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Circular Water Stories #2

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Editorial

Articles

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SPOOL is a journal initiative in the field of 'architecture and the built environment'. It puts a strong emphasis on specific topics: Science of Architecture; Landscape Metropolis; Energy Innovation, Cyber-physical Architecture and Climate Adaptation. These topics refer to existing and upcoming research programmes/interests in Europe and beyond, and ensure a steady stream of potential copy. Treating these topics as threads within one journal allows SPOOL to focus on the interrelationship between the fields, something that is often lost in specialised journals. SPOOL welcomes within this framework original papers and associated open data on research that deal with interventions in architecture and the built environment by means of design, engineering and/or planning.

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Cover images
Front: A riverine's home | This image shows how a riverine house is set up surrounded by natural resources utilized by the family. (Costa e Silva & Lucas, 2019)
Back: Map of Banjarmasin, 1916 | Settlements (green) and individual building patterns (in red) follow the course of waterways. Leiden University Libraries, Colonial Collection, KIT

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EDITORIAL

Circular Water Stories #2

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Circular Water Stories focusses on the changing circumstances of the water system and water chain, and the consequential spatial transformation. The approach highlights the vulnerable interdependency between traditional, marginalized water communities and their environments. The papers of this second Spool issue on Circular Water Stories in the Landscape Metropolis #8 investigate traditional water systems as a source of inspiration for today's water, characterised by the concepts of too much, too little, and too dirty from two main perspectives: the people-orientated cultural perspective and the systemic spatial perspective.

Historically, the presence and accessibility of water was the most critical spatial condition required by humans to settle. However, during time the central water management position in settlements and communities got lost, spatially and in its cultural importance. The livelihoods and identity of traditional water communities have been under increasing pressure since the Industrial Revolution, marking the ultimate shift to a world that can be engineered. Specialised water managers have taken over the authority of the living water systems (circular water systems). Today, water systems are separated into categories of drinking water, drainage, irrigation, sewage systems, and water safety systems, no longer managed as one system. Thus, the self-evident exchange between the natural system and the (human) water chain is not approached as such. Authorities manage the water, guided by waterworks which are controlled automatically from a distance. Water flows are no longer visible, but run invisibly through pipes. This industrialisation has caused a change from communities of water workers - aware and knowledgeable about the importance of water as the source of life and their cultivated landscape - to passive users.

Timmer & Rosbergen and Patchineelam focus on the transformation and displacement of the riverine communities and river-related spatial and cultural identities. Patchineelam's paper centres on women of marginalised traditional communities, a group often overlooked by planners and historians. The paper investigates the changed relationships between riverine women and their living spaces, both environmental and social, after forced resettlement in the wake of the Belo Monte Hydropower Dam in Brazil. This relocation disconnected the women physically from the river and totally changed their way of living. Timmer and Rosbergen investigate the potential of a participatory planning method for revitalising riverine culture and settlements in the city of Banjarmasin in Borneo, Indonesia. Known as the 'city of a thousand rivers,' modern road-oriented urbanisation, overpopulation, and illegal building activities have had a devastating impact on the once impressive river-related identity of the city.

The article by Watson, Abukhodair, Ali, and Robertson is like many in the first issue of CWS about understanding existing living water systems and learning from them. The plea for funding, rethinking, rebuilding, and scaling climate solutions supports the resilience of both communities and cities, while addressing the inequalities and distance from nature that our current systems and climate solutions support. In the article by Surajaras and Rey Hernandez, two existing water-based crops systems, the Xinghua Duotian in China and the Chinampas in Mexico, are compared, with a focus on their site-specificness and how this understanding has shaped the landscape and made circularity possible.

Considering the impact of the climate crisis and the increasing erratic patterns of drought, rain, and heat in the region of Aragón, it is quite a courageous attempt to revitalise an abandoned orchard in the eroded hills of the Barranco de Tremps, Spain. In the visual essay, Hillege, a landscape architect and photographer, documents the attempt to revive and enrich the landscape with a combination of contemporary and traditional (vernacular) irrigation techniques. This is done by experiencing the many forms in which water manifests itself through the seasons and uses such observations to further develop the project.

The contributions showcase the growing recognition among researchers and planning professionals of the knowledge, values, skills, and the ways of life of the few remaining communities of water workers. Finally, as is shown in the case of Hillege and her project in Barranco de Tremps, some people use this knowledge actively and start acting. We are hopeful that there is an increased interest in learning from the knowledge hidden in living water systems.

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Banjarmasin, where the river is the city!

Participatory Revitalization of Urban Riverine Settlements

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Abstract

The Indonesian city of Banjarmasin, Borneo, is widely known as the 'city of the thousand rivers.' Residents live and work in urban settlements that occupy the river and its banks. However, modern road-oriented urbanization, overpopulation, illegal building activity, and pollution have a devastating impact. Without adequate management, Banjarmasin's impressive river-related identity would lose its cultural and socio-economic significance. Therefore, the city government is searching for solutions to revive its river culture and to revitalize riverine settlements. In 2019, a workshop was carried out by following the HUL Quick Scan method, which is inspired by UNESCO's Historic Urban Landscape (HUL) approach. This paper focuses on the outcomes of the workshop in Banjarmasin in relation to participatory revitalization of urban riverine settlements.

Keywords

Participatory revitalization, historic urban landscape, HUL, water landscape, urban heritage, water urbanism, urban revitalization, heritage management, participatory planning

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New Life for Historic Cities

In 2011, the Recommendation on the Historic Urban Landscape (HUL) was adopted by UNESCO's General Conference. With its slogan 'New life for historic cities,' this holistic approach:

focuses on the entire human environment with all of its tangible and intangible qualities. It seeks to increase the sustainability of planning and design interventions by taking into account the existing built environment, intangible heritage, cultural diversity, socio-economic and environmental factors along with local community values. (UNESCO, 2013, p.5)

Management of change, as well as fostering cultural heritage as a catalyst for a sustainable future, are central to the HUL approach. Implementation of the approach requires full assessment of natural, cultural, and human resources, followed by formulating priority actions and integration into the wider goals of the development of the city. Besides knowledge and planning tools, regulatory systems and financial tools, implementation should be achieved by introducing civic engagement tools. Community values and community participation are vital elements within the HUL approach in order to achieve a sustainable result (Veldpaus, 2015).

The Netherlands has a solid tradition in inner-city revitalization (van Es & Voerman, 2018; Blom & Timmer, 2020) and developing management concepts in which heritage is a sector, factor, and vector within spatial planning and urban development (Janssen et al., 2017). Internationally, the Cultural Heritage Agency of the Netherlands receives requests on a regular basis to participate in workshops in this field. In addition to existing workshop models, trainings, and courses in collaboration with a wide range of partners, the Cultural Heritage Agency decided to experiment on a tool that embraces the HUL's principles and combines it with the character of a quick scan. This resulted in the HUL Quick Scan method that was developed in close cooperation with the University of Indonesia, Bogor Institute of Agriculture (IPB), University of Trisakti and the Dutch-based organization Heritage *hands-on*.

The HUL Quick Scan method does not replace the comprehensive HUL approach. It is to be seen as a practical exercise in analysing historic urban landscapes generating ideas for implementing integrated conservation and sustainable development, in a very short period of time. The HUL Quick Scan method aims to create an attractive 'horizon' for a sustainable future of historic urban landscapes, and to inspire people – governments, NGOs, the local community – to be involved. By doing so, it could pave the way for adopting the HUL approach.

The first step of the method involves an analysis of tangible and intangible heritage features, as well as socio-economic, cultural, environmental, and urban planning challenges and opportunities. Based on the outcomes of the analysis, the second step focuses on formulating a vision. Translation of the vision into brief principles for functional and spatial development is next. The final step consists of elaboration of the principles into proposals in which conservation, development, design, and the creation of favourable conditions, with regard to implementation, are integrated. Narratives – for example, historical functions, socio-economic activity, culture, and traditions – should be assessed on their relevance today and potential for the future. While performing the steps, local stakeholders and residents need to be involved as much as possible.

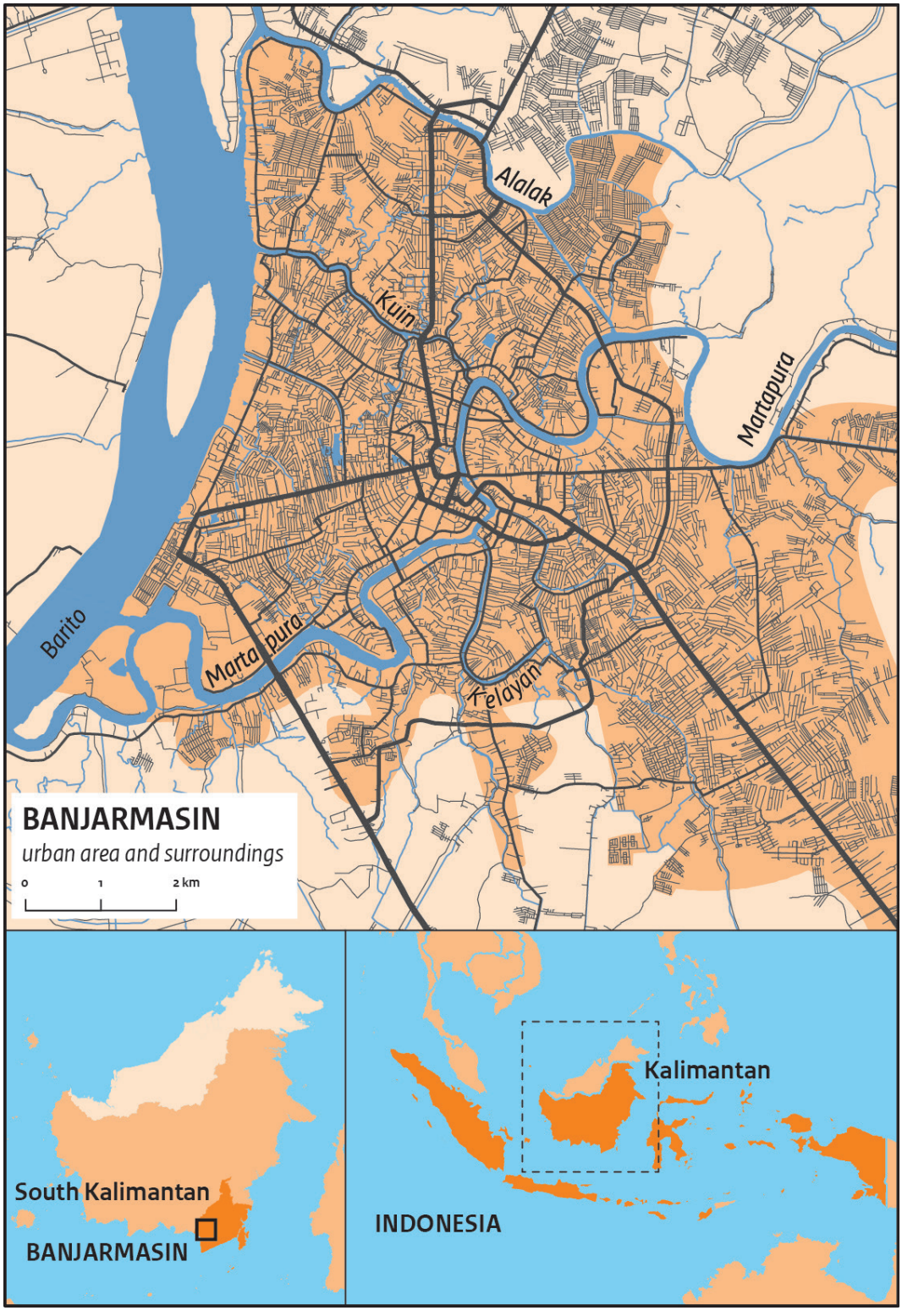

FIGURE 1 Map of Banjarmasin | Banjarmasin on the Indonesian island of Borneo, or Kalimantan, is located in a tributary delta - with rivers such as Martapura, Kelayan, and Kuin - of the Barito river that flows southwards into the Java Sea. Copyright 2021 by Cultural Heritage Agency, Bart Broex.

In 2018, the HUL Quick Scan method was first used in a workshop in the town of Muntok on the island of Bangka, Indonesia. This town had lost its historical function as the centre of the tin-mining industry. New life for a historic city was very applicable to Muntok (Dipowijoyo et al., 2019). The city of Banjarmasin on Borneo, or Kalimantan, as the island is called in Indonesia, followed as a second test case in 2019. Banjarmasin is located on a fluvial plain near the junction of two large rivers, the Barito and Martapura, and its urban landscape consists of almost endless contiguous riverine settlements (Figure 1; Figure 2). These settlements should be seen as a cultural-historical phenomenon reflecting a distinctive water-related narrative and can be found across the entirety of Southeast Asia and beyond. A lack of life is not a problem; rather, it is an existing way of life that is under threat from environmental pressure, socio-economic changes, urban degeneration, or urban development. Participatory revitalization could facilitate favourable conditions in safeguarding these riverine settlements' unique water-related narratives.

FIGURE 2 Image of Banjarmasin | Contiguous riverine settlements define the character of Banjarmasin's urban landscape.

Participatory revitalization of urban riverine settlements

Participation and collaborative design processes arose in the 1970s as part of the civil right movements, and in the current age of social media and digital platforms, a new kind of 'participatory culture' seems to be emerging (Simonsen & Robertson, 2013; Jenkins, 2006, as cited in Keeton et al., 2020). Participatory workshops offer an alternative to top-down planning concepts and enable in accessing valuable local knowledge. These "short-term, multi-stakeholder workshops are widely acknowledged as a participatory tool in the 'design participation' toolbox to catalyse stakeholder communication and negotiation" (Keeton et al., 2020, p. 286).

Participatory working methods practised in social and planning domains, and particularly in the field of architecture and urban design, incorporate cultural perspectives directly. Models of community participation and the engagement of citizens grounded in the cultural heritage sector are less common, however. Nevertheless, this topic is receiving increasing attention recently. The Faro Convention of 2011, for example, aims to encourage creative ways of active civil society involvement in heritage management and states that: "knowledge and use of heritage form part of the citizen's right to participate in cultural life as defined in the Universal Declaration of Human Rights" (Council of Europe, 2011).

The HUL approach appears to be one of the first international approaches in which experts and the local community should interact on a level playing field (Veldpaus, 2015). Community involvement and engagement are still nonetheless limited in practice, and there is a need for more tools and methodologies in this regard (Hosagrahar, 2019). Although the HUL Quick Scan method is not primarily aimed at public participation, involving the local community, government, and experts is a crucial part of it. It might be interesting to examine how this is reflected in the outcomes of the workshop in Banjarmasin. Considering Banjarmasin's challenges also apply to other riverine settlements in the region, and conceivably other parts of the world, could the applied method of working be useful in the field of participatory revitalization of urban riverine settlements?

The City of Banjarmasin

"Water, water, that is Banjarmasin! The river is the city there" (Poortenaar & Poortenaar - van Vladeracken, 1925, p. 158). This is how Dutch graphic designer Jan Poortenaar and his wife, the composer Geertruida van Vladeracken, described Banjarmasin in their art travel book, which covered their visit to the Dutch East Indies in the 1920s. Old photographs give us a glimpse of the Banjarmasin they encountered in that period (Figure 3; Figure 4). Although a lot has changed since then, 21st century visitors will largely gain a similar impression of the town. Daily urban life in Banjarmasin is closely intertwined with water, as people interact with the rivers for economic, social, and cultural purposes (Figure 5).

FIGURE 3 Riverscape in the past | Riverscape with a mosque and traditional boats, beginning of the 20th century. National Museum of World Cultures, Collection Tropenmuseum.

FIGURE 4 Riverscape in the past | Floating structures and lively activities on the water, 1920-1940. National Museum of World Cultures, Collection Tropenmuseum.

FIGURE 5 Riverscape today | Fruit sellers in their boats making a living alongside the river.

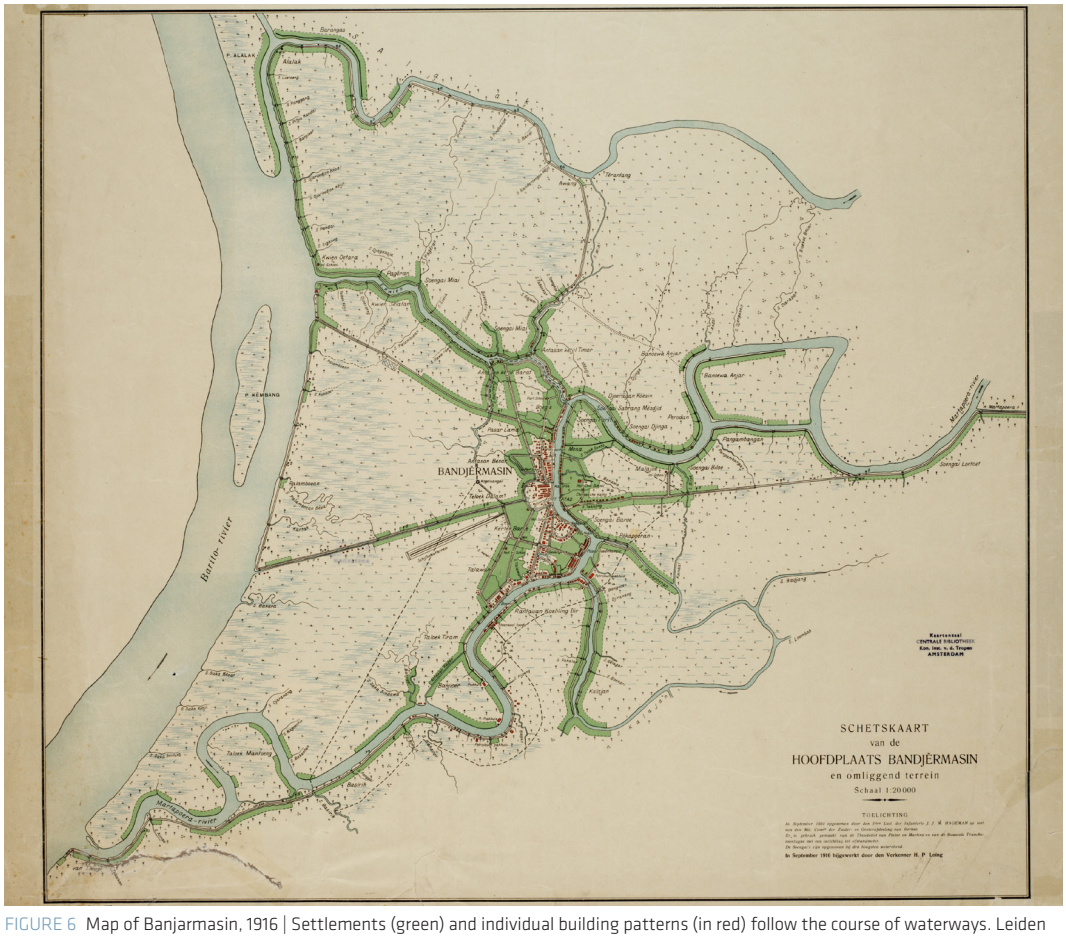

FIGURE 6 Map of Banjarmasin, 1916 | Settlements (green) and individual building patterns (in red) follow the course of waterways. Leiden University Libraries, Colonial Collection, KIT.

The city was part of the Banjarmasin Sultanate and later, during the Dutch East Indies period, it became an important trading port – for commodities coming from the hinterland – and administrative centre. This attracted Javanese, Buginese, Chinese, and Arab settlers to the area, which is native to the Dayak tribe and Banjar (Malay) people. Subsequently, the Republic of Indonesia appointed Banjarmasin the capital of South Kalimantan Province. Land reclamation projects in the 1950s, and the transmigration programme (1975-1990) that provided labour and farmers from other islands, contributed to agricultural development and widespread urbanization (Bangun et al., 2016). Today, the city has a population of approximately 693,000 inhabitants.

For centuries, the rivers have functioned as the lifeblood of local society. Roads were rare until the colonial administration constructed a few, mainly for strategic reasons (M.H., 1838). Traces of the colonial period can particularly be found in the hydrological infrastructure, such as canals and bridges. However, historical colonial buildings are barely present. The former colonial fort Tatas, for example, was demolished and today is the site of the city's main mosque (see Figure 15 for its location). A clearly defined or recognizable historic inner city is lacking in Banjarmasin. Its historic urban landscape is mainly characterized by settlements concentrated along the rivers, canals, and streams in the city (Figure 6).

Banjarmasin's Riverine Settlements

Jan Poortenaar and Geertruida van Vladeracken's visit to Banjarmasin in the 1920s was not by chance. The city was promoted as the Venice of the East Indies and it was popular among travellers from Europe who wanted to experience Borneo's exotic way of life on the water. Villages located on or near the sea or rivers are a distinctive feature of settlements on the island. Appellations such as *kampong ayer* in Brunei and *kampung air* in Malaysia, both meaning 'water village,' are apt references to the water-related nature of the islands' settlements. The highest concentration of this type of village can be found in low-lying areas and on the estuaries of rivers in South and East Kalimantan (Evers, 2015). In Indonesia, they are often named *kampung tepi sungai*, which can best be translated as 'kampong by the river.'

Banjarmasin's river-related urban landscape is unique in its scale and appearance. An urban riverine settlement in Banjarmasin could involve market, industrial, or residential sites, the latter to be seen as riverine kampongs. These sites mainly arose at cultural and religious sites and commercial areas near the river. Anticipation of geo-physical conditions, as well as floods and wild animals, plays a decisive role in the design of the local vernacular architecture (Evers, 2015). Houses on stilts create elevated living spaces above the muddy and regularly flooded ground. Structures are often row-built, and local wood is used as the building material. The building typology of dwellings can be classified as riverbank houses, stilt houses, or floating houses (Figure 7), accompanied by facilities such as walkways, docks, and latrines. Floating houses are called *lanting* which often functioned as shops or storage units in the past (Mentayani et al., 2019).

FIGURE 7 Building typology of riverine houses | Stilt houses and a floating house (left) at the junction between the Martapura and the Kuin rivers.

FIGURE 8 Green character of a kampong | Streetscape of Kampung Sungai Jingah, past and present, as assessed during the workshop. Copyright 2019 by M. N. Al Syahrin, A. Halim, K. Hanifati, I. M. P.D. Natawiguna, R. Rafsanjani.

Each riverine settlement has a unique urban character and cultural signature (Damayanti et al., 2020). Historic sites are mostly concentrated along the Martapura river and the Kuin river. The latter is a tributary of the former and flows towards the Barito, where one of the famous floating markets is located. Around Kuin river one can find ancient mosques, other places of worship, burial sites, and riverine kampongs with vernacular architecture. The old market, Pasar Lama, is located near the junction of the Kuin and the Martapura rivers (Figure 10; Figure 15; Figure 28) and is a lively trading area.

Several kampongs specialize in making Sasirangan, a type of local resist-dye fabric (*batik)*. Kampung Sungai Jingah (Figure 8; Figure 15; Figure 28) was a residential area for the local trading elite and has eminent heritage features, such as ornamental wooden architecture and religious sites. This kampong also managed to maintain its original green character to some extent (Figure 8). There is also a Kampung Arab nearby which has a goat market run by Yemeni people. The Chinese settlement is characterized by a temple, and further downstream one can find an old rice market at the mouth of the Kelayan river near Kampung Kelayan (Figure 9; Figure 15; Figure 18; Figure 19). These are just a few examples of the city's historic urban landscape, which consists of tangible and intangible heritage features.

FIGURE 9 Riverfront of the old rice market | Riverfront of the old rice market, alongside the Kelayan river, displaying vernacular architecture features.

General Challenges

Banjarmasin has expanded rapidly over the last twenty years. It has nearly doubled in terms of its built area, and new residential areas have been constructed on land near main roads on the outskirts of the city. Traditional riverine settlements and their residents were often 'forgotten' in terms of policy making and urban planning. Canals were filled and several kampongs were removed to make way for new urban development projects. At the same time, the access to and orientation of built structures in riverine settlements have been refocused on land (Figure 10). Banjarmasin is gradually changing from a river-based to a land-based city (Subiyakto, 2004, as cited in Damayanti & Spek, 2015).

