Rising above surface

Comparative Review of Xinghua Duotian and Chinampas Water Systems

Rapa Surajaras [1], **Catalina Rey** [2]

[1] *OKRA landschapsarchitecten, Utrecht, The Netherlands*
[2] *Water Resources Management Group, Department Environmental Sciences, Wageningen University, The Netherlands"*

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

DOI

https://doi.org/10.7480/spool.2021.3.6216

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.

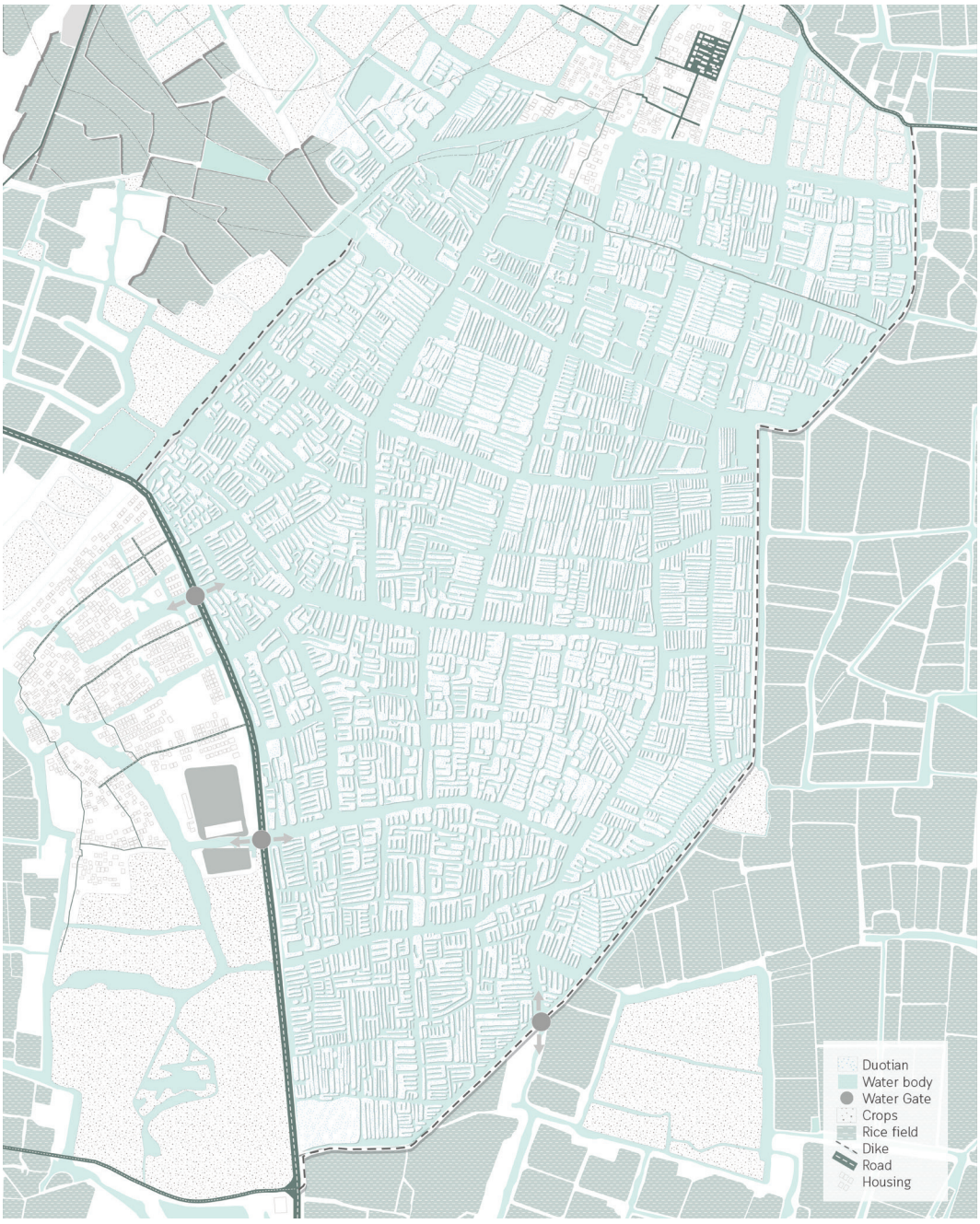


FIGURE 5 Overall plan of Xinghua Duotian Water System. Copyright 2021 by author

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.

