treib (2009) explores the difference between ruins and remains. He suggests that ruins are fragmented parts of a bigger whole that lack a sense of totality and completeness, but they are references to the past and provoke memories (Treib 2009). Fur-



^ Fig. 2 Schematic strategic map of the city and the fortification complex, highlighting the location of the three water bodies and the military interventions in relation to the naval base in Karosta and the city of Liepāja (Source: Kristiāna Ustuba, 2024).

thermore, Treib (2009) suggests that they slow time and simultaneously place the past in the present and present in the past. Monuments, however, are perceived as complete entities that exist outside of time (Ginsberg 2004). Despite the differences, the two notions share a common link with memory. Monuments have been perceived as "memory devices" that render the past tangible and simultaneously intertwine the geography and history of a place together with its identity and associated memories (Mitchell 2003).

Although military remnants can be considered ruins or monuments, both designations have been contested. Paul Hirst, a political theorist, questions whether such structures can become ruins. He argues that their abandonment and subsequent decay over time does not establish them as ruins and that the structures gain a sense of monumentality solely from their materiality and monolithic character (Hirst 2005). It is only when the purely functional features of the military structures are acknowledged as decorative elements of architectural quality that Hirst (2005) considers it right to frame these remnants as ruins.

Yet, it cannot be denied that monuments, together with the context they are embedded in, signify past conflict as well as the course of history – political, cultural and economic (Mitchell 2003). War landscapes can become entities of cultural wealth, often serving as national symbols, embodying a multitude of memories and meanings (Kim 2013).

Current Challenges of the Military Remnants in Liepāja

The military remnants of Karosta intertwine aspects of ruins, monuments, collective memory and cultural meaning, presenting assets that should be preserved. Despite the layering of story and history, the coastal forts are disintegrating. Although the remnants are what people associate with Liepāja and Karosta, their eventual disappearance could be largely justified by their lack of recognition as valuable assets and heritage.

Despite the acknowledgment of the uniqueness and history of the site, no strategies have been implemented to conserve the military remains threatened by water. Members of the public express skepticism about the possibility of saving anything at this stage, hinting that something should have been done earlier. One reason people may question the value of making efforts to preserve the structures is that they appear to be so abundant. Monta Krafte, the head of a bottom-up preservation practice, has remarked that since the neighborhood of Karosta has so many military objects, the public doesn't consider it necessary to try to save them (Šķietniece 2023).

Perhaps one reason the value of the place was not identified earlier, when the structures could still have been rescued to some degree, can be found in the harsh past of this military territory. Although the history of Karosta dates back to the nineteenth century, it is the more recent past that people recall. As a result, most of the time it is pain and anger linked to the Soviet occupation that has been projected onto the neighborhood. The military base, along with part of the fortification complex that encompasses it, became an autonomous territory during this time. Ever since, Karosta has been perceived as a place of contestation with its dark history. When the Soviet army left the territory in a demolished and vandalized state, the neighborhood could once again become an integral part of Liepāja. For an extended period of time Karosta was seen as a ghost town, characterized by crime and

destruction and associated with a mainly Russian-speaking community. Investment for rehabilitation was not immediately provided, leaving the neighborhood with many buildings in a state of decay, including the forts. It has taken many years for the place to recover on an urban and social level, and the forts as a site of military heritage have not been the priority for the local authorities (Šķietniece 2023). Recovery has rather taken shape through the promotion of residential and industrial use of the area without necessarily engaging with the historic fabric.

Although many local people are indifferent about them, attempts have been made to showcase what remains of the coastal defense structures. Karosta's preservation association, a bottom-up practice formed by local enthusiasts, has been working not only to expose the history of the coastal and terrestrial defense elements of the fortification, but also to protect them (Driķe 2019). Local historians have spoken in favor of the forts in discussions with the city council about how the historic landscape should be treated.