FIGURE 10 Changing focus of riverine settlements | Pasar Lama's alleys connecting the market streets with the river are barely used anymore.

After years of neglect and lack of adequate management, urban degeneration in riverine settlements has become a severe problem. Although bathing and washing in the river is a common sight, poor sanitation and pollution are major issues (Figure 11; Figure 12). Many residents see the river as a place for the disposal of waste and as 'empty land' to be built on (Mentayani et al., 2019). Moreover, building on the water is not formally incorporated into the planning system. This diminishes the government's ability to implement adequate management activities. Squatting – building activity without legal permits – is a frequent phenomenon of Indonesia's kampongs. A rough estimate suggested Banjarmasin already excelled in this, compared with other cities, in the 1950s (Colombijn, 2014).

FIGURE 11 Pollution of the river | Waste disposal is omnipresent in many riverine settlements.

FIGURE 12 Sanitation on the river | Public toilet on stilts.

Many people mistakenly assume every urban kampong is a slum. Academic perspectives differ by realizing most urban kampongs should be seen as traditional urban districts with socio-economic significance (Martokusumo, 2002). Nevertheless, illegally built houses and extensions, combined with pollution and the lack of maintenance and proper facilities, are gradually transforming urban kampongs into unattractive places in which to live and work. Additionally, in a river city such as Banjarmasin, squatting results in the disappearance of open areas along the riverbank once used as public places for social interaction and piers for those travelling by boat. Traditional stilt and floating houses are often found in a poor structural condition and the latter are even becoming extinct.

Change of mindset

Although the river is increasingly losing ground as a key asset of the city, the city government, various NGOs, universities, and private companies want to change this. Banjarmasin produced a *City Visioning Profile*, Cities Development Strategies (CDS), which includes reducing pollution, poverty reduction, water management, leveraging existing cultural assets and tourism development (UN-HABITAT, 2012). The city's ambition also encompasses kampong improvement, the establishment of a central water authority and a water management plan for the rivers to tackle pollution - which begins upstream - and flooding.

FIGURE 13 Floating market | Floating markets, such as this market - Lok Baintan - located upstream of the Martapura river, rely on tourism as an additional source of income nowadays.

FIGURE 14 Kampong improvement project | One of the riverside kampongs - Kampung Biru - that underwent physical improvement or 'beautification.'

A project to develop the tourism potential of the declining floating markets in the city and the surrounding area was recently implemented (Figure 13), in a way that benefits the fruit sellers and improves the conditions they work in. Raising awareness among residents about the impact of garbage disposal and even a form of social blaming by putting pictures of 'perpetrators' on social media, have reduced pollution to some extent. A few riverine kampongs have undergone physical and sanitation improvements, while the Green Kampong project provided additional vegetation in pots and painted the first row of houses alongside the river green or blue (Figure 14). The latter could best be described as a form of 'beautification,' rather than a sustainable solution.

Although progress has been made in the last few years, the process of urban degeneration has not yet reversed itself. Several other projects and activities are being prepared to safeguard Banjarmasin's unique river-related urban character. Within this scope, the Mayor of the City of Banjarmasin requested the Cultural Heritage Agency of the Netherlands to participate in a workshop. Cooperation was solicited based on the Shared Cultural Heritage Programme of the Netherlands, which is part of the international cultural policy of

the Dutch Ministries of Foreign Affairs and of Education, Culture and Science. Inner-city revitalization is one of the focus areas of this Programme.

Workshop and participation process

Given Banjarmasin's challenges and ambitions in the field of historic urban landscapes, the HUL Quick Scan was considered suitable for application in the workshop. The workshop was held from 28th October to 2nd November 2019 in Banjarmasin. It was organized by the Municipality of Banjarmasin in collaboration with the Dutch organizations of Heritage *hands-on* and the Cultural Heritage Agency, and the Indonesian institutions of the University of Lambung Mangkurat, Bogor Institute of Agriculture (IPB), and the University of Trisakti. Twenty-one students and young professionals from Banjarmasin and other cities in Indonesia participated.

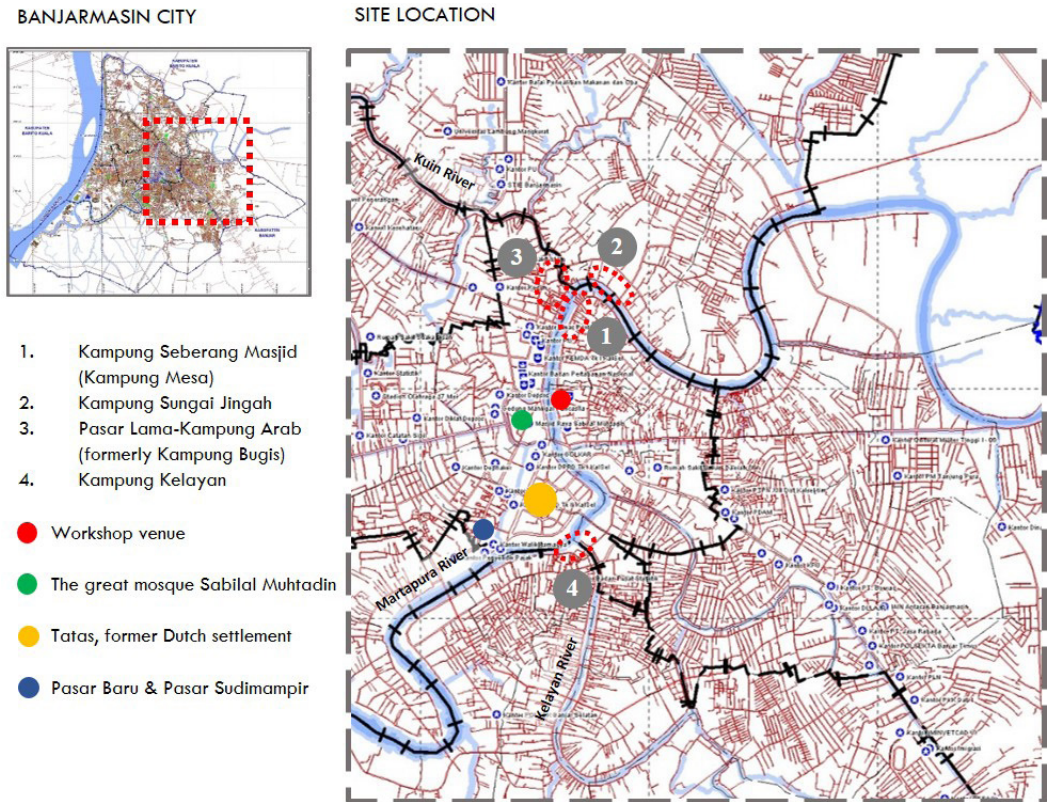

FIGURE 15 Selected study areas | Location of the selected study areas. Copyright 2009 by BAPPEKO Banjarmasin, adapted by V.D. Damayanti in 2019.

In order to accomplish an integrated approach, participants with various academic backgrounds, ranging from architecture, landscape architecture, urban design, socio-political science to tourism, were selected. Because a week-long workshop is very brief and the city is quite large, four sites were selected as study areas: Kampung Seberang Masjid, Kampung Sungai Jingah, Pasar Lama-Kampung Arab, and Kampung Kelayan (Figure 15). These sites were considered to adequately reflect the wide variety of Banjarmasin's historic urban landscape. Participants were divided into four groups, each covering one of the selected sites and following the method separately, without losing sight of the broader city level.

FIGURE 16 Field surveys by boat | Field surveys by boat were essential in experiencing the river culture and - if the occasion arose - interviewing residents

FIGURE 17 Stakeholder meeting | Discussing the preliminary result with university experts, state-owned companies, government agencies, Bank Indonesia and NGOs during a stakeholder meeting.

Experts, stakeholders, and the local community were involved on various occasions in different ways. Participants in the workshop were instructed to interview local people during field visits in order to learn more about their background, stories, experiences, and needs (Figure 16). The Mayor of Banjarmasin elaborated on his ideas at the start of the workshop and excursions were organized to learn more about the municipality's projects in riverine settlements. In addition, experts from Banjarmasin's University of Lambung Mangkurat gave presentations on the city's history, historic urban fabric, and distinctive architectural heritage features. A young creative entrepreneur, owner of local coffee shop Kota Lama Koffie (Old Town Coffee), was invited to share his experience of working in a district in need of revitalization.

Halfway through the week, a consultation meeting with the university and local and provincial government and other stakeholders was organized to receive feedback on the first results of the workshop (Figure 17). The Green Community Forum (FKH), a NGO engaged in greening the city, and the local division of Bank Indonesia, Indonesia's central bank which invests in socio-economic projects, joined this meeting. The final presentation took place at the venue of the workshop, which was centrally located near the river. Mainstream and social media, as well as a small travelling exhibition, contributed to public dissemination of the workshop results.

Outcomes of the Workshop

The following summary gives insight into the group's proposals and how input from the local community, the local government, and university experts was incorporated.

River-related housing

Almost all of the groups proposed the reorganization of the riverfront to improve living conditions and create proper housing inspired by the historical layout and existing built character of the settlements. The proposal for Kampung Kelayan is the most interesting in this regard. The local government had recently demolished densely built stilt houses on the riverbank of the kampong. Only a few traditional houses that once belonged to Chinese merchants, and a culturally significant building that houses a Keris collection

(traditional ceremonial dagger) were spared. At the same time, a low-budget apartment building had been built to alleviate local housing needs. Workshop participants spoke with a few residents of the new building and it is not very popular; the accommodation space is limited and the rent too high, and people are leaving, preferring to live in riverine dwellings elsewhere. The five-storey pitched roof apartment building is alien to its urban context and does not fit the lifestyle of its residents.

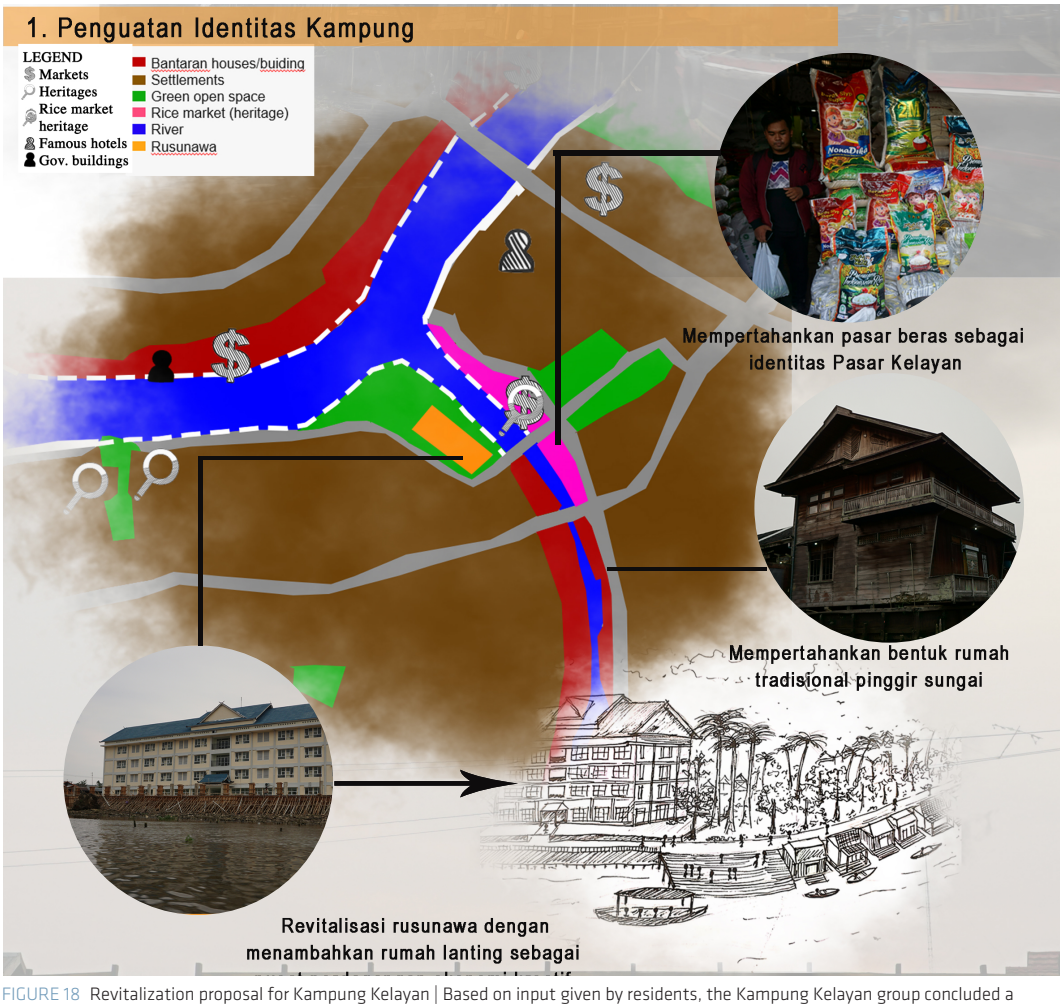

FIGURE 18 Revitalization proposal for Kampung Kelayan | Based on input given by residents, the Kampung Kelayan group concluded a new apartment building (bottom left) does not fit their social needs and river lifestyle. They proposed a concept (bottom right) integrating the building in a setting more in line with historic urban riverine principles. Copyright 2019 by I. D. Imara, N. M. P. Indriyani, T. Karina A. Luthfiana, R. Maulana, P. Saraswati.

Therefore, the Kelayan workshop group wanted to preserve the culture of the river lifestyle, provide proper housing, and meet the social needs of the residents. They designed a green setting for the new apartment building, which would involve planting local *nyiur* (coconut) trees and reintroducing the kampong's character. They also planned the conservation of historic houses and the addition of new houses that in scale, form, and building design would follow traditional riverine kampong features and by doing so, the customs of the inhabitants (Figure 18). Research projects of the University of Lambung Mangkurat - presented at the start of the workshop - with a similar design concept served as a source of inspiration in this matter.

Vital market areas

The Kelayan group also focused on the old rice market in their study area. This market is a crossroads between the rice fields in the hinterland - only reachable by water - and the city. The government planned to demolish it. Experts pointed out the cultural value of the market, due to its built heritage features and because the old market is a vital element for the identity of the riverine settlement. After consulting market vendors (Figure 19), participants of the Kelayan workshop group concluded the market also holds socio-economic significance for the local community, since it is part of a locally-based agricultural production chain on which many families rely. Hence, the group proposed to safeguard the market and additionally develop it as a tourist spot, connecting it to a public transport network (Figure 26) and making it more accessible from the riverside for vendors, customers, and tourists.

FIGURE 19 Consulting market vendors by workshop participants | Participants interviewed vendors at the old rice market alongside the Kelayan river and discovered the socio-economic significance of the site, which is related to an agricultural production chain in the hinterland.

The workshop group responsible for Pasar Lama area designed a revitalization plan for their riverine market area. Pasar Lama was built as a market by the colonial administration but its design is now barely recognizable due to uncontrolled building activity. Its connection with the river has diminished over the years. Interviews with vendors and input given by the government and experts made clear that the market is losing its relevance to modern markets that are becoming the centre of economic activity. Furthermore, the group concluded the area suffers from traffic jams, poor living conditions, and poor waste disposal possibilities. They thus suggested that the economic position of the market in the city of Banjarmasin be strengthened, by rehabilitating the original design, developing public transport by boat and accessibility by land and the river, accompanied by a customized waste management system (Figure 20). Additionally, the group created an implementation strategy taking the social context into account and focussing on community engagement.

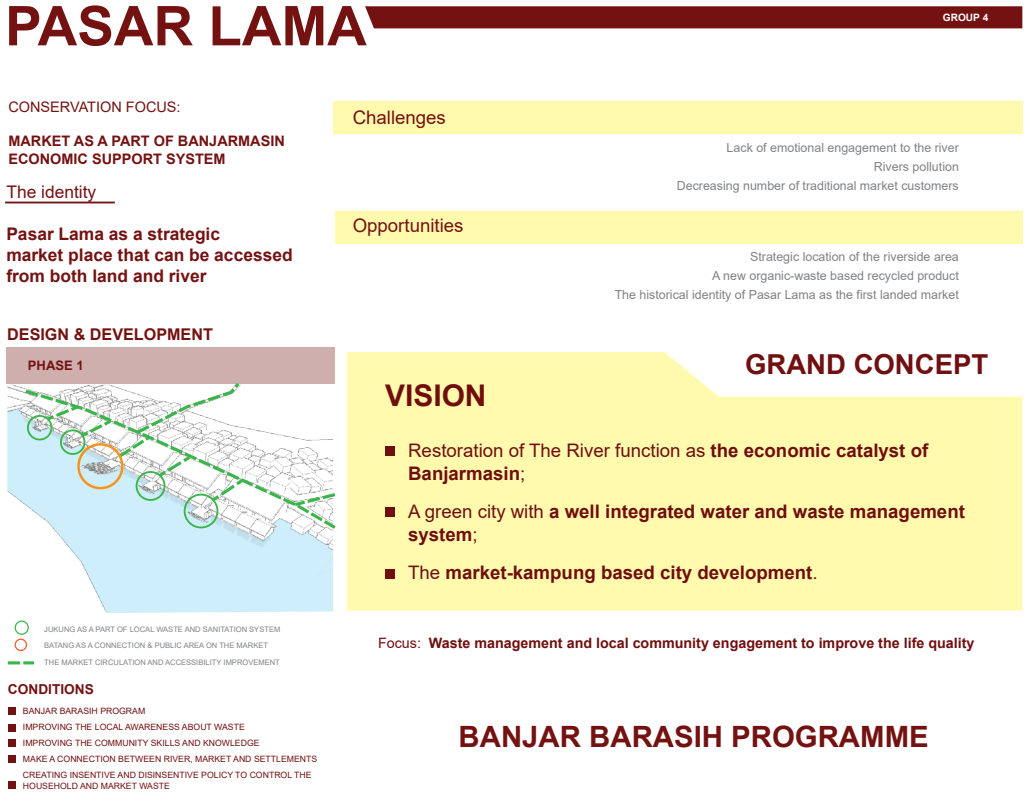

FIGURE 20 Revitalization proposal for the Pasar Lama market | After consulting vendors and experts, the Pasar Lama group aimed to restore the Pasar Lama market as an economic catalyst, improving quality of life and community engagement. Copyright 2019 by M. Anggun, N. F. Bakti, S. M. Hairini, P. A. Sancoyo, F. Wulandari.

Cultural traditions

The production of Sasirangan is widely practised in Kampung Seberang Masjid and one can find many shops selling this traditional Banjar type of *batik*. During field visits, the workshop group focussing on this kampong found that the younger generation in the Sasirangan families is not eager to step in. The Sasirangan production process is highly polluting. Moreover, as the population grew, squatting began to fill the open spaces and today this riverine kampong has a slum-like appearance. Garbage and waste gathering underneath stilt houses and around *lanting* has only contributed to this effect.

Becoming aware of this, the Seberang Masjid group's goal was to restore the ecosystem, preserve Sasirangan as an intangible heritage asset, engage the younger generation and introduce a sustainable form of waste management. The Sasirangan families gave relevant input to unravel the production process (Figure 21). After gaining a better understanding of the waste component they suggested that a Sasirangan workshop centre for the families should be created that would feature a green waste disposal regime, such as an aqua biofilter (Figure 22). Furthermore, they proposed to put nets along the riverbanks to prevent garbage from entering the river, accompanied by a routine community service programme to clean the area under the stilt houses. To enhance a sense of identity, houses could be painted with Sasirangan patterns.

FIGURE 21 Production process of Sasirangan | The Kampung Seberang Masjid group explored the production of Sasirangan with local producers and learned that polluted waste water of the colouring process (nr. 5) ends up into the river. Copyright 2019 by K. Y. Farhana, M. J. Izzati, D. D. Paramita, D. L. Pardomuan, A. Rahman.

FIGURE 22 Proposal for a Sasirangan workshop centre | Proposal for a workshop centre, featuring a green waste disposal regime, as a showcase for an environmentally friendly production of Sasirangan. Copyright 2019 by K. Y. Farhana, M. J. Izzati, D. D. Paramita, D. L. Pardomuan, A. Rahman.

River-culture tourism

The Seberang Masjid group also suggested that *lanting*, unfit for housing according to present-day standards, could become cafes, providing the local community with additional means of earning a living and could engage a younger generation in staying committed to the area.

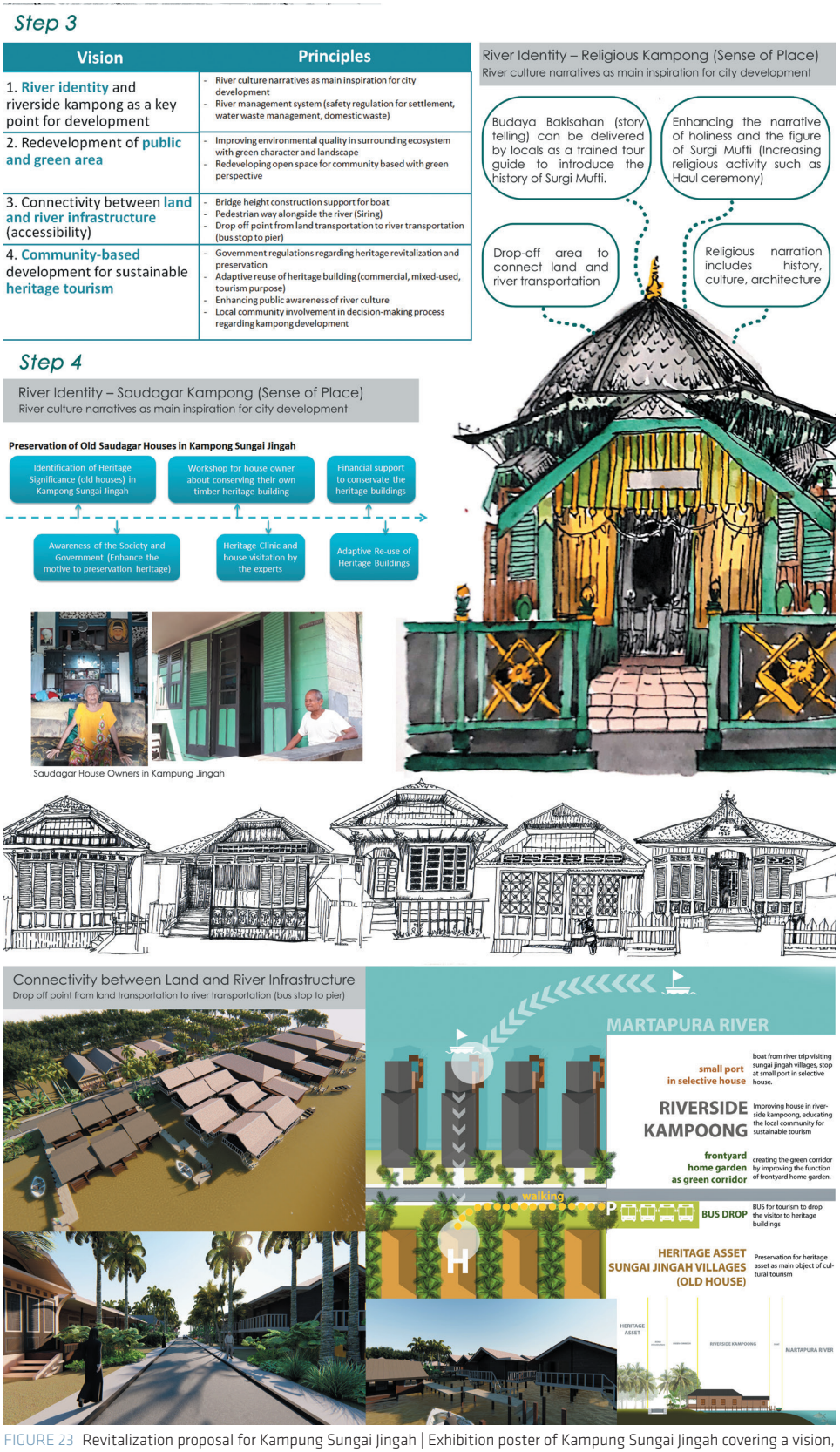

FIGURE 23 Revitalization proposal for Kampung Sungai Jingah | Exhibition poster of Kampung Sungai Jingah covering a vision, principles for conservation and development, and formulating future perspective focussing on the kampong's river identity. Copyright 2019 by M. N. Al Syahrin, A. Halim, K. Hanifati, I. M. P.D. Natawiguna, R. Rafsanjani.