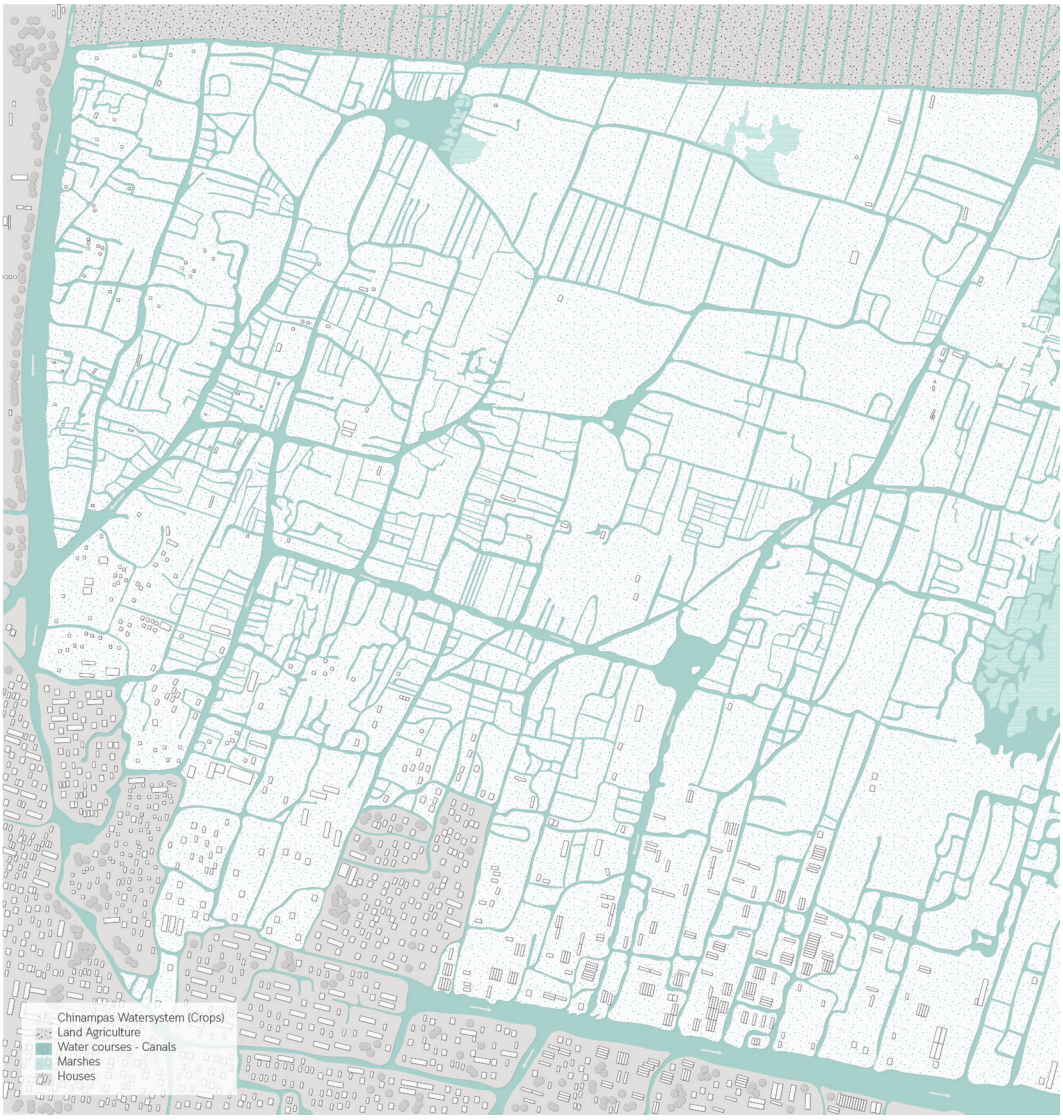


FIGURE 6 Overall plan of Chinampas Water System. Copyright 2021 by author

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).