Even if the forts appear to be valuable assets and have been perceived as local symbols and a characteristic landmark by enthusiasts, historians, locals and tourists, they have not been officially recognized or classified as heritage on a national level. Perceptions of the structures as cultural and military heritage have influenced their treatment. However, despite their perceived value, there has been no significant search for strategies to preserve the deteriorating forts (fig. 3). During a conversation, Krafte revealed that she is not aware of anyone who would have brought up or wanted to initiate preservation of the forts. She further emphasized that it is now too late to do anything about the coastal structures, suggesting that if a conservation initiative were to be proposed, it would need to be directed toward the terrestrial defense line, which has remained in a much better state than the military heritage structures exposed to the sea.

^ Fig. 3 A fort at Artillery 1. The deterioration and collapsing of the defense structures is primarily caused by waves eroding the sand below the foundations of the structures (Source: Kristiāna Ustuba, 2023).

Future Challenges of the Military Heritage

Thus far, most of the Liepāja's fortification complex infrastructure has, to a certain degree, withstood the test of time and the challenges posed by exposure to water. The forts reveal the complexity of heritage located in water. Although it is evident that some of the remains are slowly disappearing, with other structures having already vanished, locally there has been no sense of urgency to arrest the process.
Although it has been highlighted that the forts will continue to exist in some form for another century, they will sooner or later become unrecognizable as military structures (Kilevica

2018). In an essay by Māra Zeltiņa (2008), the author revealed that coastal erosion rather than deposition is what predominantly characterizes the coast of Liepāja, with most erosion taking place in the northern part of the city, near Karosta. She notes that between 1985 and 1993 the coast receded by 19.2 m (Zeltiņa 2008). As a result of the coast receding at a constant rate, the coastal defense line has been left with a single fort that remains fully intact and in its original shape. Coastal erosion, specifically during the fall and winter season, has continued to reshape the coastline together with the remains of the forts to this day. The tension between the sea and the heritage site has regularly been highlighted and reported in the local newspaper.

However, a turning point may have been reached. After a season of many storms and unfavorable weather conditions in 2023 and 2024, the rate of coastal erosion has accelerated, causing larger portions of the ruins to disappear in the sea slowly but steadily. The historic sites at Battery 1 and Battery 3 now feature warning signs informing visitors about the erosion and the structures' lack of integrity (fig. 4). They are increasingly becoming dangerous to visit and interact with and local authorities advise against entering the structures to explore their spaces both above and under ground (Šķietniece 2023). Although in the past, the preservation association offered guided tours of the coastal forts, they no longer do so to avoid being blamed in case of an accident (Šķietniece 2023).

Even though coastal erosion is inevitable due to rising sea levels in the Baltic caused by climate change, it could be delayed. Strategies have been implemented near the Karosta coast to strengthen dunes and promote the accumulation of sand rather than having it continue to wash away. Additionally, the forts could be reinforced. This approach to the heritage structures, however, has not been considered due to bureaucracy, lack of funding and the local authorities having other priorities. According to members of the preservation association, the potential of the place is not being fully realized, raising questions about the loss of structures which could be used as an asset to teach and inform future generations about local history (Šķietniece 2023).

^ Fig. 4. In recent years, the forts have become increasingly affected by water challenges, decreasing the stability and structural integrity of both the military structures and the landscape surrounding them, rendering them dangerous. As a result, warning signs have been installed at Coastal Artillery Battery 1 and 3 to warn visitors (Source: Kristiāna Ustuba, 2023).

Conclusion

The coastal defense line illustrates the battle that often takes place between water and heritage. It is not clear at this point whether the structures at risk can be saved even if preser-

vation and conservation efforts are made. Deterioration and decay caused by water will eventually erase the structures completely. Even though they are still present and distinguishable, it is realistic to assume that future awareness of the structures lies in present-day efforts to document and record them. This is a case where both the fortification fragments and the sea are considered entities that symbolize and characterize the place, and are ultimately considered an expression of identity and history, both local and national. Only through their protection could the history and remembrance of past events and conflict remain tangible. This situation invites rethinking sustainable development through preservation strategies applicable for heritage of historic, cultural and military value that is at a constant battle with water as well as through practices that aim to unravel the wealth of knowledge of such structures to the wider community, addressing the physical and semantic qualities of the structures.