One of the most advanced proposals for cultural tourism came from the group covering Kampung Sungai Jingah. This kampong is considered to be a historic district by experts and the local community, mainly due to its merchant history, cultural traditions, traditional architecture, and religious sites. However, the participants learned that public awareness among residents regarding the river culture is limited, the area's green character is diminishing, buildings are decaying and environmental problems are evident. The Sungai Jingah group developed a vision to change this situation and elaborated particularly on reviving the kampong's river identity (Figure 23) and community-based, sustainable heritage tourism.

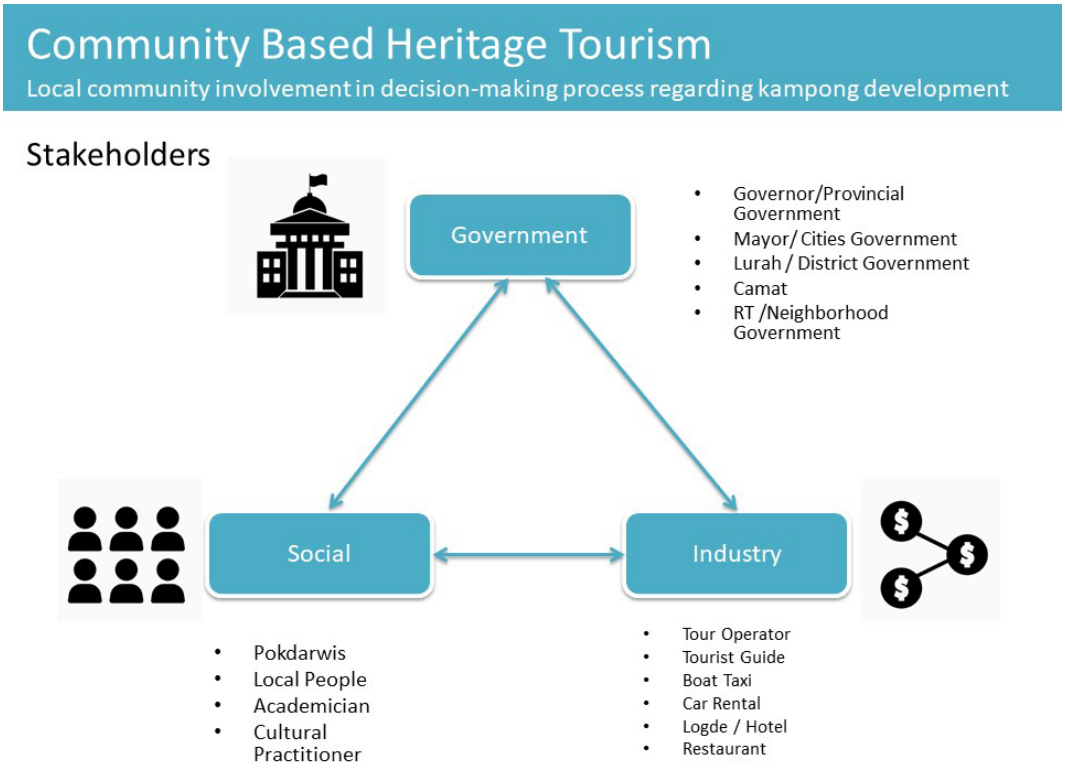

FIGURE 24 Proposal for community-based heritage tourism | Inspired by heritage-minded residents the Kampung Sungai Jingah group developed a community-based proposal for heritage tourism in the area. Copyright 2019 by M. N. Al Syahrin, A. Halim, K. Hanifati, I. M. P.D. Natawiguna, R. Rafsanjani.

Their objective was to create a kampong where the local community could learn more about their history and experience it. The kampong community should play a key role as a stakeholder in the development of heritage tourism, as part of a partnership with organizations in the field of tourism, universities, NGOs, and the local government (Figure 24). These ideas came about after speaking with a few residents who are extremely committed to preserving the kampongs' impressive heritage buildings, but are not in a position, and lack means, to contribute individually. The Sungai Jingah group developed a strategy focused on raising public awareness about heritage assets first, before turning to conservation or adaptive reuse of historic buildings and improving environmental quality. This will be achieved through workshops, a heritage clinic and the empowerment of local people who are already committed.

River-based infrastructure

By consulting the local government and interviewing residents, the participants of the workshop found out there is a severe lack of proper river transport facilities. Public transport by boat and in many cases

necessary docks, are absent. The city's river infrastructure and an adequate public river transport system remain underdeveloped (Figure 25). Furthermore, options are limited because bridges are not high enough for modern boats to pass under. Several workshop proposals suggested that the height of bridges be adapted, that a pedestrian pathway be built alongside the river (*siring*) and that (public) transport by river be accommodated.

FIGURE 25 River transport system | Privately owned boats used for transportation are often overcrowded.

FIGURE 26 Proposal for transport and tourist routes | Conservation and development of the old rice market (nr. 1 on the map) and other historic assets related to rice, connected by a public and touristic water-based transport system. Copyright 2019 by I. D. Imara, N. M. P. Indriyani, T. Karina A. Luthfiana, R. Maulana, P. Saraswati.

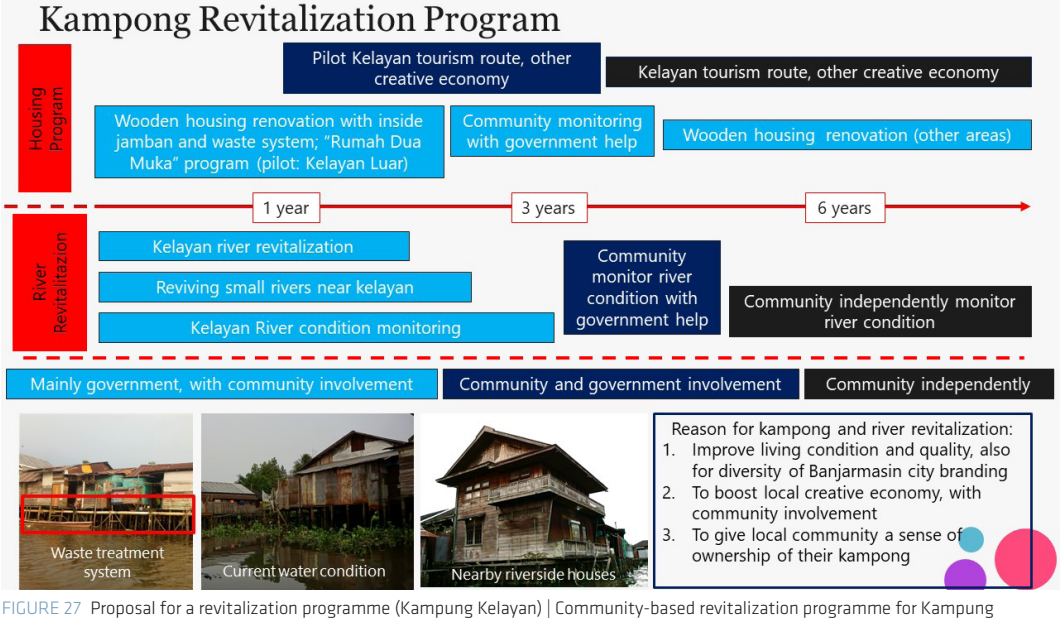

FIGURE 27 Proposal for a revitalization programme (Kampung Kelayan) | Community-based revitalization programme for Kampung Kelayan. Copyright 2019 by I. D. Imara, N. M. P. Indriyani, T. Karina A. Luthfiana, R. Maulana, P. Saraswati.

Connecting historic riverine settlements through a network of public and tourist transport could provide new incentives. The Kampung Kelayan group wanted to introduce such a network as an engine for socio-economic development and rehabilitation of the degraded riverine settlements along the entire Kelayan river, and benefiting families engaged in the agricultural production chain of rice. Cheap public transport and tourist routes with hotspots – a craft market, rice fields, a historic centre of rice production, the old

rice mill, the old rice market – were some of the ingredients in their proposal (Figure 26). The Kelayan group developed a community-based Kampong Revitalization Programme as an overall implementation strategy (Figure 27).

The Pasar Lama group aimed to revive historical river-based infrastructure in order to provide better socio-economic conditions for their market area and its vendors, as the latter pointed out there is a need for it. The group suggested restoring the *batang* and reintroducing *jukung* to connect the market area with the river again (Figure 28). *Batang* are wooden platforms on stilts, which were traditionally used as toilets, for washing, loading goods, and interaction with traders. They also served as docking sites for transportation by *jukung*, which were small traditional boats. Reviving these historical elements will improve accessibility which would benefit vendors' activities and might attract new visitors. Environmental management should also be integrated; for example, every *jukung* should be fitted with a simple water filtration system. Furthermore, the group wanted to reconstruct the old drawbridge that once dominated the urban landscape at the junction between the Martapura and Kuin rivers (Figure 28). This would make the historic kampong alongside the Kuin river more accessible to boats because the present bridge is very low, and it would foster potential interest as an icon of the Pasar Lama area.

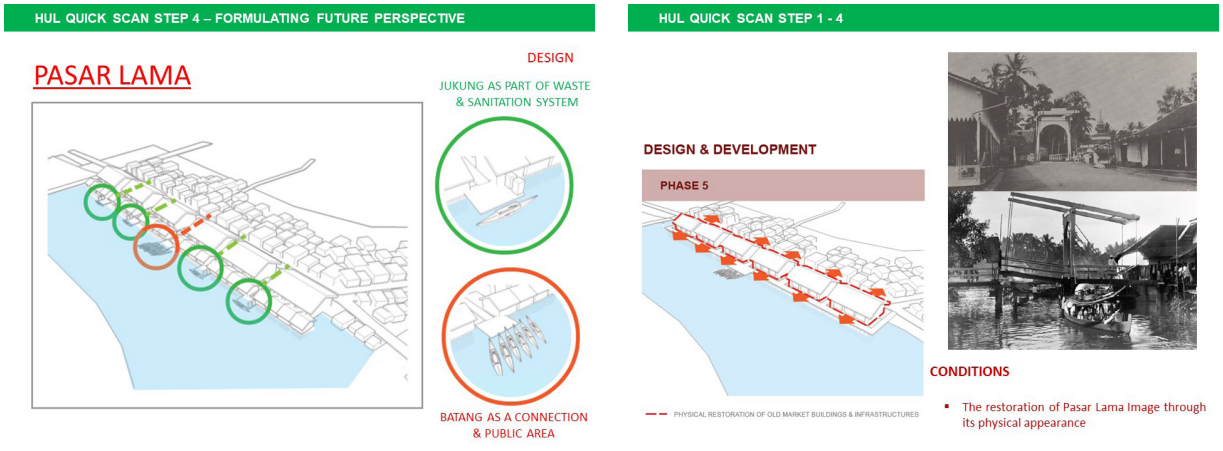

FIGURE 28 Proposals to revitalize the Pasar Lama market | The Pasar Lama group proposed using batang and jukung, and reintroducing the former drawbridge landmark, to revitalize the old market. This could contribute to better socio-economic conditions which, according to vendors, is very much needed. Copyright 2019 by M. Anggun, N. F. Bakti, S. M. Hairini, P. A. Sancoyo, F. Wulandari.

Effects of Participation

The proposals of the participants emphasize that Banjarmasin's river-related cultural heritage can serve as an asset for the future development of the city. Accommodating traditional ways of river-related living and building, in accordance with contemporary needs and at the same time meeting social and environmental demands, are crucial in this account (Damayanti et al., 2020). The workshop demonstrated that interaction of the participants with the government, experts, and residents contributed to a large degree in understanding Banjarmasin's river-related culture and heritage, the social and socio-economic needs of its residents, and the conditions and challenges present. Community involvement also seemed to inspire participants to propose community-based proposals and created a sense of urgency in delivering integrated and hands-on suggestions that follow citizen's needs and their culture.

In Banjarmasin, the government and stakeholders are more aware now of the importance of community participation in the planning process. Furthermore, several involved organizations in Banjarmasin did not cooperate before the workshop, but the workshop brought them together and encouraged them to start working together. Local participants in the workshop are establishing a heritage society, supported by a Banjarmasin Urban Heritage Team that was set up by the Culture and Tourism Office of the City of Banjarmasin. This team works closely with stakeholders and the local university, all of whom had little contact before the workshop. As a result, the workshop connected organizations and people who were passionate about Banjarmasin's heritage and, above all, eager to contribute to ensuring that river remains the essence of the city.

Limitations and Considerations

Considering the many topics that need to be addressed and stakeholders to involve, certain limitations exist for a Quick Scan. Understanding the site and anticipating eminent present-day environmental issues in a short period of time, for example, required much effort. As a result, long term threats such as climate change disappeared into the background. Questions can also be raised on how to strategically address relevant themes on a policy level. If the river narrative is the 'essence' of Banjarmasin, environmental issues that severely affect this essence might have been given more attention as a primary objective. Limitations also appeared in terms of participation range. More focus should have been given, prior to the workshop, to determining which disciplines of students and professionals, and which stakeholders to involve - and why. For example, kampong leaders could have been involved more intensively, given the fact they play an important social role in the kampong's society.

The HUL Quick Scan method is in its experimental phase and the Banjarmasin workshop provided valuable input for improvements to make. At the same time, the workshop has revealed several leads in concluding that the method of working could be useful in achieving participatory revitalization of urban riverine settlements. Solidly based in the field of cultural heritage, it contributed to a profound understanding of river narratives and underlying mechanisms of how riverine settlements functioned and function, and are valued today. This is of paramount significance in realizing revitalization projects that will work. By connecting to the city's cultural identity and continuation of the resident's appreciated river-related way of living, the workshop also invoked public awareness and commitment to participate among public and private stakeholders. In particular, local experts and other actors operating in the cultural heritage field are directly engaged now. The method of working could thus unlock potential human capital in achieving participatory revitalization of urban riverine sites.

Conclusion

Banjarmasin's urban riverine settlements represent a water-related narrative which is characterized by social interaction, economic activity, infrastructure, building traditions, and intangible heritage. Concurrently, these settlements face many challenges and the continued existence of their narrative is not self-evident. The outcomes of the HUL Quick Scan workshop focussed on revitalization by accommodating and modernizing the city's traditional river-related way of living and building. Although still in its infancy and with much to improve, the method of working revealed potential in the field of participatory revitalization of urban riverine settlements, in particular, in terms of embracing a river culture and cultural heritage as key

assets. Community participation and interaction with heritage experts provided a profound understanding of the riverine sites and resident's socio-cultural and socio-economic needs, which substantially contributed to the workshop's outcomes. Moreover, the workshop encouraged local stakeholders and actors in the field of cultural heritage to become actively engaged in accomplishing participatory revitalization.

Acknowledgements

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Rising above surface

Comparative Review of Xinghua Duotian and Chinampas Water Systems

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Abstract

The present research aims to explore a method of landscape reading and analysis through traditional water systems. Throughout the collection of local knowledge about water management in two opposite parts of the world it is possible to learn how natural resources have been used in local communities for hundreds of years to generate resilient, circular and multi-functional water and land management. In order to create a base knowledge to provide lessons for today's urban challenges, we have analyzed two traditional water systems: The Xinghua Duotian agro system in China and the Chinampas floating gardens in Mexico. Through a systematic collection of data and generation of comparative drawings, maps and diagrams, we were able to understand the logic behind the water management and to extrapolate possible design and strategic principles to be applied in present landscape and urban design. To achieve the proposed objectives, the 'illustrative method' (Bobbink and Ruy, 2017) was used. The illustrative method is based on the form-layer method (Steenbergen et al. 2008), which is used as an analytical tool to comprehend the relation between landscape interventions and its site based in 4 basic layers: basic form, program form, image form, and special form (Bobbink, 2019). During the research process, the method was adapted in order to analyze the specific cultural landscapes used as case studies (Xinghua Duotian and Chinampas). Because the form-layer method has been developed for landscape architectonic design we found it necessary to extend the analysis in further layers to reveal other landscape values such as use, maintenance and the circularity of human made traditional water systems (Bobbink, 2019). From the analysis of both water systems, we could extract two main lessons that can help us to design and plan more resilient and sustainable cities. Firstly, the possibility of designing a method of settlement and urban expansion based on natural principles where circularity is a key element to generate a sustainable way of extraction and restoration of natural resources. And secondly, that specific landscape identities, such as wetland and lakes, can be a provider of multi-functional development for cities where agriculture, economy, urban expansion and ecology are part of the similar network. Using these principles that are the basis of the analyzed water systems, we can come back to a more sustainable, circular and multi-functional way of using our natural resources.

Keywords

Traditional water system, irrigation, drainage, floating farmland, circularity, sustainable living, agriculture

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Introduction

FIGURE 1 Xinghua

FIGURE 2 Chinampas

Since ancient times, civilizations all over the world have transformed their immediate surroundings to create more suitable conditions in which to settle. One of the most important natural elements that humans have transformed since the beginning of cultures is water bodies and their corresponding flows, transforming them into controlled water systems according to the geographical conditions (Scarborough, 2009).

These landscape transformations can be understood as a comprehensive method of appropriation and adaptation to a new context in order to change the existing situation into a new cultural landscape. Furthermore, we can read these human-nature interactions as a source of knowledge to get a deeper insight into what we can learn from these vernacular interventions and how we can apply their water management principles for today's challenges.

In this context, the present research aims to understand the relationship between two similar traditional water systems developed over a thousand years ago in opposite parts of the world: The Xinghua Duotian Agrosystem in China and the Chinampas floating gardens in Mexico. This research is part of "the Circular Water Stories LAB," Landscape Architecture, TU Delft.

These waterworks are considered "traditional water systems" because they were developed by the local inhabitants as they mastered their own techniques by trial and error. By passing on the wisdom from generation to generation they created a common knowledge that with time became a tradition for the whole community.

The understanding of these water systems can give us a new insight into a different way of reading the landscape, where local knowledge offers us lessons about a more resilient, circular, and multi-functional approach for today's urban challenges.

To structure the following paper, we start with the definition of the methodology where we used a comparative chart as a guideline for the research. After the methodology chapter, we explain the existing landscape of both case studies to provide background information. In the next chapter, we developed a comparative review based on the following layers: landscape context, water system overview, development of the water system, circularity, and landscape value. Finally, from the research, we draw conclusions from which to point out some lessons for today's urban and landscape challenges.

Methodology

In different periods of time and different places in the world, various types of water systems have been developed by humans to allow them to live with water. We manage and transform the natural flow of water to be able to use, drain, retain, irrigate, and store the water (Bobbink, 2019). As part of "the Circular Water Stories LAB, TU Delft," we recognize the value of traditional water systems and we aim to understand and document that wisdom. Xinghua Duotian and Chinampas Water Systems are examples of case studies that represented an intriguing water system from different continents, which, surprisingly, share similar principles. Through comparing and contrasting the two cases, it is expected to generate insights into the landscape geomorphology, which determines the reason behind the operation of the two water systems. With this research, we want to understand what the key elements that make the water system successful are, and what lessons can be learned from developing the system. This understanding can later be used as inspiration and base information for the development of a more comprehensive and sustainable water management system.

In order to extrapolate possible design and strategic principles that can be applied in present landscape and urban planning, we used a comparative methodology of investigation. The research was conducted following an extensive analysis through a graphic-based strategy of drawing and diagramming in order to understand the logic behind the water management. Both case studies were analyzed under the same layer approach, producing a sequence of drawings to illustrate the general context, landscape condition, water system function, development of the water system, circularity, and landscape value (Table 1).

The analysis method used is an extended tool based on the form-layer method from Steenbergen et al. (2008). The extended method is called 'the illustrative method' (Bobbink & Ruy, 2017) and it consists of a layer analysis in order to understand the relationship of the water system to its landscape. These layers reveal the topographical relation with the water system, the structure and form of the intervention, the cultural expression of it, and its special experience, as well as the use, maintenance, and circularity of human-made traditional water systems in general.

The case studies are mapped according to this method. By evolving the drawings simultaneously, a set of thematic drawings and diagrams, flanked by one legend for both cases, is developed. During the process, the understanding of which layers (soil map, height maps, relief etc.) need to be combined to express the essence of the waterscape became clearer. (Bobbink, 2019).

Each set of drawings includes diagrams and drawings that represent: the climate zone; flow directions of the system; the water system drawn on the regional scale in relation to the topographical and soil map; and the development of the water system over a longer time period. Additionally, more technical drawings of the catchment area were developed to show the interaction between the water elements, water works, its ecology and use.

Once both study cases have been systematically documented under this same methodology, it is possible to compare them and discuss the values of the two traditional water systems for today's challenges.

Existing Landscape

FIGURE 3 Xinghua | Tourist routes (top left); Traditional way of watering vegetation (top middle left); Forest Zone at the border of the area (top middle right); The differences between raise field pattern and a traditional rice field (top right); Aerial view of the area and nearby settlement (bottom left); Atmosphere of in the area (bottom right)

Xinghua Duotian is a traditional water-land utilization system that has been used for more than three thousand years. It is located in Xinghua city of Jiangsu Province in China. It includes a total area of 31200 ha, covering five townships (The People's Government of Xinghua City, 2014). The following paper will primarily focus on the Duotian town since the agrosystem originated in this area.

The system was developed due to the natural condition of the area which was a flooded corridor. In the past, this area was a lagoon in which people were exposed to frequent floods and insufficient food resources. With the influence of the freshwater flow from the estuary and human intervention upstream, the area gradually transformed into a lake landscape. The former problematic area became a cultivable land with fertile soil underneath the lake (Yanying et al., 2014). With the wisdom of the local community, "raised fields" have been created to grow crops at uncertain water levels. This technique represents a sustainable way to adapt to the changes in local fluvial conditions, to tackle the threat of floods, and to meet the needs of a rapidly expanding population.

Similarly, in an opposite part of the world, another civilization developed a comparable water system called 'Chinampas' which expanded to around 150000 ha at its biggest development.

Chinampas, also known as 'floating gardens of Mexico' (Government of Mexico City, 2017), are an ancient Mesoamerican water system for agriculture and territorial expansion, located in the Valley of Mexico, an enclosed basin that once contained the bed of five now-extinct lakes (Scarborough, 2009). Because of the enclosed basin, mineralized sediments accumulated in the lakes which did not have a natural outlet for water to flow, leading to several floods in the area (Echeverría, 2009).