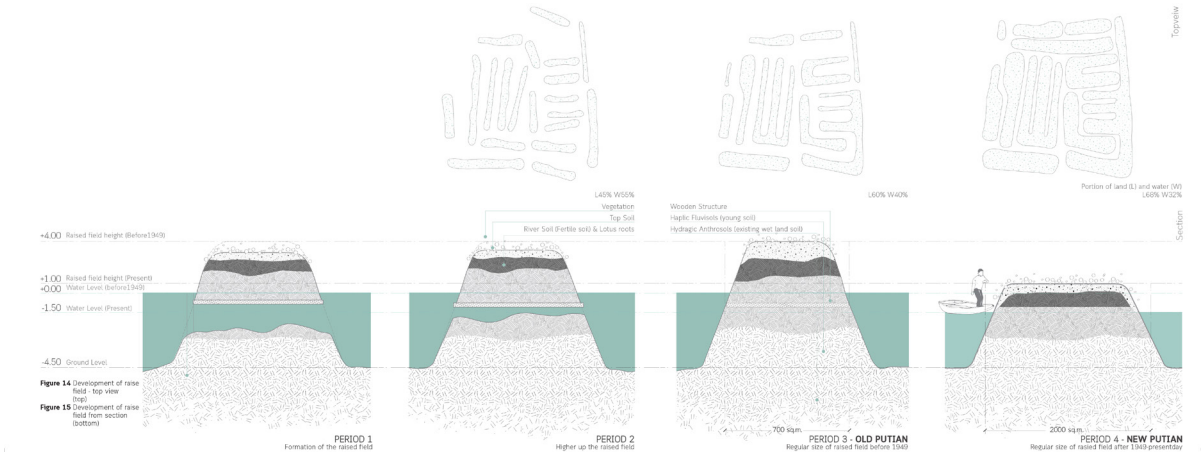


FIGURE 7 Detail plan and section through different period of time - Xinghua Duotian Water System. Copyright 2021 by author

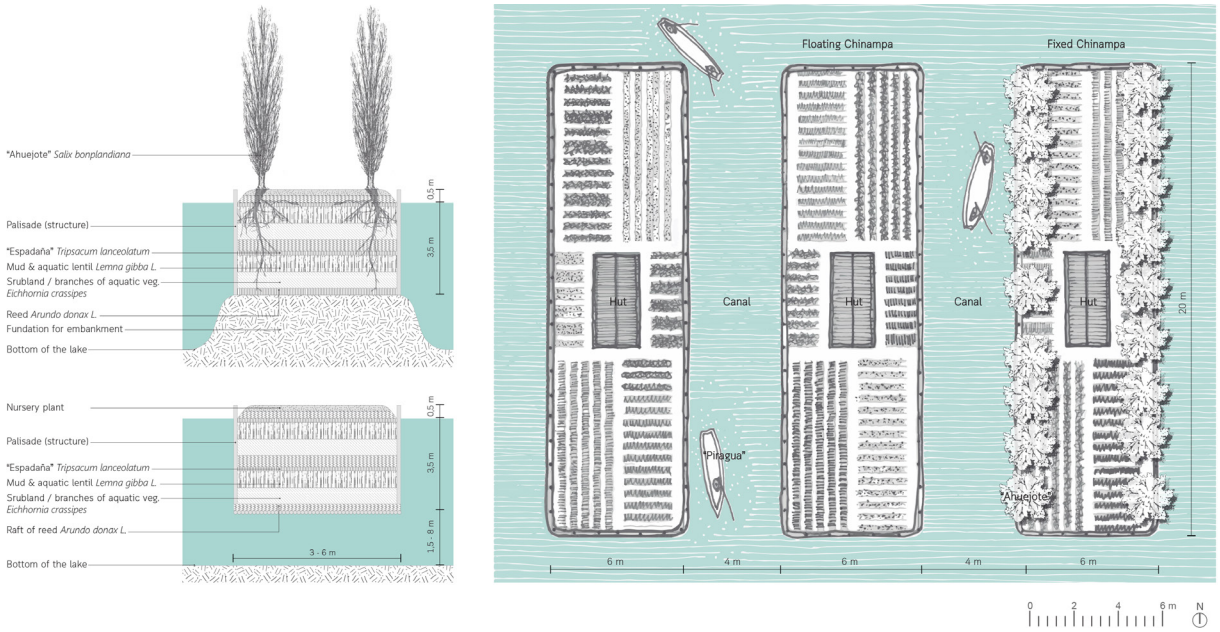


FIGURE 8 Detail plan and section of Chinampas Water System. Copyright 2021 by author

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.