Policy Recommendations

- Considering the current absence of interventions to address the erosion that is destroying the forts, possible actions include:
- Incorporating the coastal military heritage sites as an integral part of local development plans, prioritizing strategies to address coastal erosion as well as the deteriorating state of the forts by stabilizing the dunes and reinforcing the defense structures.
- Encouraging engagement among the various stakeholders including members of the local community and the city council and using bottom-up practices to educate community members and including them in decisions about the area's military heritage.

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Sustainable Water Management and Indigenous Socio-Technical Heritage in Marrakech, Morocco

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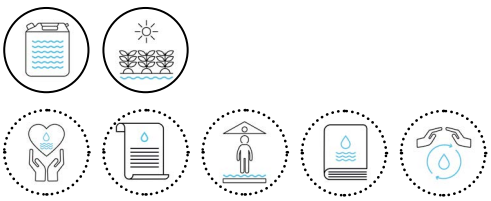
Morocco is considered a water-independent country by the World Bank, yet due to its topographical diversity, considerable land surface, and challenges posed by climate change, it ranks among the most water-stressed countries on the globe. Marrakech, an oasis city in Morocco, thrived for centuries through the ingenious use of khettarat, a traditional system of underground wells and channels that tapped into local aquifers and made use of topography and gravity to sustainably deliver water to the city. Until the early 1990s, Marrakech could still meet all its drinking water demand with the use of khettarat. Owing to a combination of institutional, political and economic factors, the khettarat system went into sharp decline starting in the 1980s and was at risk of disappearing both as a form of heritage and as an Indigenous technology. Recent efforts by multiple stakeholders aim to safeguard and re-introduce khetterat. They demonstrate the importance of local socio-technical systems in ensuring equitable and sustainable development in Morocco and similar arid regions around the world.

Keywords: *water heritage, indigenous technology, Morocco, socio-technical, underground water system*

KEY THEMES



CLIMATE

Bsh
Hot semi-arid climate

< Fig. A seasonal riverbed lies dry except for a small pool of standing water, on the outskirts of the Tata oasis, in southeastern Morocco (Source: Cristiana Strava, 2018).

Introduction

As a water-independent country[1] that does not share ownership or usage rights over its surface water or groundwater with any neighboring state, Morocco enjoys an unusual degree of freedom to determine its domestic water policies (World Bank 2020). However, the country faces challenges due to uneven distribution and uneven access to sustainable water sources across its territory. The situation has been exacerbated by accelerating climate change, as well as by political decisions to pursue water-intensive economic activities like mass tourism and export-oriented agriculture (Davis 2006). These factors have made this structural water deficit a defining feature and pressing challenge for economic and governmental actors. In 2022 Morocco experienced the worst drought in forty years, with ordinary inhabitants feeling the impact throughout the country (Manfron et al. 2023), particularly in the Marrakech region (Elshamy 2022).

The conditions for this deficit were compounded by historical precedents, most of which were set in place during the twentieth century. France's Protectorate in Morocco (1912–1956) was characterized by a settler-colonial form of occupation. Land expropriated from the Indigenous population and export-oriented agriculture became key pillars of the colonial economy (Guerin 2016). The introduction of intensive, irrigated, industrial agriculture during the colonial period overdetermined the direction of water use and water-use policy for decades to come. Historians and political scientists have documented some of the economic and political outcomes of these transformations (Bouderbala 1984; Davis 2007). However, their ecological and social impacts have not been studied as extensively. In the following sections, I present several forms of historical water management, before describing the significance of a new water heritage museum. I then set these historical approaches against the backdrop of challenges posed by accelerating climate change and the return of mass tourism to the Marrakech area, before concluding with a set of recommendations.