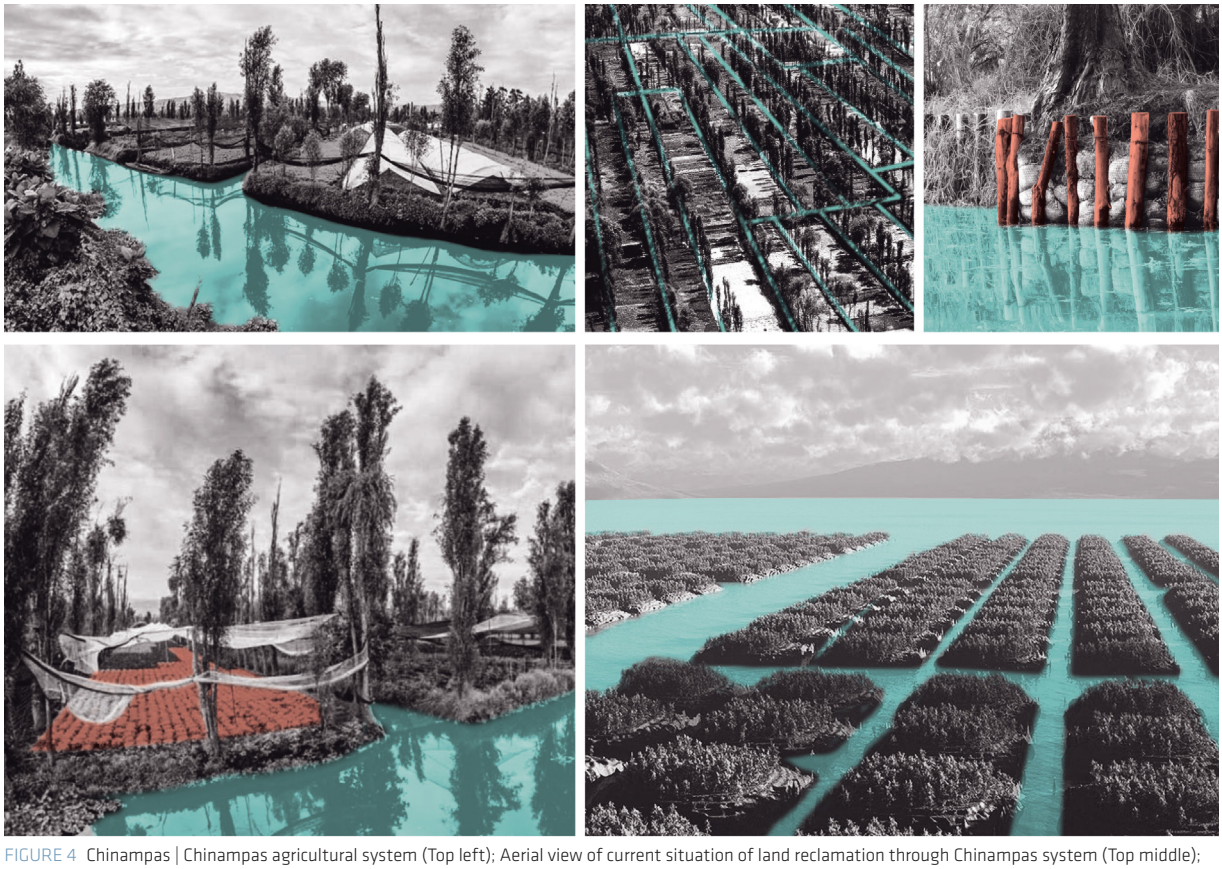

FIGURE 4 Chinampas | Chinampas agricultural system (Top left); Aerial view of current situation of land reclamation through Chinampas system (Top middle); Palisade: Detail of the construction of the fenced boundary of a Chinampa (Top right); Cultivation nurseries and channel system (Bottom left); Actual use and "reinvention" of the Chinampas water system (Bottom right))

The origin of Chinampas started with a main problem the Aztecs (original civilization of the valley of Mexico) had to face: a lack of land on which to expand their growing capital city of Tenochtitlan. Due to strategic and safety reasons, the Aztecs settled the capital city of their empire in the shallow waters of the Texcoco lake. However, with the empire's prosperity, the city needed to extend its immediate territory, which led the Aztecs to enlarge the parts of the island where the water was shallow enough to reclaim the land for urban and agricultural expansion (Gibson & Campos, 1967). Through a raft covered with soil, ancient Mexicans developed a method for territorial expansion and horticulture where they gradually expanded their territory into the water surface, thereby converting Tenochtitlan into a 'floating city.'

Finally, with the Spanish colonization, the former lake beds were drained to make the city safer, transforming the lacustrine landscape into a dry valley, resulting in the disappearance of a large extension of Chinampas.

Comparative Review

The Xinghua Duotian and Chinampas water systems were developed under similar geographical conditions. Both of them were located in lake floodplains with severe inundation events where the initial intention in each case was to reclaim land, though the purpose of land use was different.

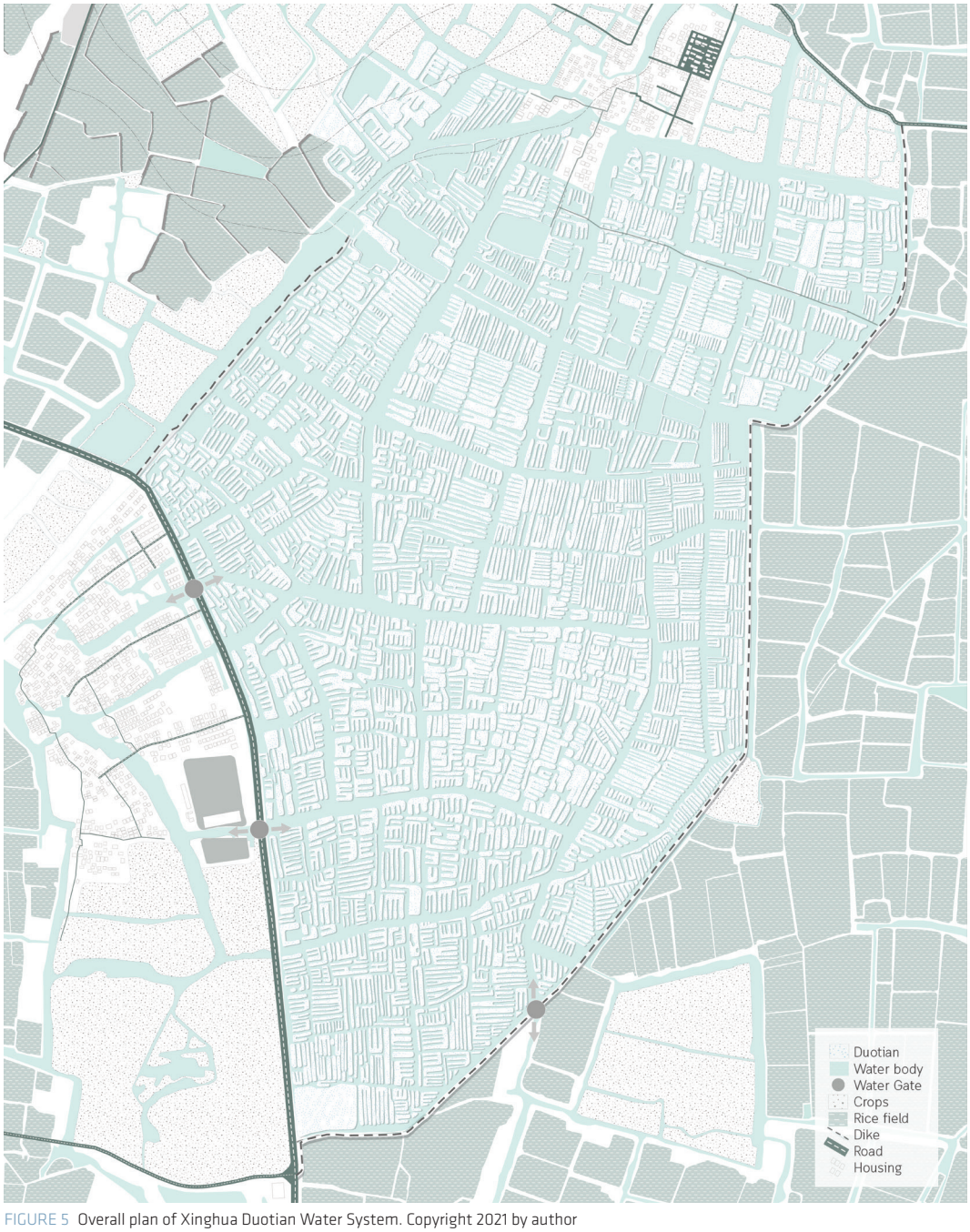

FIGURE 5 Overall plan of Xinghua Duotian Water System. Copyright 2021 by author

Xinghua is located in an area surrounded by major rivers that were used as an important commercial trade area (Yanying et al., 2014). The population rapidly overgrew, which led to massive food consumption. The land reclamation in Xinghua Duotian has been widely developed to allow for the growing of crops and vegetables under the pressure of food demand during periods of war (The People's Government of Xinghua City, 2014). On the other hand, in the case of Chinampas, the main challenge was that the 'floating city' of Tenochtitlan did not have enough room for all the inhabitants. The constructed islands were built to extend the housing area, as well as to support the wildlife for hunting and gathering (Scarborough, 2009). Nevertheless, due to pressure of war conflicts and land shortage, the two water systems were developed and extensively used for the same function, which was intensive food production to serve their growing population.

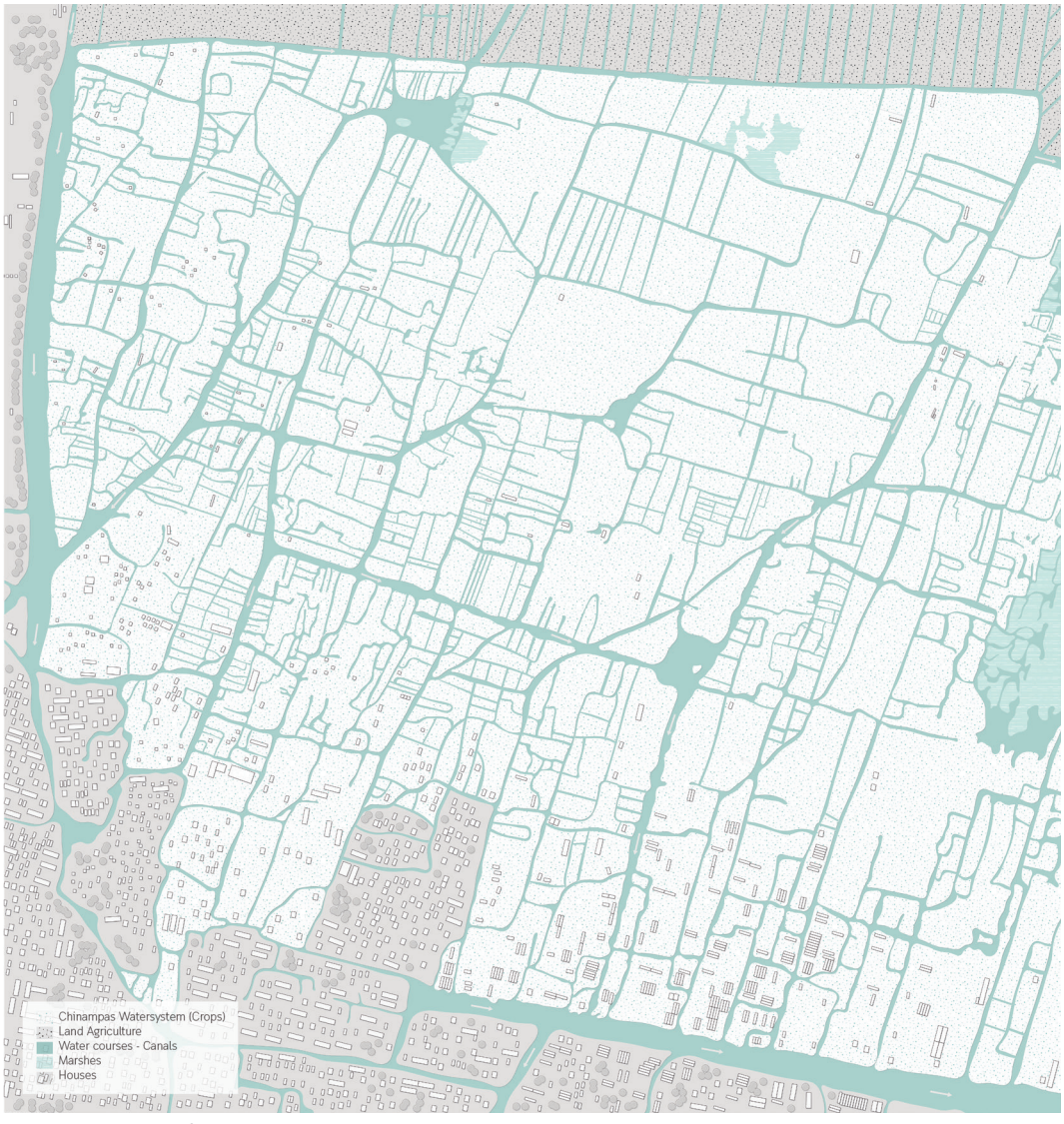

FIGURE 6 Overall plan of Chinampas Water System. Copyright 2021 by author

One of the most striking similarities appeared in how the two systems shared the same principles to build up the artificial islands. With different climate and landscape conditions, the local people managed to use the existing resources and create cultivable land above the water surface. The floating islands were created by stacking the shallow lake bed and fencing in a long rectangle shape with wattle (interlaced structure of branches). The fenced area was then layered up with mud and lake sediment. The essential similarity lies in the quality of soil from the lake bed and wetlands, which set the cultivable condition for the manmade islands. The natural sedimentation processes in the wetlands created fertile soil in which to grow crops and vegetables, where the top layer of the constructed islands consisted of topsoil with biodegradable material such as grass, leaves, and husks of different fruits and vegetables. After digging and stacking up the soil more than a hundred times, several floating islands were built and the new landscape pattern was created.

The two patterns appear to be similar due to the maintenance method: a network of channels connecting the islands is required to allow for a boat to reach them in order to keep refilling the top soil layers and manually irrigate the crops from the canoes. In the case of Chinampas, the irrigation system works mainly by capillarity due to the Salix bonplandiana tree roots that were used to fix the floating islands. (Gibson & Campos, 1967).

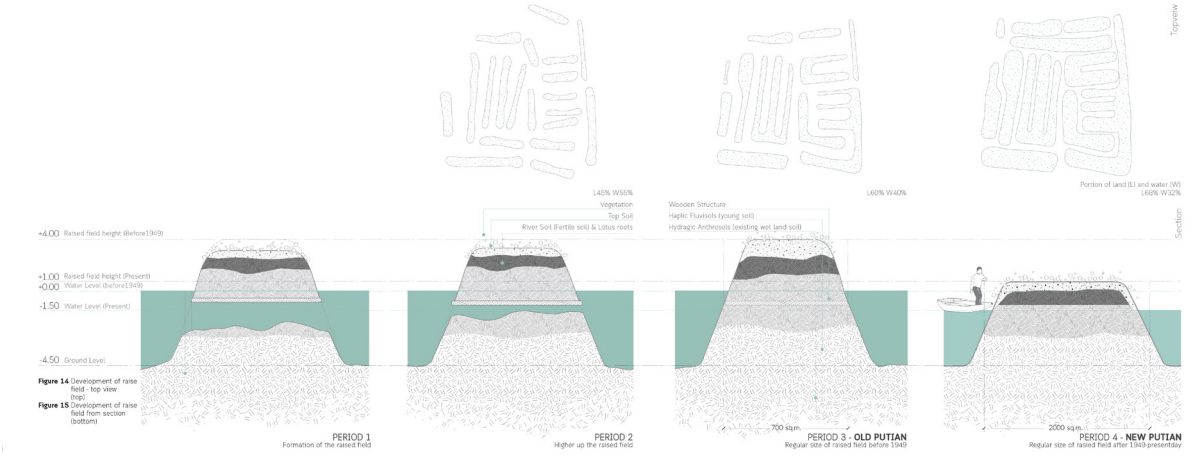

FIGURE 7 Detail plan and section through different period of time - Xinghua Duotian Water System. Copyright 2021 by author

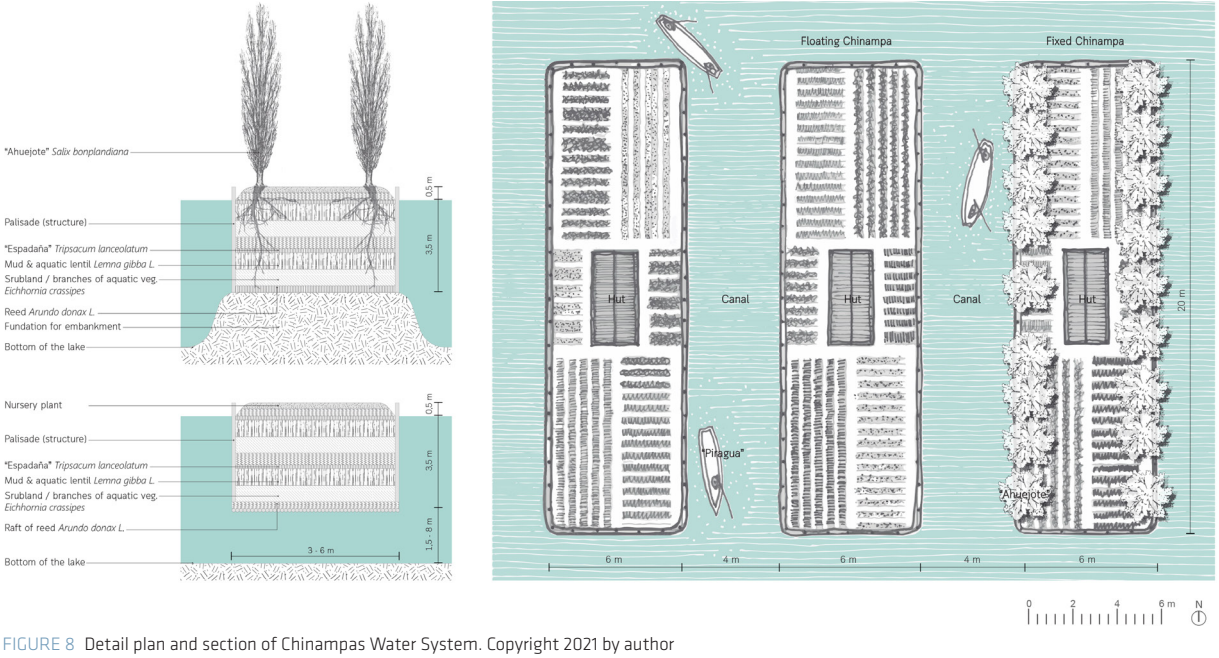

FIGURE 8 Detail plan and section of Chinampas Water System. Copyright 2021 by author

The main difference in the method of construction is the movability of the fields. In Xinghua, there is no definite evidence of the movability of the artificial islands, nor any anchor structure for the floating field. In the case of Chinampas, the crop plots were moved by the farmers when needed. The crop islands from Chinampas system changed from a movable system to a static one during the processes of Spanish colonization. The new tax system could not consider the moving island as "taxable land," so trees such as Salix bonplandiana and Taxodium mucronatum were planted at the corners to keep the island from moving (Alcántara, 2007). There is still no supporting evidence to show the benefit of movability. In general, the differences do not seem to be a fundamental matter since both crop islands have proven to produce a comparable number of agricultural products.

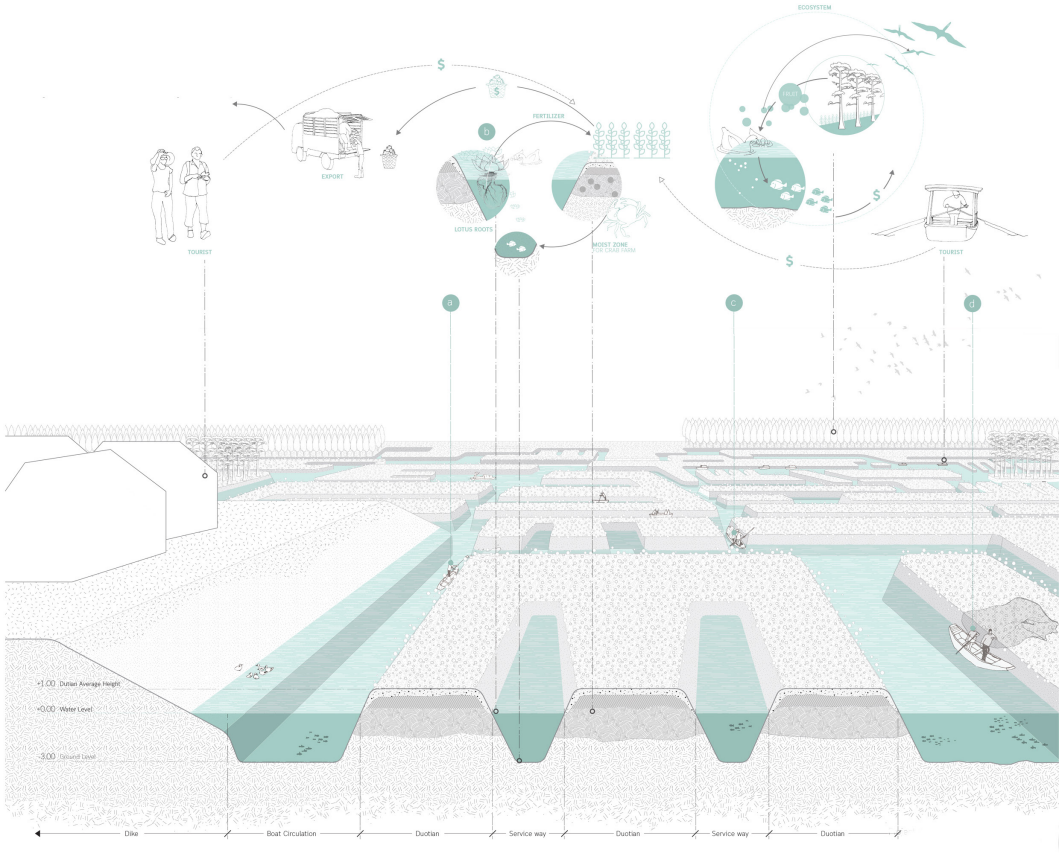

FIGURE 9 Xinghua | Circular economy of the system - representation of sustainability (top); Section perspective of the area showing the overall atmosphere (bottom). Both copyright 2021 by author

From a bigger perspective, both cases give us an insight into a sustainable and circular way of living based in cyclical farming and settlement processes. Resources are brought back into the natural circuit where roots, lake bottom mud, and organic waste from the previous harvest have been used and reused during each crop season. The use of organic matter in the construction of the agricultural system allows water to filter and soak the upper soil layers, generating natural irrigation, while at the same time the system helps to retain water through its filtration to the subsoil, avoiding erosion and subsidence. The entire traditional water management system became part of the whole natural structure that finally benefits residents and the environment.

In terms of landscape value, the two water systems are the remains of the former environment and a traditional way of understanding the natural surroundings, generating a cultural landscape that rescues the water qualities of the former water bodies. Both cases represent smart and functional uses of the existing landscape in order to achieve maximum profitability with minimum resources and infrastructure, by taking advantage of the natural wetlands that provide all the required resources to generate more efficient crops without using external sources of energy.

In addition, both water systems contribute to the landscape quality of the settlements, especially in modern times where urbanization has placed significant pressure on rural areas. Due to the development and maintenance of the crop fields, the lake water preserves its quality, preventing pollution and enhancing the biodiversity and ecosystems related to the lacustrine landscape. The mitigation of flooding events in case of periods of strong rainfall and improvement of the air quality (because of the protection of extensive areas of vegetation) are important landscape values that both systems have managed to maintain over time.

Moreover, the two systems also promoted human interaction with the landscape, which seems to be neglected in today's society. The way of living for local people has changed in line with urban developments and landscape conditions. For example, the use of boats and traditional agricultural tools have been adapted and reinvented. This adaptable condition has contributed to the preservation of identities through the revival of the agricultural system.