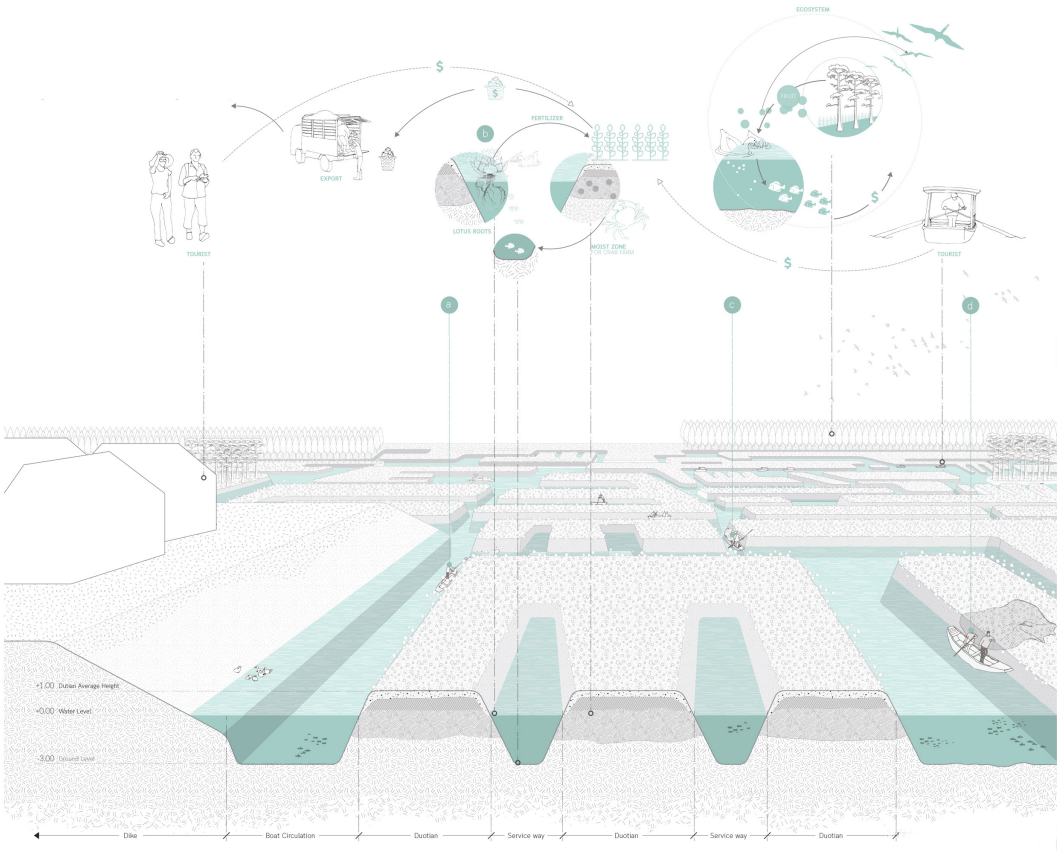


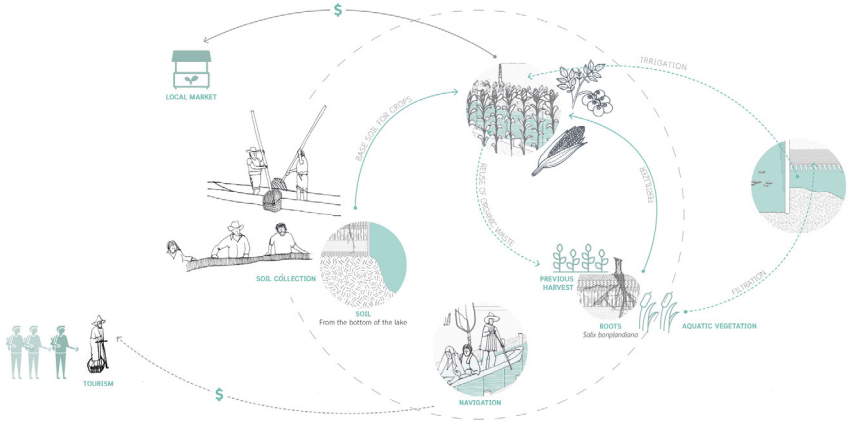
FIGURE 9 Xinghua | Circular economy of the system - representation of sustainability (top); Section perspective of the area showing the overall atmosphere (bottom). Both copyright 2021 by author

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.