Historical Attempts at Local Water Management: From the French Protectorate to Post-independence Morocco

80 cent of Morocco is arid or semi-arid (fig. 1), and water availability has dropped from 3,500 m^3 per person per year in 1960 to 730 m^3 per person in 2005 and 645 m^3 per person in 2015 – well below the "water poverty level" of 1,000 m^3 per person per year as defined by the World Bank. According to the same data from the World Bank and the Moroccan Ministry of Equipment and Water, this ratio is expected to decline to the absolute threshold of 500 m^3 per capita per year by 2030 (Taheripour et al. 2020).

To address these conditions, in the post-independence era (1956–2000s), Morocco's monarchy embarked on several large-scale modernization projects, which led to changes in institutional and practical arrangements for the management of local water systems. This entailed, for example, the building of large hydro-power dams and reforms to ownership regimes that focused on providing incentives to move from communal to private ownership (Simonk 2021). Driven by a commitment to the

1. Water-independence is a measure of how much of the overall volume of a given country's renewable water resources come from sources that are designated as internal or external to that country's sovereign space. For Morocco this measure is 0 for external sources, hence it is a water-independent country. See World Bank (2020).

^ Fig. 2 A diorama inside the Aman Museum showcasing and labeling in three languages the underground components of a *khetarra*: a long gallery that taps into the water table and angles down toward an irrigation field or oasis community, and several maintenance wells that can be accessed from above ground. (Source: Cristiana Strava, 2023).

economic orthodoxies of the 1970s and 1980s, this ultimately prioritized economic growth through free-market logic over communally managed public goods. This in turn contributed, among other things, to the decline of agricultural commons such as the *agdal* and collectively managed water systems such as the *khettarat* (Strava and Amarouche 2022). Marrakech, an oasis city in Morocco, thrived for centuries through the ingenious use of these *khettarat* (fig. 2), a traditional system of underground wells and channels that tapped into local aquifers and made use of topography and gravity to sustainably deliver water to the city (Faiz 2002). Until the early 1990s, Marrakech could still meet all its drinking water demand with the use of *khettarat* (Faiz and Ruf 2010).

Institutional and Indigenous Approaches: Aman Museum for Water Heritage

On 5 January 2017, on the outskirts of the oasis city of Marrakech, Crown Prince Moulay Hassan inaugurated the Mohammad VI Museum of Water Heritage and Civilization - Aman, Morocco's first water heritage museum, built on land donated by the Ministry of Charitable Endowments and Religious Affairs (Ministère des Habous et des Affaires Religieuses, hereafter Habous). Nicknamed the Aman Museum after the local Indigenous Amazigh word for "water," and managed by the Habous, the museum and surrounding site, together with the local institutions involved in its planning, constitute a unique example of not only recuperating socio-technical water knowledge but also ensuring its preservation through education.

The choice of planning, building and managing the museum under the tutelage of the Habous is not as arbitrary or strange as it might first appear. Drinking water fountains and wells, as well as washing fountains needed for the performance of religious rituals and everyday cleaning, have been and continue to be a key infrastructure of Moroccan cities and small towns. Historically, establishing and maintain-

^ Fig. 3 The main atrium of the Aman Museum contains a 3D model of the region's hydrological system and is designed to visually connect all three floors, seeming to reference a deep and wide well (Source: Cristiana Strava, 2023).

ing this infrastructure has been the responsibility of religious institutions like the Habous, whose knowledge and custodianship of these socio-technical systems extend back many centuries (Ftaita 2010).

However, by bringing together previously disparate actors from the Moroccan community, policy and technical sectors, the museum provides an unprecedented example of mixed institutional stewardship. The work of setting up the museum was anchored in an inclusive approach that combines public outreach with public-private partnerships in the work of heritage preservation and knowledge ownership. This approach is further illustrated by the consortium of actors who participated in the planning, financing and scientific coordination of the museum: from the German Technical Cooperation Agency (GIZ; Deutsche Gesellschaft für Internationale Zusammenarbeit), to the local University Cady Ayyad in Marrakech, Moroccan engineers and historians of the environment and international museum consultancies (K Nour). The Aman Museum demonstrates that the preservation, valorization and management of unique water systems and associated forms of heritage can greatly benefit from cross-sectoral and international collaboration. Beyond extending this knowledge and custodianship into the future, the creation of Morocco's first water heritage museum and its location in one the most water-stressed regions of the country might also be interpreted as a statement of commitment by local and international actors to safeguard and valorize Indigenous knowledge systems.