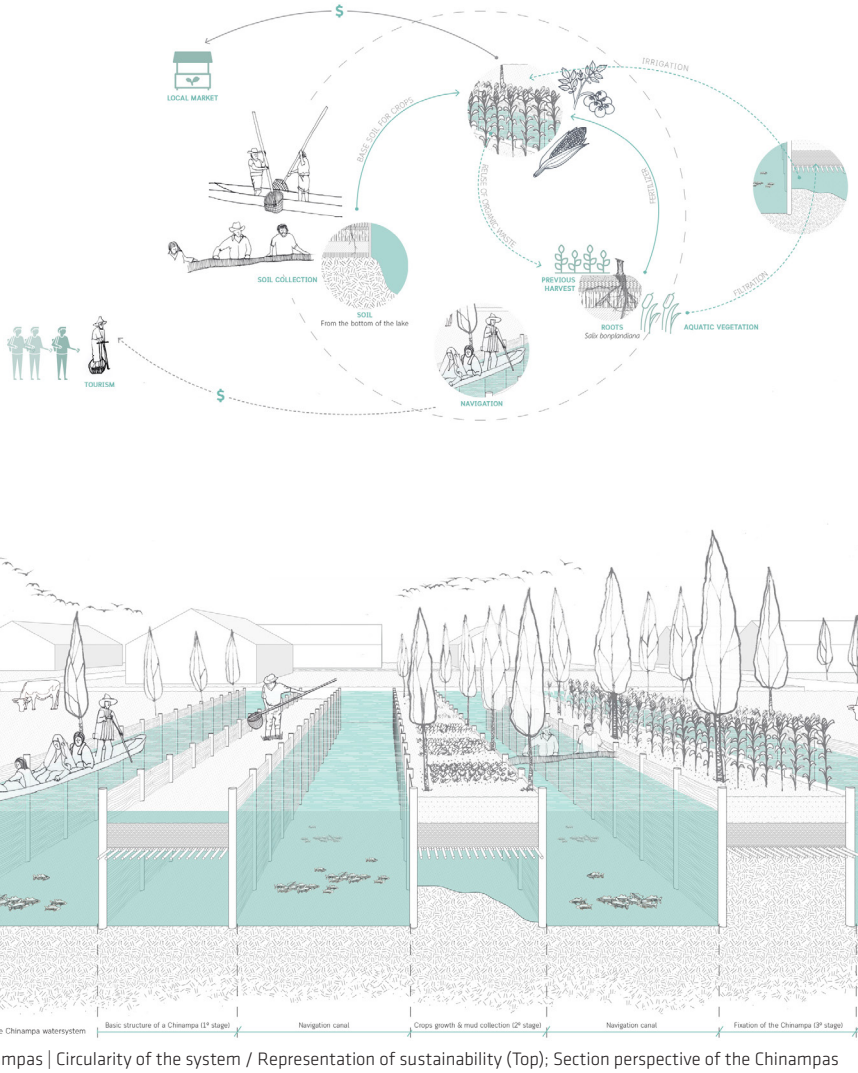

FIGURE 10 Chinampas | Circularity of the system / Representation of sustainability (Top); Section perspective of the Chinampas Watersystem (Bottom). Both copyright 2021 by author

In the present day, the Xinghua Duotian has remained the major agricultural hub for Jiangsu Province and a nearby city for more than three thousand years. The territory has also expanded to four more townships and the wisdom has been prolonged. The floating islands still function as a cultivable land for crops and vegetation. Furthermore, the new landscape has become an important tourist attraction for the city of Xinghua, currently known as "City with a thousand islets."

In the case of Chinampas, there has been a significant change caused by the Spanish draining process of the basin of Mexico City. Because of the need for safer areas to settle and expand an increasingly urbanized area, the basin of the former lake has been continuously drained in order to gain more land for the expansion of the capital city of Mexico. This major change in the large-scale water system had a considerable

effect on Chinampas. The Chinampas area was reduced significantly (from 150000 ha at its largest to 7500 ha nowadays), many fields have been naturally joined together due to the drying up of the canals and some are still used for sustainable agriculture.

However, the Chinampas agricultural system is still present in the southern part of the Valley of Mexico, on the canals of Xochimilco where many of these plots of land are still in active use, especially for floriculture and tourism (Echeverría, 2009).

COMPARATIVE LAYER	XINGHUA DUOTIAN	CHINAMPAS
General context		
Location	Xinghua City, China	Mexico City, Mexico
Area (Originally)	31,200 ha	150,000 ha (currently 7,500 ha)
Climate	Warm temperate and sub tropical	Sub tropical
Landscape condition		
Landscape type	Lagoon (then developed into lake) Fresh water	Lake
Water Quality		Fresh and Brackish Water
Water system function		
Initial purpose	Reclaim the land for food production	Reclaim the land for urban expansion
Current function	For agriculture and tourism (aesthetic and recreation)	Partially remain for water supply and tourism (aesthetic and recreation)
Development of water system		
Island construction:		
Base structure	Wattle	Wattle
Soil Structure	Mud and Lake sediment	Mud and Lake sediment
Topsoil	Biodegradable material	Biodegradable material
Movability	No clear statement	Static
Maintenance:		
Irrigation	By human	By trees and vegetation
Channel network	Require dredging (by human)	Require dredging (by human)
Soil Refilling	By human (from bottom of the lake)	By human (from bottom of the lake)
Circularity	Yes	Yes
Landscape Value		
Impact on water system	Mitigate flood Maintain water quality	Mitigate flood Maintain water quality
Other Benefit	Improving Biodiversity Sustainable use of natural resources Preserve ecosystem of the lake Improve air quality Create social-cohesion	Improving Biodiversity Sustainable use of natural resources Preserve ecosystem of the lake Improve air quality Create social-cohesion

TABLE 1 Overview of comparative review

Conclusion

The knowledge behind traditional water systems can inspire spatial, smart, and sustainable approaches to water management (Ryu, 2012). To design with water, we need to comprehend the geomorphology of the landscape, the operation of the natural water system, and its transformation, in order to relate to it. The illustrative method used during the research process revealed a vernacular relation between landscape, water management, and people. In general, the analysis of different traditional water systems delivers ancient knowledge for sustainable, adaptive, and circular water design. From that general knowledge, the analytical work creates tools for design proposals (Bobbink, 2019).

From the comparative analysis, it is possible to understand the similarities of water-based crops and the differences in construction details between both systems, in order to draw some conclusions and extrapolate landscape, resilience, and adaptability values that might be applicable for new landscape transformations.

As the main value, both systems gave us insight about a landscape-based method of settlement and urban expansion based on natural principles. This value has as a key element the circularity in the use of resources. In that way, by creating cyclical processes of urban and natural growth, we can generate a system in which resources such as water can be brought back into the natural circuit through natural irrigation and water filtration. By taking this into consideration, we can make our cities and human settlements part of the bigger natural-urban system.

The benefits of both water systems are beyond agricultural profits and food supply. Because of the circularity of these crop fields, the ecosystems and biodiversity associated with the existing landscape have been improved due to the preservation of rural-natural areas. Next to this, the development of extensive areas of green crops has helped to maintain water quality as supply for the nearby cities as well as generating a natural source of air purification for heavily urbanized areas.

Finally, an important lesson to be highlighted from the research is that we need to understand landscape as a multi-functional provider. Landscape entities such as wetlands and lakes should not be seen just as ecological areas to be protected and isolated from human interaction. These natural areas should be understood as an opportunity for multi-functional development with cultural, economic, and ecological value. From that understanding, cities can evolve in a way where agriculture, leisure, ecology, education, and urban expansion are part of versatile water and land management.

Applying these values in our way of reading and understanding the landscape can generate the opportunity to – at some levels - come back to a more sustainable, circular, and inclusive way of relating with our environment

Acknowledgements

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Riverine Women after Resettlement

The Case of the Belo Monte Hydropower Dam Project

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Abstract

The construction of Belo Monte Hydropower dam has resettled riverine communities from their homes to the outskirts of the city of Altamira, kilometres away and disconnected from the river. Resettlement can be a threat to both women and men's adaptation in the new environment, whereas the lack of in-depth studies regarding gender policies and local traditional communities can create even more obstacles for women. The disconnection that stems the resettlement from these individuals has resulted in the loss of their spatial identity and livelihood. This situation caused local traditional people to share resettlement units with city dwellers, thereby jeopardising their traditions and distancing them from both the river and their livelihood.

Keywords

Traditional riverine settlements, resettlement, gender, riverine, livelihood, tradition

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Introduction

This paper explores the impact of resettlement on a Brazilian riverine community, with a particular focus on the women, following a move in to the outskirts of the city of Altamira, as a result of the construction of Belo Monte Hydropower dam, the third biggest hydropower dam in the world (de Sousa & Reid, 2010). The data, gathered over the course of two field studies in 2018 and 2020, shows how riverine women's lives shifted after such resettlement. It further illustrates how several layers of their livelihood have been transformed in the wake of this environmental change and how they are adapting to their current living situation. For this study the same families were interviewed during both field studies, inside their homes in the Collective Urban Resettlement - CUR. This enabled me to understand how these individuals adapted over the years and how much of their tradition had been lost. I will be guiding this paper to answer this research question:

What has changed in riverine women's relationships with their traditional living spaces and with their personal connections, environmental and social, after resettlement in a CUR, considering the resulting disconnection from the river and their livelihood?

Who are the riverine people?

In the 1800s, workers from the north-eastern part of Brazil came to the Amazon looking for work in the rubber industry. When the rubber period was over, men and women created a way of living from the natural resources found in the forest and river, mixing indigenous and traditional knowledge (De Francesco et al., 2017). Currently, the riverine people are found living along riverbanks and on islands in Brazilian rivers; many are isolated and have no contact with the neighbouring cities (Fechine, 2012). Traditional people, including the riverine people, were recognised by the Brazilian Constitution only as of 2007, from which time their culture has been officially considered part of the national heritage (Brasil, 2007; Lopes, 2013). Today, the riverine people, also known as '*povos das aguas*' (people of water) (Khouri, 2013; Youssef Filho, 2015) have a strong relationship to the rivers and the forest. This 'invisible' group of people found throughout the dense forest live sustainably, in very intimate contact with the natural environment (De Francesco et al., 2017; Khouri, 2013). Factors such as the river tide and annual season, knowledge of when to plant crops, which fish to catch, and where and when to hunt (De Francesco et al., 2017) also have a strong influence on the riverine culture (Lopes, 2013).

A traditional riverine settlement, for many riverine families in the Middle Xingu region, comprises two houses, one alongside the river or island and another in the city (Magalhaes, 2017; Costa e Silva & Lucas, 2019) (see Figure 1). The reason for maintaining two homes is to have access to public services, the healthcare system, and the educational system (Instituto Socioambiental, 2015; De Francesco et al., 2017). Although there are schools alongside the river offering education for children up to 10 years of age, most mothers move to the city with the children for further education (Parente & Lopes, 2017); others find it easier to take their children to the city on a daily basis (De Francesco et al., 2017). De Francesco et al. (2017) explained that the urban houses are built by these individuals, mostly from stilts, and are located along the streams in the city or on the river, close to the city centre and public services to facilitate access to these services (see Figure 2).

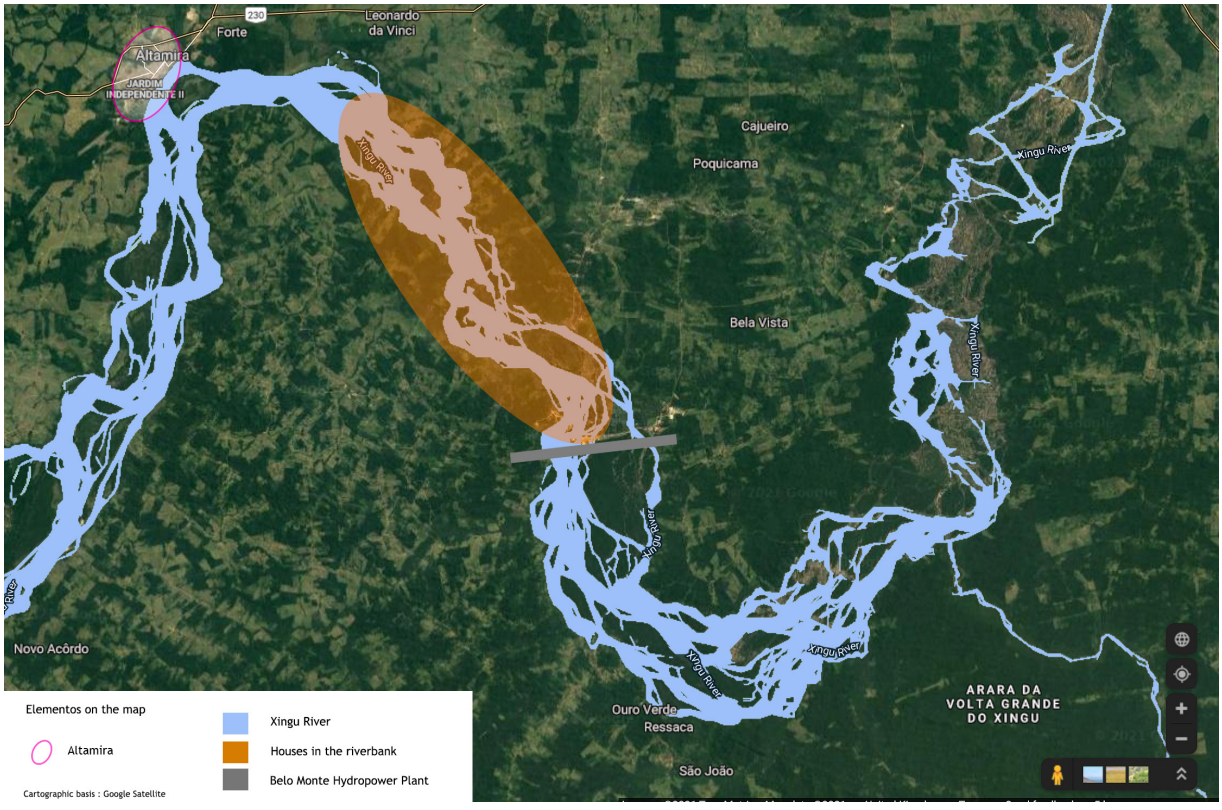

FIGURE 1 Map of Xingu River and Altamira | This map shows the location of the dam and where the riverine families lived before the reservoir.

FIGURE 2 Stilt houses along the Xingu River | Photo taken from the city of Altamira of the stilt houses along the Xingu River (2015)

Riverine communities survive on collective support. The families who are part of these communities live off subsistence activities, where sharing and exchanging of goods and services is common among the people (Khouri, 2013). This mindset extends even to taking care for one another's children when needed (De Francesco et al., 2017). To obtain some capital income, the families also sell goods grown on their land or fish from the river at the city's local market (De Francesco et al., 2017; Khouri, 2013). As Kuokkanen (2011: 218) clarified, "(...) subsistence activities are an expression of one's identity, culture, and values. They are also a means by which social networks are maintained and reinforced." This movement is created with trust built over time between people. Kuokkanen (2011: 218) continued, "Subsistence is both an economic and a social system, encompassing various spheres of life that often are inseparable from one another. It is characterized by endless circulation of goods, services, (...) and other activities which provide income in kind—food, heat, clothing, shelter, and a variety of other subsistence good and services." The abundant availability of natural resources found in the riverine people's environment meets all the families' and community's necessity for controlled and structured production within their immediate surroundings. The relationship between the natural environment and the people differs depending on experiences (Castro-Diaz, 2018; Agarwal, 1996), cultural roles (Agarwal, 1996), gender, age, class, and occupation (Castro-Diaz, 2018).

Resettlement and Gender

Resettlement is a decision made by authorities, which no opportunity for negotiation is available to those affected (de Sherbinin et al., 2010). Fernando et al. (2009:2) summarized resettlement as "... a response to displacement, or involuntary forced migration, where people move because of an external shock—whether it be a development project, a natural disaster, or civil conflict." Many communities experience trauma, especially those who have had their livelihoods disrupted (Dwivedi, 2002) and have been disempowered (Mehta, 2009). Homogeneous and gender-blind policies make it harder for women to adapt to the new environment (Asthana, 2012). Apart from that, when policies are gender sensitive, they mostly apply to women who are mothers (Moser, 2012), despite the documented need for such policies during the resettlement process (Mehta, 2009). The aftermath of development-induced displacement reinforces the disadvantaged position of women (Terminski, 2013).

The lack of policies, funding, political motivation, careful execution, and monitoring (van Eerd, 2017) after resettlement weakens women's adaptation and decreases opportunities in the new environment (Asthana, 2012). As affirmed by Asthana (2012), the patriarchal culture tends to create spatial limitations, thereby preventing women from rebuilding their livelihoods. Subordinate positioning decreases women's practical ability to earn a living and increases concern over the family's well-being (Mayoux, 1995). It also strengthens the unequal divisions of labour, increasing the lack of autonomy that governs women's quality of life.

Resettling Riverine People

Norte Energia S.A., the company responsible for the construction of the Belo Monte Hydropower dam, along with the mitigation and compensation programmes, have registered 20,000 people affected by the reservoir (Hernandez-Ruz, 2018; Randell, 2016), but only 4% from the riverbank have chosen resettlement as compensation (Instituto Socioambiental, 2015). Every household located below the level of 100m was registered and offered compensation to leave their homes due to the permanent flooding, not only those living alongside the river but also in nearby cities such as Altamira and Vitoria do Xingu (Randell, 2016;

Eletrobras, 2009). The resettlement process started in 2012–2013 (Instituto Socioambiental, 2015). Riverine families received money as compensation for their riverbank house or credit (Randell, 2016), but for the urban houses, families were able to choose between money, new housing, or credit compensation.

The Collective Urban Resettlements - CURs, in which alternative housing offered as compensation is located, are found on the outskirts of the city of Altamira. Some sites are three kilometres away from the river, whereas others are kilometres away (Instituto Socioambiental, 2015). Four of the five CURs are located up the hill, away from the river, and all five are far from the city centre (see Figure 3). Altamira is a city that does not offer regular public transportation, which isolates the resettled population even more.

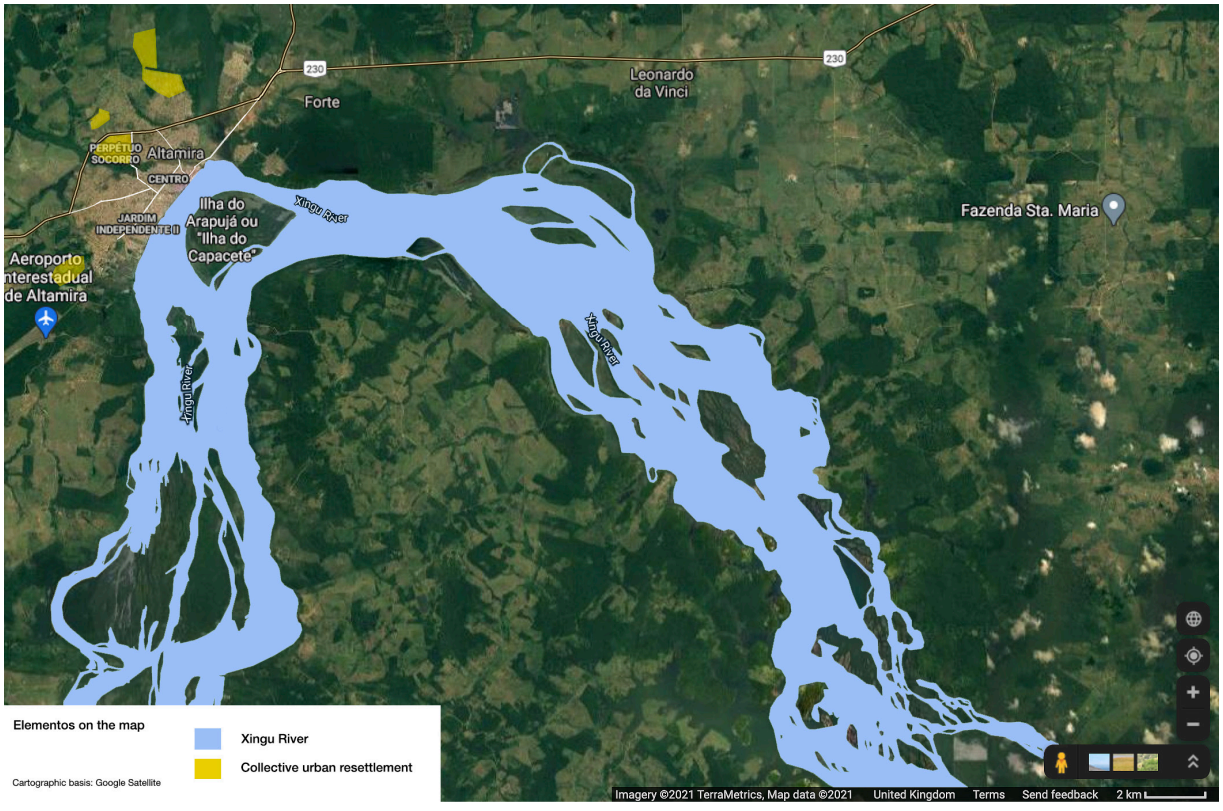

FIGURE 3 Maps indicating the location of the city of the CURs | Adapted by author from Costa e Silva and Lucas, 2019

This distance of the CURs has impacted both riverine men and women's work and daily routines, access to the river and public services, with the overall effect on each gender being different. As Terminski (2013) confirmed, the aftermath of development-induced displacement reinforces the disadvantaged position of women and strengthens the household roles.

Research shows that women's relationship to the environment, to practices, to knowledge, to management, to needs and to priorities is different from men's (Castro-Diaz, 2018; Agarwal, 1997). In a riverine household, it is common to see women being the ones responsible for the internal affairs and men responsible for outside activities (Silva et al., 2010; da Silva et al., 2011), reinforcing women's connections to the environment and the community, which are very different from those of men. As Women's Environment & Development Organization & United Nations Foundation (2004, p.50) have cited, "Many invest great vigour and energy into ensuring the day-to-day survival of their families and community." Within the riverine

community dynamics, women are responsible for the lighter physical tasks, whereas men bear the heavier burdens. For example, men cut down the trees and prepare the lumber for house building, and women oversee medicinal plants and the plants surrounding the home (Fechine, 2008).

Data Collection

The data for this research was gathered through a field study at the beginning of 2018, over the course of nearly three months, and then again in early 2020 for a month and a half. During both of these field studies, I participated in activities with the riverine community, engaged in meetings, interviewed both men and women inside their houses in the CUR, spent a week with two different families, participated in an expedition in the forest with riverine men and members of NGOs, and talked to employees of various NGOs and federal departments. I conducted 21 in-depth interviews with riverine peoples to understand their stories, the resettlement process, and their current life situation within their urban resettlement. Fourteen of the 21 interviewees were women, seven were men, and I was also able to conduct interviews with riverine couples. I used the going-along method to learn about the CUR and the changes that occurred in the natural environmental. I also had an opportunity to go to the river with some riverine people to understand how their life was before the dam was constructed and the current challenges they face. This method, as Carpiano (2009: 236) quoted, "is a variation on qualitative interviewing techniques that has a great utility for exploring – and subsequently improving understanding of – people's experiences of their local residential context (…) place and space (…) not only neighbourhood environment, but the larger local area in which a neighbourhood may be part and in which people move about in conducting their activities or practices." This method has enabled me to broaden my understanding of people's histories, their environment, their relationship to the river, and the impacts on their livelihood and social relationships.

The oral interviews were recorded and transcribed, and during the field work, a daily diary was kept. Most of the interviewees were illiterate but were very good storytellers; their past and present are told in detail. Oral interviews empower people who are voiceless and enabled me to receive information from unexplored territory (da Silva & Junior, 2012). Embracing what Alberti (2004:14 – translated by the author) cited, "It is the experience of a person as treated: his narrative ends up colouring the past with the value that is dear to us: one that makes man a unique and singular individual in our history, a subject who actually lived." During the interviews, I was able to capture feelings, histories, and details on the previous and current living situations and memories. I also heard myths that have moulded the riverine people's daily lives and beliefs. All this information allowed me to obtain a deep understanding of their past and present with more clarity. All the names in this paper have been changed with the purpose of protecting people's identities.

Findings

To better understand how the riverine families lived before the dam came into the picture, Ana de Francesco, an anthropologist from an NGO Instituto Socioambiental- ISA, explained how a house in the riverbank is perceived by a riverine person: A house is not only the constructed building; it is the space around the house of an extended radius of not just one hectare but greater than 20 hectares (personal communication, 2018). This space has to offer fruit trees, medicinal plants, space for the family crops (Costa e Silva & Lucas, 2019) (see Figure 4), a hunting area, and river areas for fishing and leisure. One riverine woman, Mrs. Mariana (personal communication, 2018), explained:

"It is from it that we make our living, what we need to survive. (...). In our (urban) houses, we have walls or limits of our homes, while in nature that does not exist, and the usage of space is greater than what is created by the infrastructure."