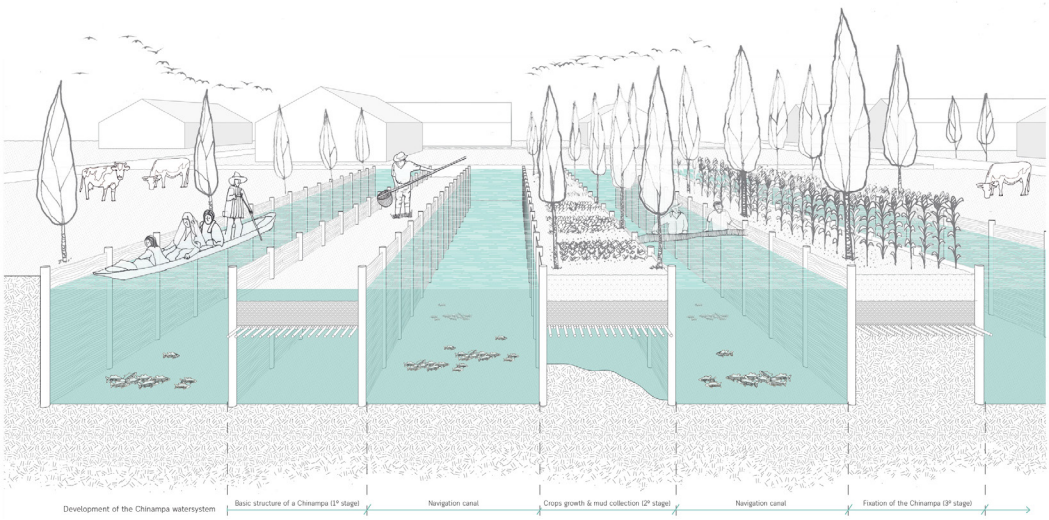


FIGURE 10 Chinampas | Circularity of the system / Representation of sustainability (Top); Section perspective of the Chinampas Watersystem (Bottom). Both copyright 2021 by author

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

The analysis of the individual cases was conducted in the first Circular Water Stories Lab 2018/19. The lab is part of the graduation studio Flowscapes at the master track of Landscape Architecture at TU Delft and is led by Dr. ir I. Bobbink.

References

Alcántara, S. (2007). *The Chinampas Before and After the Conquest. In Botanical Progress, Horticultural Innovation and Cultural Change* (pp.159-175). Dumbarton Oaks Research Library and Collection.

Bobbink, I. (2019). Testing the illustrative method: How to reveal hidden knowledge stored in traditional water systems. In L. Gao, & S. Egoz (Eds.), *Lessons from the Past, Visions for the Future: Celebrating One Hundred Years of Landscape Architecture Education in Europe* (pp. 100-102). Norwegian University of Life Sciences.

Bobbink, I. & Ryu, M. (2017). *Traditional water systems, an analytical method to reveal its knowledge for today*. Unpublished manuscript.

Echeverría, I. (2009). *Parque Ecológico, Lago de Texoco.* http://www.parquetexcoco.com/descargas/presentacion_en.pdf

Gibson, C., & Campos, J. (1967). *Los aztecas bajo el dominio español [Aztecs Under Spanish Rule]*, 1519-1810. Siglo Veintiuno.

Government of Mexico City (2017). *Chinampa Agricultural System of Mexico City.* GIAHS Proposal - A proposal for Designation as Globally Important Agricultural Heritage Systems (GIAHS).

Ryu, M. (2012). *Typologies for Sustainable Water Use in Historical Japanese Towns.* http:// stimuleringsfonds.nl/toekenningen/928/typologies_for_ sustainable_water_use_in_historical_japanese_towns. Accessed 27 July 2017.

Scarborough, V. L. (2009). The flow of power: Ancient water systems and landscapes. SAR Press.

Steenbergen, C., Meeks, S., & Nijhuis, S. (2008). *Composing landscapes. Analysis, Typology and Experiments for Design*. Springer

The People's Government of Xinghua City (2014). *GIAHS Proposal Globally Important Agricultural Heritage Systems (GIAHS) Initiative*. Xinghua Duotian Agrosystem.

Yanying, B., Xueping, S., Mi, T., & Fuller, A. M. (2014). Typical WaterLand Utilization GIAHS in Low-Lying Areas: The Xinghua Duotian Agrosystem Example in China. *Journal of Resources and Ecology,5(4).* doi:10.5814/j.issn.1674-764x.2014.04.006

里下河平原 [Lixiahe Plain]. (2018, July 21). https://zh.wikipedia.org/wiki/里下河平原