Across ten permanent exhibits, through varied mediums and techniques, the museum traces the historical, bio-chemical, legal, spiritual, polit-

^ Fig. 4 The tops of *khettara* maintenance shafts with signs of dereliction and overgrown vegetation, threatening their collapse, Guelmim region, Morocco (Source: Cristiana Strava, 2010).

ical, socio-economic and geographical aspects of hydrological systems in the country (fig. 3). By placing a particular emphasis on the Indigenous knowledge and practice associated with *khettarat* and the skillful management of water in Morocco's arid regions, the exhibits offer more than educational information. They also remind local and international visitors of the immense knowledge that Indigenous communities already possess – and that this knowledge can be lost unless efforts are made to preserve it and bring it back to life (fig. 4–5).

Climate Impacts and Sustainable Tourism

The Aman Museum's proximity to Marrakech is not arbitrary and acts as a stark reminder of the human and climatic challenges faced by already stressed water systems. Until the early 1990s, Marrakech could still meet all its drinking water demand with the use of khettarat. However, at present, the oasis city consumes 66 million m3 of fresh water per year which can lead to severe aquifer depletion. One significant factor is the over-pumping of groundwater from wells for intensive agricultural uses and leisure activities (thirteen golf courses, five waterparks and many private lawns and pools) that give the city its reputation as the "Las Vegas of Morocco."

As the city's tourism industry has returned to activity levels matching the years before the COVID-19 pandemic, pressure on the local aquifer is set to increase. Recent studies also highlight the impending threat posed by the rapid depletion of underground aquifers resulting from a decrease in rainfall and from their being heavily tapped for agricultural expansion (CESE 2014). For three consecutive years (2020, 2021, 2022),

^ Fig. 5 Inside an underground desiccated gallery of a *khettara* light shines from above through the maintenance shafts. The gallery is tall enough for an average-sized person to stand up straight and wide enough to comfortably walk through. (Source: Cristiana Strava, 2010).

the region recorded a steady drop in precipitation, with 2020 being one of the driest years on record since 1981. Aquifer water has also been degraded by seawater intrusion, nitrate pollution (from fertilizers or untreated sewage) and natural increases in salinity (Hssaisoune et al. 2020). Given the slow recharge rate of these aquifers, their depletion and degradation will have severe effects on Morocco's water systems.
However, like many other middle-income countries in the Global South, Morocco's national strategy for economic development continues to rely heavily on both a strong tourism sector as well as export-oriented agriculture. Taking into account the urbanization and population growth required to keep these sectors profitable, current predictions warn that unless urgent measures are enacted, Morocco expects to reach "absolute water scarcity" (less than 500^2 m per person per year) by 2030 (Taheripour et al. 2020).

Conclusion

Recent efforts at recuperating, revitalizing and celebrating Morocco's rich Indigenous water heritage have been instrumental in mitigating, and in some cases even reversing, some of the most detrimental effects of previous water-management policies and practices in the country's arid regions (Dahan 2017).

Public-private partnerships and the phased but sustained introduction of renewable sources of energy can help alleviate water stress in Morocco's arid regions, while also helping to mitigate risks in other regions where flooding and

coastal erosion pose a threat to local communities and their livelihoods. Artificial recharge of existing aquifers, seawater desalination and wastewater reuse are some of the promising approaches currently being tested across the country. Alongside efforts to revitalize local socio-technical water heritage, these approaches stand to offer viable solutions that have the potential to ensure equitable sustainable water futures for all (Hssaisoune et al. 2020).