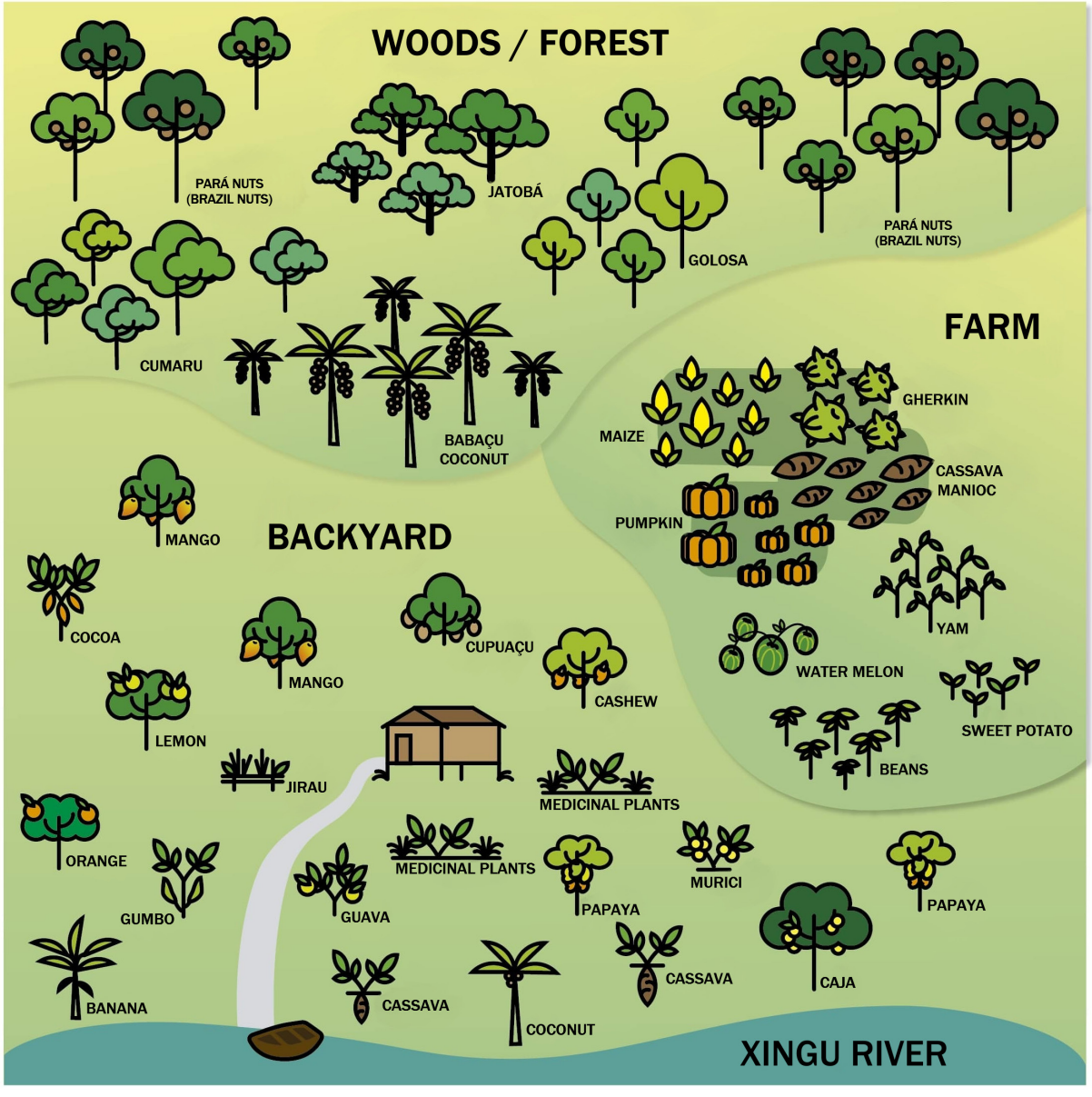

FIGURE 4 Illustration of a riverine's home | This image shows how a riverine house is set up surrounded by natural resources utilized by the family. (Costa e Silva & Lucas, 2019).

The 'people of waters' relationship with the river reflects itself in many layers of the riverine people's daily life, from transportation to income, social network, and traditions. The location occupied by each family holds history, not only as a place where one grows their food or hunts, but also where the community members gather for annual parties, exchange goods, and bury their family members. The meaning of place is a combination of people, places, activities, and memories (Papmehl-Dufay, 2015). During the expedition, the riverine guiding the work explained that before building their homes in such places, it is important

to first analyse the quality of the soil for crop growing, as well as determining the trees available for the construction and maintenance of their houses and what the trees could offer to the family, whether there are wild animals, and if the location was close to their family and friends. The occupancy of each land is acknowledged by the riverine and respected. If that land has an existing owner, then the new family cannot settle there, or should ask for permission to occupy a space, for example. Similarly, the houses in the city or the space made available for construction of the houses are also analysed before occupancy, with the most important factor being closeness to the river, where access is easy (see Figure 5).

FIGURE 5 Map | The map shows the location of the CURs and the previous location of the riverine urban houses before resettlement.

A riverine woman explained that she owned a piece of land along the stream close to the city centre, which she shared with both her daughters and their families. This land had a small house and a two-storey wooden house. After months of negotiation, her family was able to receive two houses in the same unit. Today, this riverine woman lives close to one of her daughters but not to the other. The daughter living further away rented a house with her husband and children in another CUR. All three women have stopped working because of the distance to the river and the lack of regular public transport. Before resettlement, they had fished and sold their catch at the city market, while the women also took turns taking care of the children each day.

Because of the long distance between the CURs, family members are now distanced from each other; they are not able to help each other as before. As a riverine woman, Mrs. Flor, said:

"I rarely see my sister; she lives very far [in another CUR] and it is hard to get there. Before, we used to see each other all the time, every day. Today, I must take two buses, which takes around an hour on each bus only one way."

Due to the distance of the CURs, the riverine people must walk approximately two hours from the river to their homes. To be able to work, they must pay for private transportation to take their boat's motor, isotope box, pans, hammocks, and many other items to the river for work. Every woman interviewed, with the exception of two, decided to sell their boats since this situation was not logistically nor financially viable. This has resulted in the women staying at home while the men become the main supporters of the household.

Additionally, due to the distance to the river and the rising violence in the CURs, women are the ones staying home to take care of the house (see Figure 6). The lack of family and social connections, coupled with the violence, is forcing women to stay inside their houses, thereby strengthening their dependency on men and their roles, defined by the duties understood to be women's under the patriarchal culture, within the household (Asthana, 2012). Apart from this dependency, many couples argue that the dam has also driven them apart. In the middle Xingu, it was traditional for the riverine couples to work together, whether it was fishing or farming. Today, the men are working alone, with the women staying inside taking care of the children and the house. The low count of fish in the Xingu River (Val et al., 2016; Castro-Diaz et al., 2018) has contributed negatively to the riverine families' income and food security and prolongs the day's men stay away from home because of work. Mrs. Francisca and Mr. Leo said that they used to work together, but now because she must stay home, they spend weeks apart.

FIGURE 6 Riverine woman | Riverine woman in front of her house in the Collective Urban Resettlement (CUR), 2018.

Another tradition that has changed with the dam is the subsistence economy that was adopted by the riverine community, which allowed families to help each other; this is not as common today. If a household produced more crops than needed, the rest would be offered to the neighbours. If there was more food than the community could consume, it would be taken to the city to sell in the local market. Today, the families are not able to farm, therefore they buy what they eat and due to the lack of fish, the consumption

of canned meat and beef has increased. This low count of fish in the river has resulted in many families discovering hunger and poverty for the first time. Before the dam, the riverine people did not consider themselves poor because the food was abundant, and they felt no necessity for more. Now, due to the low count of fish, these families must choose which bill to pay each month.

Mrs. Mariana and Mr. Jose, a riverine couple (personal communication, 2020), described how their Christmas and family events were before the dam:

"We used to invite our neighbours because we had a table full of food; it was a feast. The entire family and friends. But now, after Belo Monte, we are very poor. This year, we had a few dishes on the table and could not invite anyone. It is hard because now we don't have money to buy anything, and the fish we catch now are very small and very few."

FIGURE 7 Riverine woman |Riverine woman showing the extension built from her house in the Collective Urban Resettlement (CUR), 2018.

According to all the interviewees, lifestyle and quality of life have changed, even with respect to the comfort of their houses. A riverine house normally has three rooms (bedroom, living room, and kitchen), but many have only one room (Fechine, 2012), with a strong structure to hang the hammocks. Both riverside and city houses were not as comfortable, but, as many said, it was peaceful there. Today, the windows and doors of the houses in the CUR have grids. Every family interviewed had a wooden extension on the back of the house (see Figure 7). The extensions were either rooms for family members or somewhere to keep their extra furniture and fishing equipment. Every family, except for one, said they felt unsafe once they moved into their new house, especially because of the slab which is an element they are not used to. Mrs. Ilma (personal communication, 2018), confirmed:

"I don't trust these walls and this slab. I think it will fall on me at any day, so I built an extension of wood on the back, this way I can sleep well, in colder temperature, and on my hammock."

Conclusion

The lack of opportunities available for riverine women after resettlement have strengthened men's roles within the family. This dependency on men has increased due to many elements that accord for the first time in these women's lives: the violence in the CURs that mean someone must always be home and the women are the ones selected for this task; the impossible daily work routines due to the distance to the river; and the isolation from city centre due to complicated and irregular public transportation. Family members that used to live nearby, and see and help each other daily, are now meeting once or twice a month due to the distance between the CURs and the poor public transportation. The lack of reliable, affordable, and regular public transportation has disconnected riverine women from the river and natural environment, isolating them in the outskirts of the city. The location not only affected women's lives but also that of the couple. Today, due to the previously cited factors, the couple are not able to work together as is traditionally common, but the men go to the river alone.

Currently, the riverine traditions and connection to the river are diminishing. Riverine families are not involved with their traditional space, have been disconnected from their livelihood and spend weeks without seeing the river. Their lifestyle, which before was surrounded by nature and intricately linked to the natural environment, is now away from nature, between houses. When living closer to the river, their main concern was about the tide of the river, cleaning of the boat, the crops and what type of fish they would like to catch that day. Their habits are slowly changing to those more common to an urban lifestyle, where the main concerns are about earning income and protecting the house from burglars.

This article comes from ongoing PhD research, which is due to be completed. My suggestion for future research on resettled riverine women is to compare how other countries have compensated and considered their traditional population with regard to development-induced displacement and respect for their traditions. It is important to maintain the riverine population along the riverbank, since they are the protectors of the forest and rivers.

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Design by Radical Indigenism

Equitable Underwater & Intertidal Technologies of the Global South

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Abstract

This article considers the traditional water systems of indigenous cultures and explores their innovations as unique responses to the impacts of climate change in the global south. Local communities have been living with and developing water-responsive infrastructures for generations that engage and support the complex ecosystems they inhabit. Many of these innovations improve coastal resiliency, yet remain undocumented and unexplored in the evolution of contemporary solutions. Rooted in traditional ecological knowledge, or TEK, these technologies work symbiotically with, rather than against nature, and offer examples of a more comprehensive approach to underwater and intertidal design. These innovations are Lo–TEK, a term coined by designer and author Julia Watson, that is defined as resilient infrastructures developed by indigenous people through Traditional Ecological Knowledge (TEK) (Watson 2019). The movement to bring these innovations to the forefront of the design field counters the idea that Lo–TEK indigenous innovation is low-tech, a term often incorrectly applied to indigenous innovation that means unsophisticated, uncomplicated, and primitive. In actuality, Lo–TEK aligns to today's sustainable values of low-energy, low-impact and low-cost, while producing complex nature-based innovations that are inherently sustainable. Lo-TEK expands the definition of contemporary technology by rebuilding our understanding of climate resilient design using indigenous knowledge and practices that are sustainable, adaptable, and borne out of necessity. Indigenous people have learned to live symbiotically with their environments, especially water. This essay will explore the *Kuttanad Kayalnilam* Farming System by the Malayalis in India, the *Sangjiyutang* Mulberry Dyke and Fish Ponds in China, and the *Ramli* Lagoon farms in Ghar El Melh, Tunisia. These innovations are inherently resilient to the stresses of the climate and are multi-functional, symbiotic structures themselves. While not directly intended for protection from the new challenge of sea level rise, they can inform how we can build circular water systems that work with the environment, rather than disrupting it.

Keywords

Lo–TEK, climate adaptation, adaptation pathways, adapt, surrender

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Introduction

This article retells an ancient mythology—that humankind can and must live symbiotically with water. It is an indispensable part of life on earth, and essential to healthy ecosystems. In the past, civilizations and settlements were built on the availability of water resources. Today, this is reversed as humans manipulate the course of water bodies for their benefit. This has fractured our innate connection to the earth's water systems and we have become blind to the strain it is putting on the planet and our livelihoods. Climate change is forcing us to rethink this strained relationship with water and how it has led to disasters and a rising sea. Today, the existential risk of climate change is a global challenge, evidenced by universal metrics and approached with universal solutions. If we continue this generic approach of universality, we perpetuate the thinking that led to this climate crisis. We need to prepare ourselves to face the increasing climatic extremes by turning to complex solutions that have been in existence for centuries and acknowledge an adaptive relationship with the earth's water resources.

With wealthier nations causing climate change, poorer nations are suffering in a crisis that disproportionately affects people living in the global south, a term used for regions that are identified as lower wealth or undeveloped. An increasingly contentious term, however, the ideology behind identifying certain regions as less developed in the western sense is still maintained in discussions of technological progress and resilience. In specifically referring to regions that have been identified as part of 'the global south' the intention is to reverse the stereotype of less valuable and present the innovations and knowledge present in these overlooked areas. In the wealthier nations of the global north, homogeneous, high-tech infrastructures are being deployed in response to climate events. Designed primarily by and for affluent communities, these single-purpose solutions, considered 'best practice,' are so often counterintuitively incompatible with local conditions and the living water systems that have been evolved by local communities (Nunn, 2017). This current practice fails to acknowledge that an immediately available and more equitable typology of solutions already exists. In the global south, there are thousands of sustainable Lo–TEK living water solutions that have evolved by continual adaptation over millennia in response to climate extremes. Instead, the south is sold a belief that the high-tech solutions of developed nations are superior to their own local innovations, even though the latter embody the intelligence of the environments and cultures that have evolved them.

This article challenges this 'north knows best' narrative on the topic of climate solutions that disregards traditional knowledge and frames the need for high-tech and costly infrastructures. Many of the cities and coastal communities in the global south that will be greatly affected by a rise in sea level are already living with these climate extremes, and have developed ecologically intelligent resilient living water systems. This research argues for the imminent need to recognize these overlooked climate solutions, which are inspired by indigenous innovation and embedded with the traditional ecological knowledge (TEK) of communities working with ecological systems thinking.

The research presented here documents the traditional, indigenous responses to coastal resilience found across the global south that amplify local cultural, ecological, economic, and agricultural resilience. These indigenous innovations acknowledge the human relationship to water, through both built infrastructure and cultural practices. The following chapter examines three systems written in collaboration with local indigenous experts. These technologies have evolved from traditional ecological knowledge and work with local conditions and culture. The examples explored are the *Kuttanad Kayalnilam* Farming System in India, the *Sangjiyutang* Mulberry Dyke and Fish Ponds in China, and the *Ramli* lagoon farms in Tunisia. While indigenous peoples and their responses to coastal resilience remain largely excluded in global discussion on design solutions, these studies, reframed through an architectural lens, intend to inform the future of design for climate resilience.

Lo–TEK

Lo–TEK, a term coined by designer and author Julia Watson, is defined as resilient infrastructures developed by indigenous people through traditional ecological knowledge (TEK) (Watson, 2019). The movement to bring these innovations to the forefront of the design field counters the idea that Lo–TEK indigenous innovation is *low-tech*, a term often incorrectly applied to indigenous innovation that means unsophisticated, uncomplicated, and primitive. Instead, Lo–TEK aligns to today's sustainable values of low-energy, low-impact, and low-cost, while producing complex nature-based innovations that are inherently sustainable. Forming the foundation of indigenous technologies, TEK is a field of study in anthropology defined as a cumulative body of knowledge, practice, and belief, handed down through generations by traditional songs, origin stories, and everyday life. By using TEK, humans have been able to harness the energy of ecosystems and adapt to environmental obstacles using soft and symbiotic living systems. Developed through direct contact with nature, TEK is engineered to sustain, rather than exploit resources. It fosters symbiosis between species, while making biodiversity the building block used to construct sustainable technologies.

Lo–TEK innovations come from a deep understanding of working with nature and are evolved from the philosophy of radical indigenism. Coined by a citizen of the Cherokee Nation, Professor Eva Marie Garoutte, radical indigenism argues for a rebuilding of knowledge and understanding of indigenous philosophies from their roots (Garroutte, 2006). For design, this rebuilding can expand our understanding of nature-based technologies and generate new, sustainable, and resilient infrastructures informed by TEK. Lo–TEK is how humans have been dealing with the extremes of the climate for millennia, by harnessing the energy and intelligence of complex ecosystems. It is eminently possible to weave ancient knowledge on how to live symbiotically with nature into the ways in which we shape the cities of the future. We can rewild our urban landscapes and apply Lo–TEK ecological thinking to climate solutions for sanitation, storm surge, sea level rise, drought, deluge, wildfire, food supply, and water, that have worked for indigenous peoples for thousands of years. Lo–TEK expands the definition of contemporary technology by rebuilding our understanding of climate resilient design using indigenous knowledge and practices that are sustainable, adaptable, and borne out of necessity.

Role of Lo–TEK in IPCC Adaptation Pathways

In 2019, the Intergovernmental Panel on Climate Change, a UN body that evaluates climate science and analyses adaptation and resilience options, released a special report on the ocean and cryosphere in a changing climate. The fourth chapter of the report focused on sea level rise and the implications for low-lying islands, coasts, and communities by outlining five typologies of response: protection, accommodation, advance, retreat, and ecosystem-based adaptation. In the following article, the two climate adaptive scenarios in the advancing and accommodating classifications are reframed using the underwater and intertidal technologies of indigenous peoples.

Presently, the IPCC acknowledges the political and social challenges that arise with the current toolkit of responses, but continue to undervalue indigenous innovation. Categorizing the following indigenous innovations - the *Kuttanad Kayalnilam* Farming System by the Malayalis in India, the *Sangjiyutang* Mulberry Dike and Fish Ponds in Huzhou and Shenzhen, China, and the *Ramli* Lagoon Farms of the Andalusians in Ghar El Melh, Tunisia - in accordance with the IPCC's definitions of response towards sea level rise opens the door for our contemporary, resilient design strategies to embrace the more equitable TEK approaches. The IPCC strategies outlined favour western responses of hard protection such as sea walls or relocation,

for responding only when it is already too late. While the IPCC acknowledges the political and social challenges that arise in the discussion of which response to take, existing indigenous knowledge remains an unrecognized or undervalued factor, that can be a part of resilience today.

Kuttanad Kayalnilam Farming System by the Malayalis in India

Kuttanad, a low-lying wetland at the mouth of the Vembanad Backwaters in India, is the only place in the country where paddy farming has been practiced below sea level for more than two centuries. Due to this area's unique geographical phenomenon, life here revolves around water with the daily activities like commuting, bathing, washing, and their livelihoods and seasonal celebrations like the snake boat race festivals. During the Pre-Holocene period this was a shallow embayment in the Arabian Sea that later silted up, giving rise to a deltaic formation at the confluence of four major river systems and the backwaters (Padmalal et al., 2014). In the 1800s, when the region encountered an acute food shortage, these virgin landscapes, considered a gift from the backwaters, were reclaimed in a process colloquially known as *Kayalkuthu* which literally translates to thrusting into the backwaters (Chandran & Purkayastha, 2021) .

This comes under the Advance strategy as classified by IPCC which is adopted in many coastal cities, and through which land is expanded into water by reclamation or by the use of dikes. In this system, the artificially created landforms are called *Kayalnilams*, where *kayal* means backwaters and *nilam* means ground, implying that they were lifted out of water (Chandran & Purkayastha, 2021). The *Kayalnilam* system intelligently accommodates seasonal flooding and salinity intrusion, allowing the Malayalis to grow rice, coconut, and other fruit trees through the local technology and water management practices associated with the *Kayalnilams* (Figure 1)

FIGURE 1 An aerial view of two Kayalnilams separated by a water canal, which is similar to the dike and polder system in the Netherlands. (CGH Earth Resort, 2021)

Existing as a striated topographical undulation rising and falling above the backwaters, the system is composed of bio-bunds and canals (Figure 2). The constructed module forms a two-tier system, making it adaptable to seasonal precipitation. The bio-bunds, known as *kuttiyum chirayum*, are made of local materials including coconut poles, bamboo mats, sand, twigs, and sedges like cattail (*Typha latifolia)* and common three square (*Schoenoplectus pungens),* interspersed with high quality clay dug from a lake depth of 20-25m (Nagarajan et al., 2014). The bunds separate the canals which hold water used for irrigation. The water enters the paddy fields through a flexible opening in the bund called a *thoomba*. However, to

avoid excess water entering the paddy fields, dewatering[1] technologies called *pettiyum parayum* (Figure 3) that periodically remove water, are placed at strategic junctures between the bunds and the canals. To block the seasonal entry of salt, temporary barriers called *orumuttu,* made of sand bags and twigs are built above the salt level allowing only fresh water to enter the paddy fields. The entire system is lined with an exterior bund two metres above the intertidal level, which acts as a sea defence barrier against fluctuating tidal levels.

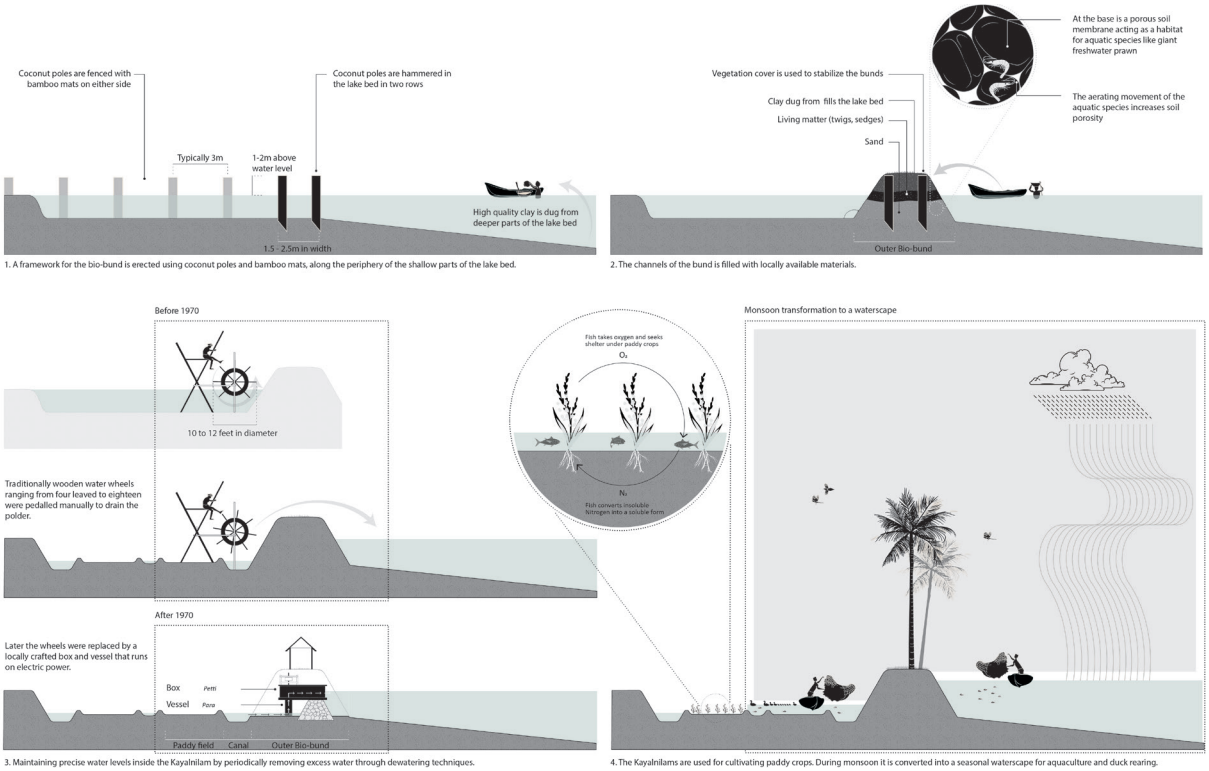

FIGURE 2 The stages of construction of the Kayalnilams and their performance through multiple seasons. The drawing is based partly on research developed within the Circular Water Stories graduation lab at TU Delft. (Ali, 2021)

Beyond climate resilience and agricultural optimization, these bunds and canals also improve water quality and structure a complex habitat. As a permeable structure, the bunds act as a favourable ground for freshwater prawns and other aquatic species while the canals serve both as a fish nursery and hunting ground. Fish venturing upstream during high tide are trapped in the system by a detachable net fitted inside the dewatering technology. The introduction of fish into the system creates opportunities for aquaculture with some fish that seek refuge under the roots of the paddy crops. Stirring movements of the fish aerates the planting bed improving the surface soil conditions both in terms of porosity and fertility. This accelerates the growth of paddy crops which in turn provide oxygen and food for fish, as their roots favour the growth of microorganisms which are natural fish food. This symbiosis between rice and fish is further enhanced by the recurring movement of salt and water in the system.