However, it is also clear that current models of development that remain wedded to capitalist, market-driven and financial incentives cannot, in the long run, safeguard water resources and will ensure neither the survival of heritage practices nor that of communities who have developed and preserved these practices for centuries. Instead, the recuperation of Indigenous water-management knowledge in Morocco demonstrates that to build and maintain resilient and locally-adapted solutions, decentralized, collective and communal forms of resource use and stewardship like the *khettarat* merit broader support and a more central role in water-management plans.

Policy Recommendations

- Establish new or reinforce existing partnerships between governmental agencies and local communities in charge of safeguarding water resources.
- Allocate structural funding to local efforts that integrate Indigenous knowledge in national water-management strategies.
- Concerted efforts can together ensure sustainable, participatory and locally appropriate approaches to water conservation, in Morocco as well as in similar semi-arid countries.

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Cultural Heritage Conservation as a Driving Force toward Sustainable Water Management in Djerba Island

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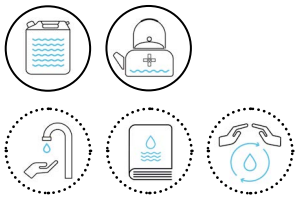
The island of Djerba is a tourist destination in the southeastern semi-arid region of Tunisia. Especially during peak tourism seasons, it experiences severe pressure on its water supply. Given the island's historical water scarcity, locals have developed solutions to address the shortage, with one of the most notable being the rainwater harvesting and storage system. This system has evolved intricately over time, with meticulous attention to construction details, material selection, maintenance, and management strategies. This article posits that embracing and disseminating traditional rainwater harvesting knowledge can play a pivotal role in achieving sustainable water management. It also raises the question of whether fostering cultural heritage through a sustainable tourism orientation, aimed at highlighting heritage, aligns with this objective.

Keywords: *water-scarce islands, rainwater harvesting systems, sustainable water management, water heritage, cultural heritage tourism*

KEY THEMES



CLIMATE

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Hot semi-arid climate

< Fig. 1 Close-up view: View captured from the rooftop of a traditional house (Source: Sarra Ben Youssef, 2023).

Djerba's Water Challenges

Djerba has historically grappled with water scarcity. Over the centuries, the island's residents have thrived by fostering a robust ethos of self-reliance, self-sufficiency and a deep respect for the natural environment. Lacking perennial watercourses, their ability to endure has depended on the meticulous collection and storage of rainwater (fig. 2). With only a small number of wells, Djerba islanders have sustained lush homestead gardens, where they cultivate trees and plants for their own consumption (fig. 3). The plants were arranged in tiers to provide each species with protection from the sun and hot winds. At the top were tall palm trees acting as the first canopy, followed by fruit trees like pomegranates, figs, apples, oranges, and lemons forming the second canopy and filtering hot, humid air. Finally, at the bottom were vegetables or cereals, benefiting from the humus and fresh air at ground level (Djerbi 2011). As Elisabeth Fentress (2001) describes "Palms shelter fruit trees, which shelter pomegranates, which in turn shelter little vegetable plots. Wells provide water for these systems, the water trickling into the gardens through tiny channels (*sequia*)."

On the island, traditional knowledge of water management has been passed down through generations via oral tradition, hands-on experience, and communal interaction. However, the 1960s marked a turning point as the transmission of this knowledge began to decline amidst significant economic and social transformations.

During this period, Djerba underwent notable economic shifts, transitioning into a tourist destination and briefly adopting the cooperative system (Tmarzizet 1993). This reform, spearheaded by Minister Ahmed Ben Salah and President Habib Bourguiba, proved brief and unsuccessful, pushing retail trade into cooperatives and transforming merchants into employees (Bernard 2002). Prior to this reform, Djerban had successfully operated small-scale businesses, showcasing their entrepreneurial prowess in various trades such as merchants, weavers, fishermen, and potters (Roulston 1993). Consequently, islanders felt their economic independence threatened by the cooperative system, which restricted their earnings to cooperative wages (Bernard 2002). Many islanders chose to seek opportunities elsewhere to maintain their autonomy, leading to their departure and establishment of new businesses in different locations (Tmarzizet 1993). While Djerban (both Ibadi and Jewish) departed, migrants from the mainland arrived to work in the burgeoning construction and tourism sectors, contributing to the mutation of the socio-economic landscape of Djerba.

In the wake of their departure, homesteads were abandoned and irrigation systems neglected, contributing to the decline of once-prosperous gardens and infrastructure. In subsequent decades, these assets deteriorated further as heirs fragmented large estates into smaller parcels. The smaller plots often became the site of vacation villas, exacerbating the informal tourism sector's lax approach to water management.

Local people who remained on the island continued to uphold traditional practices, recognizing the long-term value of investments like cisterns for both financial and ecological sustainability. Also, some members of the Djerban diaspora have taken steps to rehabilitate ancestral estates, reintroducing traditional water management methods such as the irrigation system (*sequia*) and rainwater cisterns (fig. 4).
In 2017, tourism accounted for 25 per cent of the island's water consumption provided by the National Company for the Exploitation and Distribution of Water, a rate notably higher than

^ Fig. 2 Courtyard of a mosque, Djerba, where rainwater is collected and stored. This photograph depicts several underground cisterns employed for rainwater collection (Source: Sarra Ben Youssef, 2023).

^ Fig. 3 View captured from the rooftop of a traditional house (Source: Sarra Ben Youssef, 2023).

what has been reported for other Mediterranean destinations, with an average consumption of 766 l per guest per night, a figure raising concerns (Wood et al. 2018). Despite the presence of a desalination plant which entered into operation in 2018 and has reduced the volume of water piped from the mainland, helping to satisfy the island's fresh water requirements (Ajala et al. 2022), water shortages persist. When confronted with these shortages, residents often resort to fast, low-cost solutions lacking sustainable value. This reliance on temporary fixes often results in increased use of plastic tanks.

The erosion of traditional water management practices diminishes the island's resilience and ability to cope with water scarcity. Preserving these practices is crucial for long-term sustainability in Djerba, as they not only mitigate water shortages by reducing reliance on piped water but promote a cultural ethos of responsible water consumption.

Water Management Heritage

Water management heritage in Djerba includes three key aspects. First, the technical elements involve constructing and maintaining rainwater cisterns, wells and irrigation systems. Second, the management strategies of Djerba's residents emphasize self-sufficiency, with individuals taking steps to collect and conserve water for their personal use, alongside a community-driven approach to building and maintaining charity rainwater cisterns to ensure access to water for all. Finally, knowledge transmission plays a vital role, with the teaching and sharing of water management techniques through oral tradition, hands-on experience and community interaction. In this way islanders ensure the continuity of water management knowledge and skills for future generations and preserve the island's water heritage.

In the city of Meninx, the aqueduct and cistern complex were notable features (Ritter and Ben Tahar 2020). Residential buildings, sanctuaries, and commercial buildings were equipped with cisterns, suggesting a sophisticated water management system within the urban landscape. Archaeological excavations have revealed the presence of cisterns in the macellum located near the coasts, a cistern and a large water reservoir in a bath complex, a cistern in a temple, and subterranean cisterns in residential buildings (Ritter and Ben Tahar 2020). Although the ancient city of Meninx was eventually abandoned, islanders have continued to utilize impluvium cisterns to harvest and store rainwater

^ Fig. 4 A public rainwater cistern for charitable purposes, Feskia type (rectangular with impluvium) (Source: Sarra Ben Youssef, 2023).

in both residential and public buildings.