1 Dewatering is the process of pumping water out from the low-lying paddy fields to the major canals or backwaters. Traditionally, wheels of ten to twelve feet in diameter with a blade width of one to fifteen feet were used. They were pedalled manually by men to remove water. The water wheel ranged from 4-leaved to 18 leaved. Owing to the extensive labour, these wheels were later replaced by a technology crafted by local blacksmiths which runs on electric power.

FIGURE 3 The pettiyum parayum is an indigenous dewatering technology, which runs on electric power, to periodically remove excess water from the paddy fields. (George, 2021)

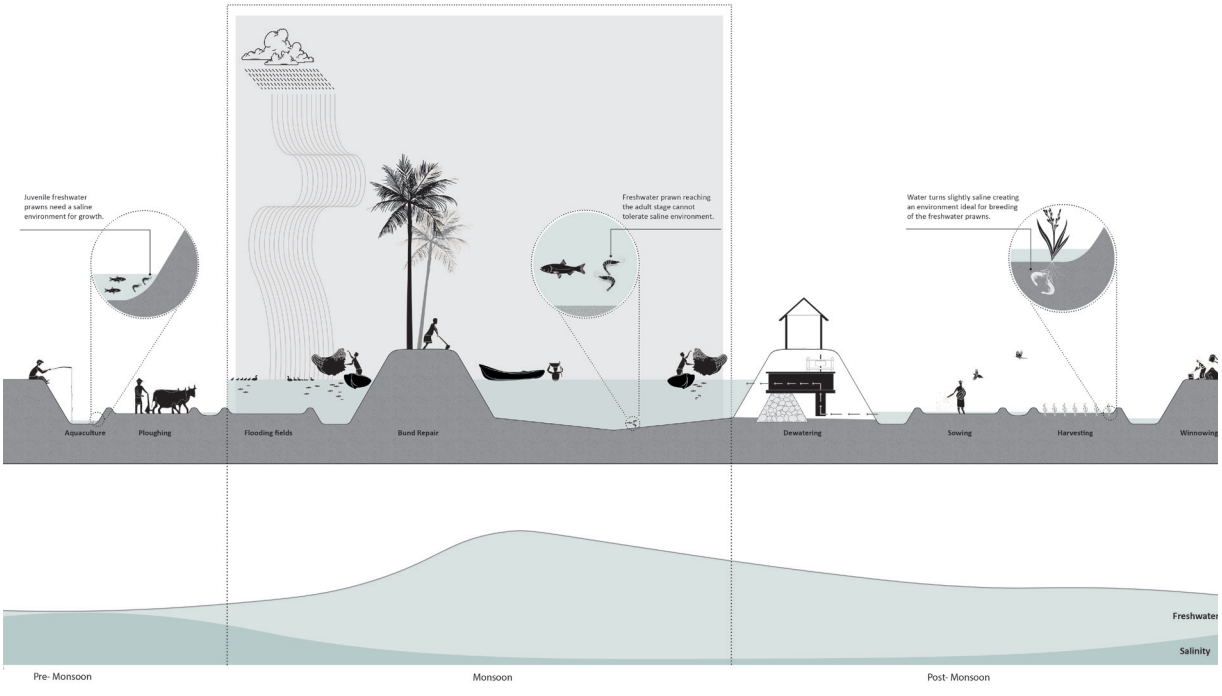

FIGURE 4 The cycle of shrimp, salt and water which influences the seasonal operations of the Kayalnilams. The drawing is based partly on research developed within the Circular Water Stories graduation lab at TU Delft. (Ali, 2021)

Rotating between agriculture and aquaculture, the people of Kuttanad live in harmony with the seasonal mixing of fresh and saline water (Figure 4). While water flows from rivers into the sea for most of the year, during the pre-monsoon when river flow drops below sea level, water flow reverses to travel inland from the sea, bringing salt which is universally considered a curse for farmers. The increased salinity is unsuitable for paddy cultivation, so *kayalnilam*s are deliberately flooded to create a watery landscape for the seasonal transition to aquaculture and duck rearing (Figure 5). With the onset of the monsoon, river flows again

reverse and flow back into the sea, restoring the freshwater needed for paddy cultivation. Paddy fields accommodate excess water during heavy rains while the soil is enriched with silt and duck droppings. During this period, the farmers prepare the submerged ground with simple tools and animals. Post-monsoon, water levels recede, and the paddy fields are dewatered to begin growing crops, which are harvested before the next saltwater intrusion from the sea.

FIGURE 5 The Kayalnilams flooded during monsoon. (Chandran, 2021)

Due to the resemblance with the Traditional Dutch landscape, Kuttanad is often referred to as the *"Holland of the East"* by the western world. But unlike the polder dike system constructed for flood prevention in the Netherlands, the *kayalnilams* engineered in local building materials allow a higher degree of flexibility for seasonal exchange of salt and water, while exerting less control over the natural processes. As a local technology, the *kayalnilams* are living, intertidal landscapes that adapt to the vulnerability of flooding and salt intrusion by supporting food production, securing livelihoods, and minimally disturbing the natural balance of the ecosystem. At the watershed scale, these landscapes act as a seasonal retention basin, harmonizing the construction, maintenance, and operation of agricultural infrastructure with the water cycle.

The circle of life in the *kayalnilams,* characterized by a multi-species ecosystem, is linked to this cycle of water and salt, intermingling with the cycle of agriculture and aquaculture. This relationship with water is further accentuated by the daily lifestyle of the people and their unique cultural practices. In the wake of global food insecurity and salt intrusion upon vital coastal agricultural lands, further aggravated by climate change, this traditional land-water technology can be a model for the future direction of intertidal agricultural landscapes.

Sangjiyutang Mulberry Dike and Fish Ponds in Huzhou and Shenzhen, China

For over five thousand years, parts of the Yangtze and Pearl River Deltas have flourished through the development of an ingenious adaptation technology of dikes and fish ponds located in low-lying areas, which aligns to the 'advance' strategy of sea level rise adaptation. Advancing by way of polderization has a long history in China as well as in Germany and the Netherlands (IPCC, 2019). This system uses polders to redirect water, forming a new ecosystem and a sustainable water management system that fully integrates the water cycle. This honeycomb-like network of polders and dikes appear as a sprawling mosaic of ponds, interconnected by ribbon-like green strips that are dotted by dense settlements (Figure 6).

FIGURE 6 The honeycomb morphology of the mulberry dike and fish pond system in Huzhou, China. (Dai, 2017)

This system, which is still in use today, first developed in Huzhou in the Yangtze river delta, and began with the planting of mulberry trees and the subsequent rearing of silkworms, known as sericulture. However, the lower reaches of the district of Huzhou faced serious seasonal waterlogging during the monsoon from the flow of the Dongtiao River. In response, the farmers converted the seasonally flooded areas into fish ponds lined by dikes, and the entire system integrated the mulberry tree sericulture practice with the rearing of fish and livestock. Two thousand, five hundred years later, a similar dike-pond system emerged in the lower reaches of the Pearl River Delta, with fruit trees, like banana, planted atop the dikes surrounding the fish ponds (Gongfu, 1982) (Figure 7). In the early seventeenth century, the system evolved into a combination of mulberry sericulture and aquaculture, farming four major fish species and creating a local silk and fisheries economy integrated with industries and settlements (Figure 8). For both systems located in a low-lying marshy ecosystem, the dike-pond technology is the smallest module of a multi-scalar water management system for these deltas (GIAHS, 2017).

FIGURE 7 A more recently constructed mulberry dike and fish pond system located in Shenzhen, China. (Sun, 2019)

FIGURE 8 Sited within a dense urban settlement and surrounded by industries, the mulberry dike and fish pond system serves multiple functions. (Sun, 2019)

FIGURE 9 Sericulture on the banks of the fish pond amidst the leaves of the mulberry trees. (Okic, 2021)

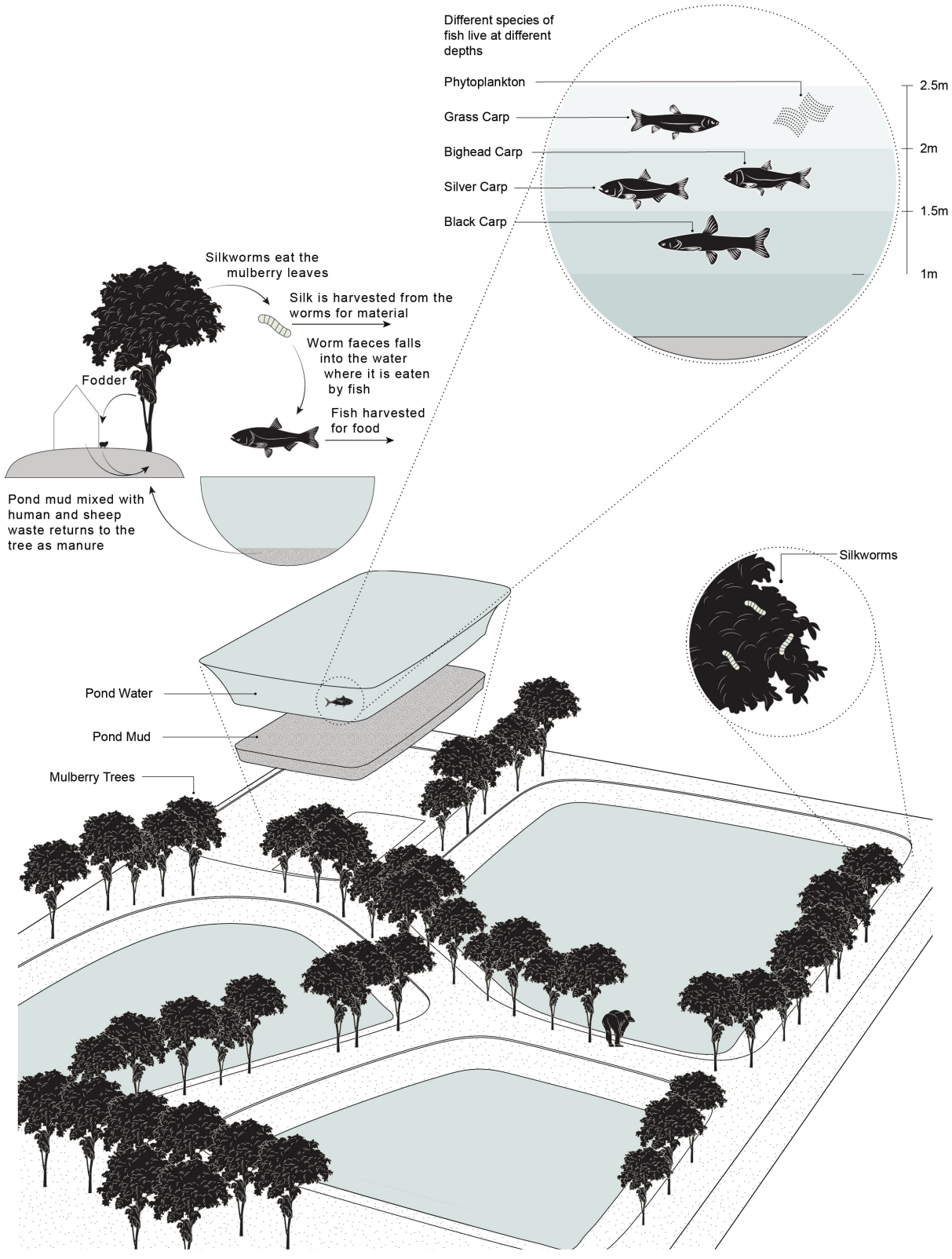

FIGURE 10 The closed-loop energy and material cycle of the mulberry dike and pond system. (Robertson and Ali, 2021)

The systems are characterized by their ability to maximize productivity within closed-loop energy and material cycles. Grown on the banks of the fish ponds, mulberry trees (Figure 9) provide leaves for silkworms to eat, while silkworm faeces and sloughs falling into adjacent ponds provide food for fish. The fish faeces along with the unconsumed silkworm and mulberry waste, are then decomposed by aquatic microorganisms, which produce nitrogen, phosphorus, and potassium, that return to the mulberry trees as nutrient-rich manure, thus restarting the cycle (Gongfu, 1982). Species selection is foundational in maintaining a biological balance in this circular ecosystem. The four fish species introduced were chosen according to the level of water in which they reside. The slopes between the mulberry fields and the fish ponds creates a trapezoidal pond edge, which reduces soil erosion in the mulberry fields. In addition, fertilizer leaching from the mulberry fields in the rainy season flows down the slope and into the pond, contributing to an organic cleansing technique (Qing, 2013). The system also introduced other seasonal activities that integrated symbiotically with the sericulture cycle, including raising a special breed of sheep adapted to the cycle of sericulture. Mulberry leaves provided the main fodder for the sheep. In return, sheep manure was then combined with human waste to fertilize the mulberry trees, introducing a secondary cycle of symbiotic activity (Figure 10).

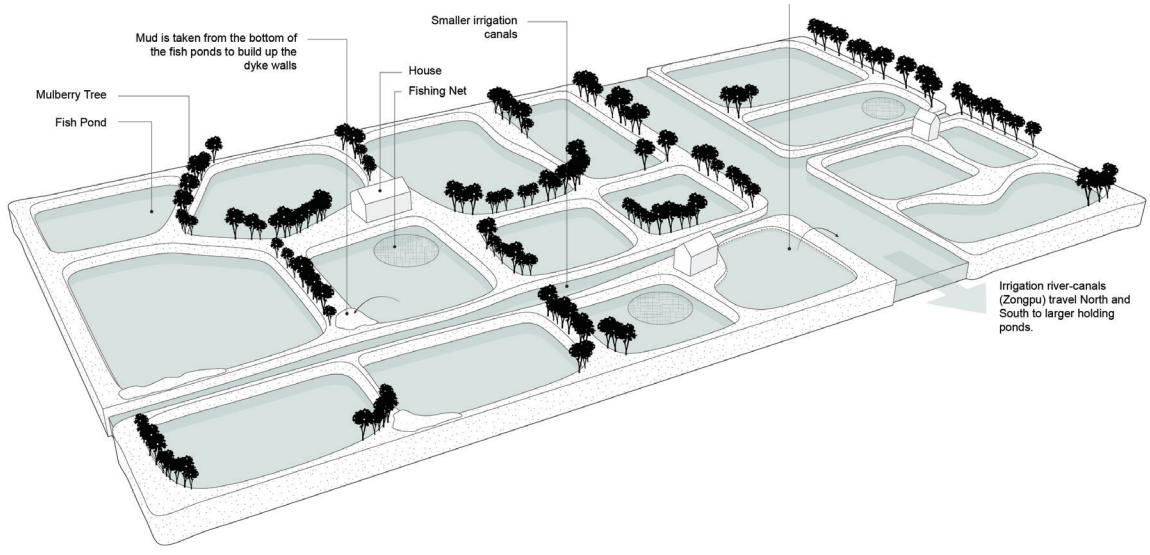

FIGURE 11 The aggregation of ponds and canals in the mulberry dike and fish pond system. (Robertson, 2021)

Besides complimenting the sericulture cycle, the fish ponds are the smallest unit of a larger irrigation, drainage, and flood prevention system (Figure 11). The lowland of Huzhou has always been vulnerable to flooding because of poor drainage during the monsoon, resulting in long-term, large-scale waterlogging. In these lowlands, the fish ponds were integrated into a larger water management system, called *Hengtang-Zonglou* reaching Lake Tai, the largest freshwater lake around the Yangtze River Delta (Zhuang, 2018). The fishponds maintain the water level in the surrounding settlements by accommodating excessive rainwater, while the overflow drains to Lake Tai in monsoon season, through *Zonglou*, a water channel system perpendicular to the lake. In the dry season, the water is led into the fishponds to soften the channels and dikes. On the other hand, *Hengtang* are rainwater channels that direct water from the east and west mountain areas into the lake. Together, both these networks of channels create a checkerboard-like water-management pattern. The same process occurs in the fishponds of the Pearl River delta near Shenzhen, where the fluvial swamplands are converted into a fishpond landscape connected to a multi-scalar water management system.

FIGURE 12 Satellite image of the Huzhou area showing the dike and fish pond system connected to the macro water management network. (Google Earth Pro, 2021)

The mulberry dike fish pond systems have an ecological multiplier effect upon the ecosystems they inhabit, beyond creating a closed-loop water management system. Local resources are maximized to produce commodities like fish and silk, which in turn provide income and secure livelihoods. The nutrient-rich mud creates an organic fertilizer and a terraforming building material. This recycling of waste and energy replaces the need for chemical fertilizers, pesticides, herbicides, and concrete flood barriers, while cutting costs. Further, due to the aquatic diversity of the ponds, they also act as excellent carbon sequestration technologies. When coupled with the Mulberry tree - an air purifier, and carbon sequestering vegetation more effective than other agricultural plants - a carbon negative, zero-emission, textile-producing, aquaculture, agriculture, waste-water system emerges (GIAHS, 2017). This integrated system of water and land forms a resilient, hybrid solution that can inform both water and land management practices, in areas that experience frequent flooding. The system can serve as an inspiration for managing highly urbanized intertidal zones or frequently flooded urban areas to constitute a new typology of the green city. The Shenzhen area is a living example of how these Lo–TEK solutions weave the threads of the city's past with legitimate technological ambitions of the present-day while bringing biodiversity back into the city and humans closer to nature - ultimately crafting a resilient future with added economic and ecological benefits.

Ramli Lagoon Farms of the Andalusians in Ghar El Melh, Tunisia

A strategy for sea level rise outlined by the IPCC is 'surrender' or 'accommodate,' which takes the approach to sea level rise of letting water in. This strategy can take place at various scales, methods, and levels of temporality. It can be applied in urban environments through flood zoning restrictions, insurance plans, warning systems, emergency planning, setbacks, and flood barriers. The IPCC's definition of accommodation refers to the redesign of physical and political infrastructure to accommodate sea level rise and reduce

vulnerability. In addition to urban flood accommodation measures, strategies include updating building codes, raising buildings on stilts, floating houses and gardens, aquaculture and adapting to salinity intrusion, though changing crop varieties and land use. In this section the *Ramli* Lagoon farms in Ghar El Melh, Tunisia, are explored, due to their unique agriculture on man-made islands that utilizes fresh water accumulation on salt water surface.

On the shores of Ghar El Melh lagoon, adjacent to the Mediterranean Sea, is a drastic gradation across the landscape from a thin belt of elevated dense urban fabric opening to a vast lagoon with scattered irregular sized vegetated islands (Figure 12). In the 17th century, following a Roman invasion, the Andalusian people (of modern day Southern Spain) were forced to relocate to places along the coast of Tunisia. These farmers established crops by terracing the foothills of the Ennadhour mountain and feeding the agriculture with manure transported on the backs of men and donkeys. Today, some of the terrace agriculture that was managed by families remains, while much of it has moved to the shores where it was better protected from invaders by the Ennadhour mountain (FAO, 2020) (Figure 13).

The Tunisian coastline today is home to nearly two-thirds of its population of twelve million people. However, these dry, coastal areas make agriculture a challenge. The early inhabitants who occupied the banks of the Ghar El Melh lagoon located in the Gulf of Tunis faced a shortage of arable land with the city wedged between the shores of the lagoon and the rocky mountains of Jbel Ennadhou (IUCN, 2020). At the time, the only arable land was in the mountains and fed by natural springs. In response to the lack of cultivable coastal land, the poor-quality soil, and the scarcity of irrigation water, came ingenious agricultural techniques like the two hundred and ninety ramli farms cultivated by the farmers, or fallahs. Since the year 1000A.D., the lagoon has silted up, which has led to the formation of sand barriers parallel to the coastline. In the 17th century, a coastal barrier called a *Boughaz*, separating the lagoon from the Mediterranean Sea, was introduced, allowing seawater to flow into the lagoon (FAO, 2020) (Figure 14). Today, the lagoon is further shaped by the construction of the ramlis using sand excavated from the shoreline. The word *ramli*, which means sand in Arabic, points to this transportation of sand from the shores to reclaim land along the shoreline of the lagoon (Aissaoui, 2020) (Figure 15).

FIGURE 13 An aerial view of the ramli lagoon system showing the artifical islands located south and downstream of Mount Ennadhou. (Google Earth Pro, 2021)

FIGURE 14 In the background lies Mount Ennadhou, which supplies irrigation water to the ramli farms by natural springs and run-off from seasonal rains. (Aissaoui, 2020)

FIGURE 15 Ramli plots are divided by sugar cane fencing to protect crops from sea spray and wind. (Aissaoui, 2020)

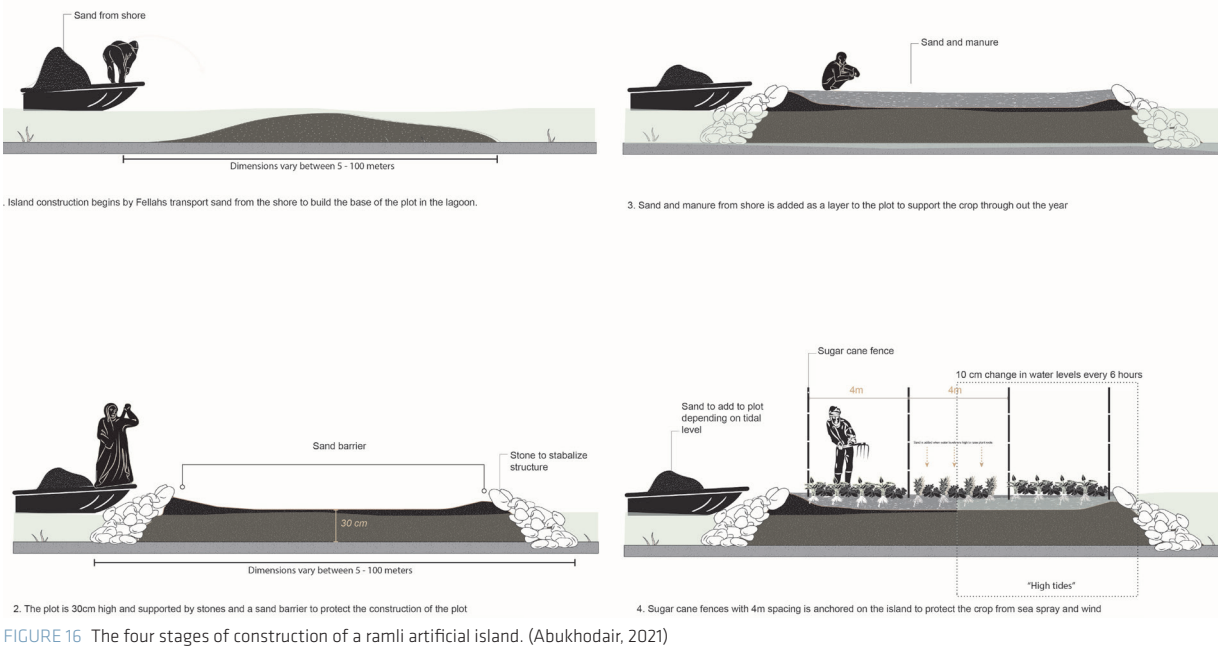

FIGURE 16 The four stages of construction of a ramli artificial island. (Abukhodair, 2021)

The varying sizes of the ramli sand beds form the base modules of construction for growing an intensive polyculture of seasonal, shallow-rooted crops like potatoes, onions, watermelons, tomatoes, pepper, and fennel (FAO, 2020). The whole system is lined by reed trays, planting hedges, and fruit trees located peripherally with sugarcane branch fencing added every four meters between crop rows to protect them from the sea spray, slow the evaporation process, and stabilize the sand beds. (Figure 16). A major challenge these cultivated plots encountered was saline intrusion from the lagoon. In response, the *fallahs*, or farmers, developed an innovative year-round passive irrigation system that makes use of freshwater tidal

fluctuations in the lagoon (EuropeanSeed, 2020). Relying on tidal movements in the lagoon, and seawater being denser than freshwater due to its salt content, freshwater reaches the plant roots through capillary action (FAO, 2020). This layer of fresh water moves up and down about ten centimetres, twice a day, every six hours, at high and low tides. As the freshwater saturates the sand twice daily, it nourishes the roots of the crop from the ground up. Any imbalance to the system, such as low roots that come into contact with saltwater or high roots that dry, will cause the crop to fail (Aissaoui 2020) (Figure 17). The *fallahs* who manage the system are charged with balancing both the sea and soil levels which must remain equal, by adding sand and manure (GIAHS, 2020)(Figure 18).