In the past, each building, whether public or private (including houses, homesteads, and mosques), had one or multiple cisterns. Even the countryside gardens, where islanders would spend only certain short periods of the year for agricultural purposes and which did not have built houses, had their cisterns (Tlatli 1942). Rainwater collected in cisterns was never used for irrigating fields (Reiss 1980). These cisterns, all of which were underground, varied in morphology, as well as in their management and ownership status. Rainwater was collected on flat surfaces, used as an impluvium, and from the roof of the house. The water collected from the roof was then channeled through gargoyles onto the sloping blanquettes that typically encircled the *houch* (traditional house) before being directed to the cistern. The surfaces used for water collection were regularly coated with lime to ensure a watertight and hygienic process of conserving potable water (Djerbi 2011). There were different types of cisterns in terms of ownership: domestic cisterns built within houses (thus privately owned), public cisterns built by the government in public spaces to enable islanders to "recharge" their domestic cisterns in times of drought, or simply to obtain potable water when their own cisterns were dried out (Tlatli 1942). Islanders were also able to obtain water from "charity cisterns" built by fellow islanders, often located near or around mosques, as a form of charity (Amayed 2023).

Using Water Heritage to Mitigate Water Challenges

The individual rainwater collecting system, regarded by locals as significant ancestral knowledge, has deep cultural roots within the community. In 2023, Djerba was inscribed on the UNESCO World Heritage list. Many of the proposed monuments on this list, including mosques and some *houch*, feature their own cisterns.

These cisterns can serve as a renewable source of fresh water. They offer a way for locals to meet their water needs during shortages, particularly during the high tourism season when water consumption peaks. The government is promoting the adoption of private rainwater cisterns nationwide through the implementation of two laws regulating their use:

- Decree n° 2016-1125 of 22 August 2016: The National Home Improvement Fund can assist in financing the construction of a rainwater cistern for low-income households. This law specifies that the interest rate, the amount of the fund and the repayment period are calculated based on the monthly income of the beneficiary.

- Decree n° 2018-171 of 19 February 2018: This law regulates the construction and use of rainwater harvesting and storage tanks, as well as their maintenance. It stipulates that the rainwater must be tested at least once a year by a laboratory that specializes in this work. Anyone who wants to build a rainwater cistern must sign a written commitment agreeing to these stipulations when submitting a building permit application.

However, while the construction of a rainwater cistern is a good long-term investment (not only as a sustainable solution to reduce reliance on desalination plants, which consume large amounts of energy, but also to mitigate water shortages), they remain costly to build and, more significantly, they are costly to maintain, particularly for people with low incomes.

In alignment with national policies aimed at enhancing the diversity of tourist attractions, including a focus on sustainable heritage tourism, the Destination Djerba Management and Promotion Organization, in collaboration with municipalities in Djerba and interested locals, are working to incorporate *menzels* (traditional homestead compounds) with cultural significance into the tourist and cultural circuit.

Sustainable cultural tourism, which highlights heritage and integrates cultural sites into tourist activities, offers a promising avenue for preserving and continuing traditional methods of water management in Djerba. Converting heritage locations into guest houses that feature traditional water-saving technology, like rain cisterns, is a practical step toward this goal. These initiatives facilitate the oral transmission of heritage, hands-on experiences, and communal interactions. For example, converting heritage sites into guesthouses requires various elements, including cisterns, to be restored. This work entails the transfer of knowledge, giving those involved a deeper understanding of traditional water management techniques and practices. Consequently, spreading this knowledge helps raise awareness and motivates a shift toward more sustainable water management. Moreover, using tourism to promote sustainable water management techniques offers a strategy to address the water issues that tourism amplifies. This approach repositions tourism from being a contributing factor to water scarcity to becoming part of the solution.

Conclusion

Djerba islanders have an inspiring heritage of resilience in the face of water scarcity. They should be empowered to be self-reliant through knowledge sharing. Sharing information about traditional water management can help people make informed decisions about water and participate in mitigating water challenges. This approach not only aligns with the cultural heritage of Djerba but also revitalizes its essence, emphasizing the significance of communal involvement and responsible water resource management.

Policy Recommendations

- Traditional water management heritage, both its technical and cultural aspects, should be encouraged. In addition to preserving ancestral knowledge and practices related to water management, it is important to promote their adaptive reuse in contemporary contexts. Sharing knowledge of what has worked in the past can empower stakeholders to make informed decisions regarding sustainable water management practices in the present and future.

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