FIGURE 17 The Coastal Barrier Boughaz in view with the Ramli plots landscape. (United Nations Development Programme - Tunisia, 2021)

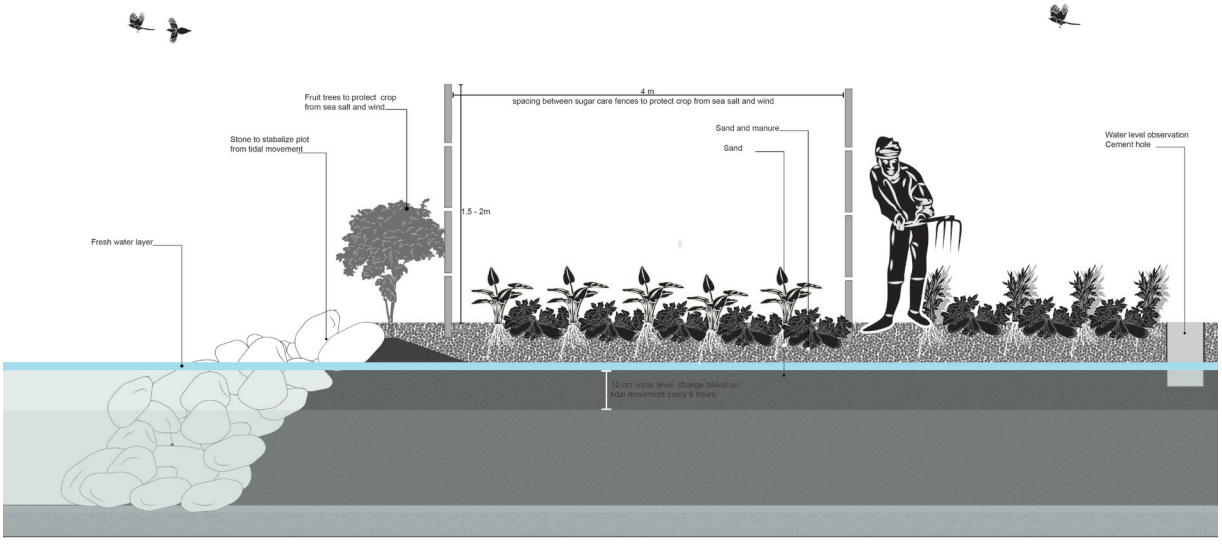

FIGURE 18 The technology of the ramli artificial islands works with tidal levels and a thin sliver of freshwater which is more buoyant than the salt water. (Abukhodair, 2021)

Although the island farms were constructed to support agriculture in a lacustrine environment, they have also played a critical role in shaping the morphology of the lagoon (IUCN, 2020). Without the farms, the lagoon banks and subsequently the city would have washed away. The *RAMLIS* offer a living example of

humans and nature exchanging roles, alternating between being makers and takers of the landscape. With half of the village populations along the coastlines dependent on ramlis for their daily livelihood, the balancing act of the system plays an incredibly vital sociological and ecological role. By planning intelligent crop rotations, the *RAMLIS* can be cultivated throughout the whole year. Due to these ingenious, natural irrigation methods that work symbiotically with the water cycles and the water regimes of the plants, these techniques are vital to areas facing water scarcity due to the lack of availability of freshwater and where saltwater poses a constant threat.

Lo–TEK for Climate Resilience

Climate change and sea level rise are unprecedented adversaries that are adaptive, responsive, and capable of complex interactions along coastlines. Variations in local conditions, communities, and ecosystems coupled with global weather patterns warrant unique responses that amplify strengths and counter weaknesses. In the end, avoiding catastrophe will largely depend on individual responses by communities and governments, rather than universal approaches. While the global north biases the universal climate solutions of high-tech, hard infrastructures and carbon-credited conservation areas, another approach found predominantly in the global south remains unacknowledged. The existing and undervalued Lo–TEK nature-based technologies that have evolved from thousands of years of place-based knowledge are continually erased following the 'north knows best' narrative (Watson, 2019). These local technologies offer a more socially and environmentally equitable alternative for nations fortunate enough to have these highly sophisticated technologies that work in complex symbiosis with their natural systems still in existence.

Scientists have acknowledged that the world is in the midst of the earth's sixth mass extinction, but species extinction alone will not be the twenty-first century's greatest loss. Those same forces that drive species extinction endanger the local, nature-based technologies - not yet recognized as technologies - that may hold a key to the survival of the world's population in the global south. These are technologies that have evolved and passed through generations in response to flood, fire, drought, sea level rise, and severe weather – the same crises we face today. These are incredibly well adapted to their environments and play an important role in conserving global biodiversity.

Indigenous people have learned to live symbiotically with their environments, especially water. In this article, three case studies have been presented. The examples are inherently resilient to the stresses of the climate and are multi-functional, symbiotic structures themselves. While not directly intended for protection from the new challenge of sea level rise, they can inform how we can build accommodating and advancing protection systems that work with the environment, rather than disrupting it, and provide services in the forms of agriculture and aquaculture. These Lo–TEK infrastructures are not a replacement for sea walls and urban hard infrastructure, but are an important part of designing for overall sustainability in the face of climate change as they work with rather than against nature. We cannot go backwards, fixing all of the hard infrastructures, creating more extractive activities, and displacing more communities in the name of conservation. These activities have caused and exacerbated climate change and a great loss of biodiversity. Further, the thinking that glorifies high-tech infrastructures has undervalued the Lo–TEK solutions and has eventually put them in a position of risk. Instead, we can go forward by funding, rethinking, rebuilding, and scaling Lo–TEK climate solutions that support the resilience of both communities and cities, while addressing the inequalities and distance from nature that our current systems and climate solutions support.

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In Search of Eden

Landscape laboratory for the enrichment of abandoned orchards in the Barranco de Tremps, Matarraña, Aragón, Spain

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Abstract

The Barranco de Tremps is one of many valleys in the vast hills of the region of Aragón, in the northeast of Spain. A barranco is a natural watercourse created by excessive rainfall, visible only as a dry river bed in summer. Such watercourses and riverbeds are no longer present in this valley.
Today, the valley is full of olive and almond orchards surrounded by pine forests. Summers are increasingly hot and without rain. Since the advent of the tractor in the late 1980s, the soil is ploughed more often and more deeply, and there is little soil life left. During the winter months, wind and rain erode the bare soil, which absorbs almost no rainwater. The water retaining old stone walls have been breached by new wider tractor access paths, through which rainwater also washes away.

Eight hectares of orchards and forest in this valley are owned and cared for by a landscape architect and her partner. A longing to work closer to nature and a desire to transform a semi-arid area into a rich and biodiverse landscape brought them to this spot. They are exploring old and new horticulture techniques to enrich the terrain with diverse planting, to improve soil quality and increase its ability to hold water. Some of these experiments fail, some succeed. In this in-situ laboratory, all experiences contribute to the knowledge of the relationships between soil, vegetation, land use, cultivation, and water cycles.

This visual report gives an impression of the terrain, shows the various experiments of the past two years and the gradual development of spatial principles for design and management.

Keywords

Landscape architecture, in situ design research, semi-arid landscape, land management, maintenance, fresh water resource management, rainwater harvesting, reforestation

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Location

FIGURE 1 The site is located between the rivers Guadalope and Matarraña

The Barranco is close to the village of Mazaléon, between the Guadalope and Matarraña rivers in the Aragón region. The area slopes down from the Iberian Mountains to the lowlands of the Ebro Delta. The hilly landscape is relatively green and its valleys come in many different shapes.

The valley is named after the 520-metre high hilltop, the Tremps. The site is situated at the beginning of the 9-kilometre long valley that runs off to the west into the Embalse de Caspe, the barrage in the Guadalope river tapped to irrigate the surrounding land. Today, there is no trace left of the watercourse that once flowed through the valley strip.

Love

For many years, we have been fascinated by the impressive developments of reforestation and re-greening projects in Africa and Asia. At this very spot in Spain, we have the opportunity to explore and experiment in re-greening by working on the land. Exploring an unknown territory, connecting with the landscape, and the possibility to exchange ideas are some of our motives for this undertaking. More simply, this adventure is about our love for trees, landscape, and nature.

Laboratory

We are experimenting with several techniques. We acquire knowledge by talking to local farmers and residents, looking into publications and research, into centuries-old practices and methods, as well as innovative techniques. Moreover, we carefully observe the terrain, like the continuous changes during the day and across the seasons.

FIGURE 2 Long lines of the stone walls in the orchards contrast with the dark pine forests.

FIGURE 3 In the scattered barns, different families used to live and work together during harvest time.

The stone walls[1], a land cultivation practice dating back to the early middle ages, and overgrown vegetated ramps between the terraces follow the height lines of the terrain. These remarkable lines, together with the grey-green olive trees, contrast with the dark pine forests on the top of the hills.

Happy days

Until the late 1970s, before the advent of the tractor, several families lived in stone barns for a few weeks each year to harvest and work on the land. The locals tell us stories about eating, singing, and dancing together in those old, happy days. They say it rained more and often, the temperature was lower, and stormwater was retained by the terraces that preserved enough water to grow vegetables, allowing them to eat from their own gardens. In recent years, the small-scale, scattered orchards are no longer profitable and are not maintained as well as they once were.

FIGURE 4 Summer 2019

FIGURE 5 Winter 2019

Water cycle - year round

Summers are increasingly hot and dry; the temperature can rise to 40 degrees Celsius and there is no rain for many months. The soil is rock-hard. Due to the constant deep ploughing, the soil in the orchards has lain fallow for decades. We have observed little remaining life in the soil.

In the winter, the rain is harsh and heavy. Swirling streams of water gush down from the flattened terraces, causing erosion and loss of topsoil. The soil is soft and soggy. On average, 350 mm of water falls per year, mainly in the winter season.

1 Most of Spain was brought into culture by the Moors from 711 onwards. The quality of the most beautiful walls in this region are attributed to the skill and knowledge of the Moors. In the middle of the last century, the walls were neglected and later destroyed by the rough work of the tractor. The walls on our site are of varying quality and were probably made in the late Middle Ages.

FIGURE 6 Early morning mist

Presence of water

In spring and autumn, water is subtly present. Every day, a moment appears when the water shows itself; for example, right before the sun rises over the hill, in the early morning mist, or when you dig deep into the mulch, or as thick drops on branches,and since this year, the water of the night lingers longer in the emerging vetch and winter grain.

FIGURE 7 Moist mulch

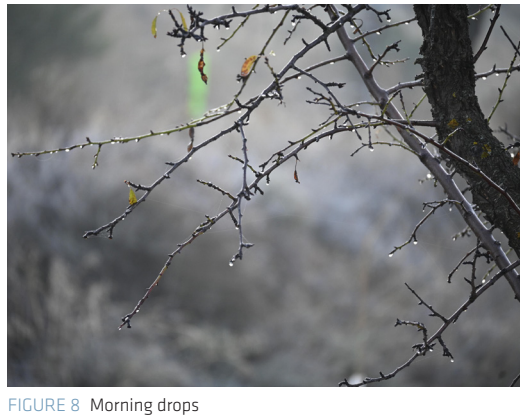

FIGURE 8 Morning drops

FIGURE 9 Dew in emerging grain

FIGURE 10 The barn after renovation

Off Grid

The barn has been converted into a comfortable 'off grid' home. Solar panels generate electricity while rainwater is harvested in a newly built underground cistern. It is a remote place; only the farmers of the surrounding plots occasionally drop by for a chat. The isolation and the daily work on the land, as well as the overwhelming heat and drought, the strong wind, and the rare but heavy rain have changed us. In the Netherlands, we work systematically, often with a defined goal and clear steps to achieve it. In the valley, plans are made as we go along. Ever-evolving new insights, responding to the present circumstances, and plain pragmatism guide us on how to gradually transform the land and to live and work with nature.

Planting Water

The concept 'Planting water' was our first leitmotiv: roots, shade, and falling leaves enrich the soil with nutrients and improve water retaining capacity of the soil. We used various planting techniques, such as the Dutch Groasisbox[2], the Brazilian Syntropic Agroforestry planting method[3], treeprotectors for individual trees and the installation of irrigation hoses close to the plantings. All of these are done with the aim of improving the growing conditions of new trees, and with success; the majority have taken root and are starting to grow.

FIGURE 11 Preparation

FIGURE 12 Placement of Groasis box

FIGURE 13 Removal

FIGURE 14 Aftercare

A Groasis box is filled with 16 litres of water when placed. Rain and dew water can be collected through the white lid. A small string in the bottom of the box gives just enough water to the young plantings to keep them alive. This tree-linked irrigation method supports the development of the roots in the first season. After a year the tree is able to stand alone and the box is reused for a new tree.

2 Groasis Waterboxx is an instrument developed to grow trees in dry, deserted areas and rocks. The patented Waterboxx consists of a water container with a cut-out for planting the seedling in dry soil. At the bottom of the Waterboxx, there is a cut-out with a moisture-conducting string that is applied next to the seedling's roots when planting. Thanks to this artificial but limited moisture supply, the roots grow into the deeper soil, unlike sprinkler or drip irrigation, allowing the young plant to survive dry periods.

3 Syntropic Agroforestry is a design and management method for agriculture and forestry developed by the Brazilian Ernst Götsch. The method is based on understanding and imitating natural growth and succession processes. Some of its characteristics are: very dense sowing and planting distances, planting structure with many species in layers and strategic frequent pruning.

FIGURE 15 Preparing planting beds

FIGURE 16 Vetch explosion

FIGURE 17 Protecting remaining trees

At two locations, herb, shrub, and tree layers are planted very closely together on rills flanked by horse manure, according to the ideas of Syntropic Agroforestry. The rills are sawn with green manure crops and winter grain, visible in the middle picture. The densely planted trees, in combination with the frequent pruning of the fast-growing trees, increases the vigour of the young trees, according to the theory. Unfortunately, due to the unforeseen explosion of vetch and the voraciousness of the wild animals, both of which were rampant during our unforeseen absence, the herb and shrub layers did not survive. The remaining trees are now sticked in plastic tubes, for extra protection from sun, wind, and animal attacks.

FIGURE 18 Hoses & strings

FIGURE 19 Caps

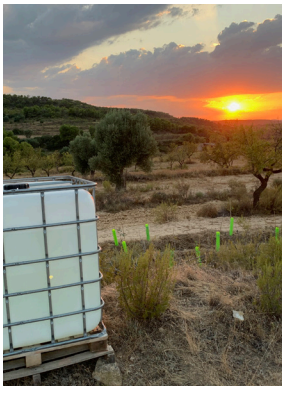

FIGURE 20 IBC tank

FIGURE 21 System of hoses

Large plastic IBCs[4] are filled with water, which is piped to the young trees through a system of hoses. Next to the trees, a hose with a string is placed vertically in the ground. This is a system that we created ourselves and, with the help of a timer, worked fairly well last year.

4 An IBC is a Intermate Bulk Container engineered for the mass handling, transport, and storage of liquids e.o.

FIGURE 22 Digging swales..

FIGURE 23 ...on a horizontal contour line

Swales

We try to keep the rain on the land for long as possible, by digging swales and creating ridges and small dykes. A swale is a shallow channel with gently sloping sides on a horizontal contour line. The swales we made are infiltration basins, designed to manage and slow down water runoff and increase rainwater infiltration in a deeper layer of the ground.

The swales were dug by a large excavator in a steep sloped hillside surrounded by abandoned groves where the soil had eroded due to wind and water and had been taken over by pioneer species. In wintertime, a good amount of water remains in the swales after heavy rainfall. The collected water sinks through a deeper layer into the bottom of the hill, causing it to stay longer in the terrain.

FIGURE 24 Filled swale in wintertime

Soil

From experience so far, we have noted that the improvement of the soil is, more than planting trees, most crucial for the development of the terrain. The cessation of deep ploughing makes a big difference for instance. From start we cultivated the land in various ways with the aim of improving structure and permeability of the soil and soil life, so that more water is retained in the soil.

FIGURE 25 The soil is covered with fresh green grain in spring 2020.

Grains

We have been sowing winter wheat and nitrogen fixatives such as vetch, wheat, oats and barley. Last spring, our part of the valley was extremely green. We noticed a lot of bees, insects, birds, and even a mole. In autumn, the vetches and grain are mowed with a flail mower. The clippings are left on the land to create a nutarian rich soil.

In the coming seasons, we will continue to experiment with different forms of tillage such as mowing, fertilizing, sowing and also doing nothing.

FIGURE 26 Spring 2019

FIGURE 27 Spring 2021

The work of the first year (Figure 26) consisted of planting young trees in some slopes of the terraces. Most were planted with Groasisboxes. The soil was rock hard at the time; digging a planting hole was almost a day's work. A small part of the terraces was no longer ploughed. Pruning wood was used to cover the soils of the abandoned orchards. The stone barn was renovated and a large cistern was dug by the contractor and his team.

In total (Figure 27), we planted over 1700 trees and shrubs, in rows, groups and in a loose formation. The majority have been planted at the edges of the forest. The trees were purchased from Spanish nurseries, as well as from our own cultivation: fruit trees, various types of oak, forest trees, and a few park trees, mainly local species from both recent and older days. All the terraces are newly sown and we dig more long swales and a small pond.

FIGURE 28 Digging

FIGURE 29 Sowing

FIGURE 30 Drilling

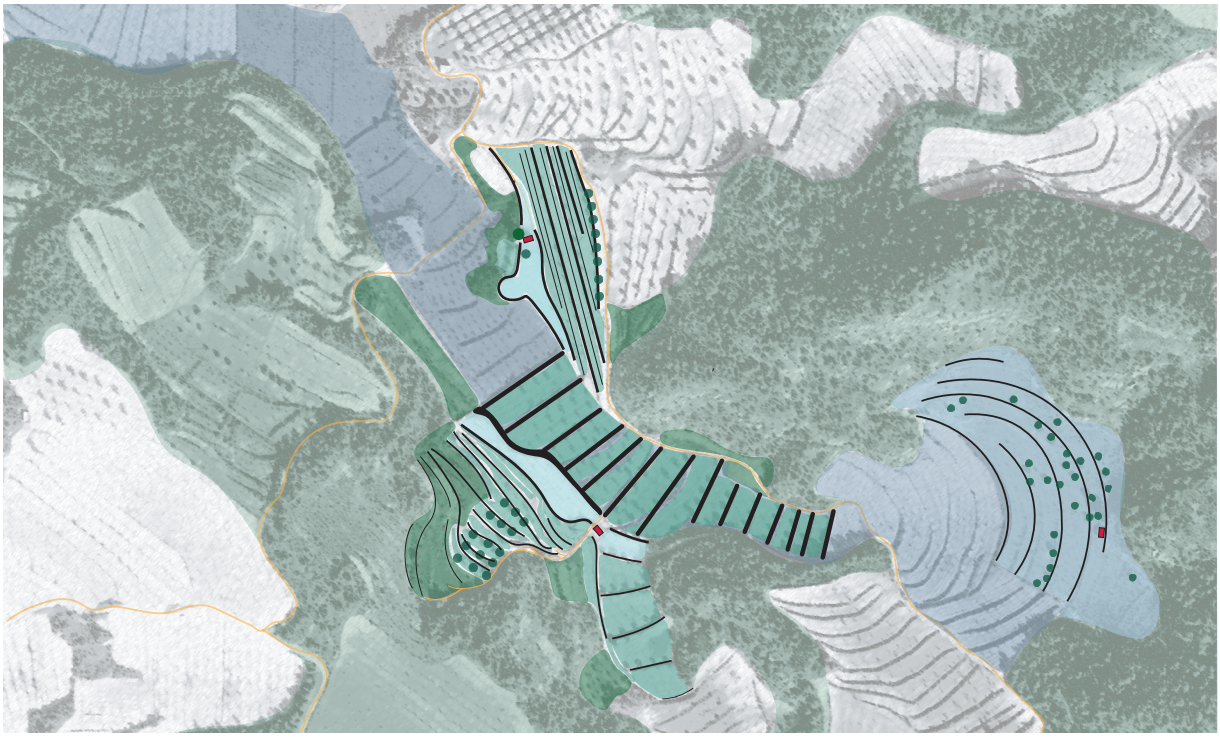

FIGURE 31 Patterns and structures in the valley

Structure

Along the way, the patterns and structures of the terrain and its position in the surrounding environment have come into sight. Patterns and structures shape the character, soul, and identity of this place. We add our own modest, sometimes outspoken, but above all natural layer to the landscape. Characteristic patterns are the elongated stone terraces and the groves with rows of olive trees surrounded by dark wild pine forest. New trees, water courses, and cornfields are added to these old structures. New trees and shrubs are mostly positioned along the edge of the pine forest, amplifying the contrast with the existing olive groves. Circular shapes in the grass, scattered terraces as look-out points and marked footpaths are new, more outspoken ad ditions to the landscape.

Designing

Designing during construction does not mean constantly changing plans. It is more about establishing a robust framework in which the unforeseen can take place. Such a frame creates coherence, beauty, and a connection with the greater whole of the past and the future in space and time.

Lessons Learned

For the last three years, we have lived for regular periods in the valley while working and shaping the land. With enough time on our hands to try, to fail, and to start all over again. Time and space are luxuries and a great asset to understanding the relationship between soil, plants, and water. We have experienced and learned how to work with these ingredients at hand, without importing materials from 'elsewhere.' We have learned to use all our senses more intensively; we can better smell, hear, and feel the land. Over time, we have become more sensitive to understanding where we can seize the moment and when we need to step back and let nature take its course.

It has been challenging to break with our initial instinct to preserve all the smaller parts we learn to love. This sometimes prevents us from making a bigger impact while risking lingering in the details. This conflict, at the same time, forces us to keep our greater goals and strategy in mind and keep on going with robust interventions while avoiding transformations of the landscape that are too drastic.

We've experienced and acquired a deep knowledge of the landscape by 'doing.' While trying out techniques and methods on the spot, you immediately see what might work and what doesn't. By physically engaging with the landscape, you appeal to all your senses, engage more deeply with the local community, and build your intuition and trust. I wish for any designer to be able to leave their desk and computer, and to go outside to build up a physical and emotional relationship with the landscape in which they design.

Future

We are working on the landscape with the awareness that we are only here for a few decades. The approach, the ambitions and also the techniques of our project are familiar to more large-scale and long-term reforestation and regenerative land-building projects that are also being developed in Spain. A more large-scale approach is also conceivable in the landscapes of Guadalope and Matarraña. We explore and investigate how we can contribute to the quality of the landscape on a bigger scale. We are convinced through commitment, love, and attention there will be movement and growth towards a more sustainable biodiverse landscape, sometimes apparent only by talking with our neighbours.

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While this visual essay was in development, Marjolein Hillege was interviewed about the Barranco de Tremps project by the Dutch landscape magazine De Blauwe Kamer (nr. 01 / 2021). Due to this there is some overlap in imagery and content.

Further Information

www.alvelal.net - *this association unites farmers, livestock breeders, businessmen from various sectors, traders, researchers from universities and other institutions to build a more prosperous future, especially for agriculture land in Granada*

www.commonland.com - *Commonland is an organization with a mission to transform degraded landscapes into thriving ecosystems and communities based on sound business cases and aligned with international policies and guidelines*.

www.ecosystemrestorationcamps.org - *Ecosystem Restoration Camps is a global movement of people that is creating an abundant earth by repairing broken ecosystems together.*

www.rewildingeurope.com - *this organization is working in eight large rewilding areas* across Europe, *Their aim is to create large, rewilded landscapes, demonstrating how Rewilding Europe's vision can be put into practice on a far larger scale*.

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