HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

Water management-

New ways for sustainable cultural landscape

NingDongGe

Budapest

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The PhD School

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Approval of the Head of Doctoral School	Approval of the Supervisor(s)

1. BACKGROUND OF THE WORK AND ITS AIMS

Water Management for Sustainable landscape in a Changing Climate

Recent years have seen a marked increase in environmental and ecological issues attributed to climate change, elevating sustainable development to a global priority. The essence of sustainable development, as reflected through Maslow's hierarchy of needs, is humanity's pursuit of a favorable environment essential for survival and development. Water resources, pivotal for sustenance and progress, are at the heart of the United Nations Sustainable Development Goals, emphasizing the critical role of water resource management in maintaining ecological balance and social welfare.

Urbanization and population growth have exacerbated challenges in water management. Urban surfaces, once facilitators of water cycling, are now increasingly covered by impermeable materials, reducing the natural water cycle's efficiency. Additionally, the increased demand for water in agriculture and industry, coupled with inefficient usage and pollution, has strained available water resources. Climate anomalies, such as frequent extreme weather events, have altered precipitation patterns, exacerbating water scarcity and urban flooding, thus posing significant hurdles to sustainable development.

Effective water management strategies are crucial for adapting to these challenges. These strategies encompass improving water collection, storage, distribution, and efficient usage, as well as protecting and restoring aquatic ecosystems. This approach helps mitigate the impact of climate anomalies on agriculture, ecosystems, and human communities, reinforcing the importance of adaptive water management.

Taking a broader perspective, different climatic zones present unique challenges and opportunities for water management. The varying impacts of climate change across regions like the Eurasian continent, with its diverse climatic zones from monsoon climates in Southeast and South Asia to Mediterranean and temperate maritime climates in the west, necessitate region-specific adaptation strategies. Learning from local survival strategies, which have evolved over time, provides invaluable insights into crafting context-sensitive and culturally aware adaptation strategies.

Furthermore, hydro-cultural landscapes, shaped by both natural geographical features and human adaptations, play a significant role in human settlement patterns and socio-economic activities. Traditional water systems, often rooted in deep cultural and religious significance, demonstrate sustainable practices that optimize water use, protect ecosystems, and foster community connections. Integrating cultural heritage into modern water resource management strategies not only preserves these rich traditions but also proposes a forward-looking approach to sustainable development that harmonizes modern practices with historical wisdom.

In conclusion, addressing climate change and advancing sustainable development requires a comprehensive understanding of hydro-cultural landscapes and a commitment to applying traditional wisdom in modern water management practices. This approach not only addresses the immediate challenges posed by climate change but also ensures the long-term sustainability of water resources, crucial for the survival and flourishing of future generations.

Aim

This research, centering on traditional water management, aims to summarize the knowledge, techniques, and experiences of predecessors from the perspective of cultural landscapes. The primary research objective is to identify water management strategies that align with current sustainable development needs, and based on this, to establish new, innovative ways to develop and manage cultural landscapes.

Initially, the study conducts a historical review of several cases related to traditional water management strategies, identifying similarities and differences across various regions and scales. Conducting comparative analysis, the study synthesizes the common logic underpinning traditional water management strategies and explains why this logic can be applied across cultures and regions.

Representative cases of traditional Chinese water landscapes are selected for field investigations to delve deeply into the technical knowledge of traditional water management. This research incorporates interdisciplinary methods from disciplines such as geography and landscape architecture, aiming to provide a multifaceted perspective for the study of traditional water management strategies. It also explores how various factors, including culture, society, religious beliefs, and traditional philosophy, influence or dictate the formation of water cultural landscapes.

Theoretically, this study conducts an in-depth exploration of traditional water management strategies. By engaging with discussions on Nature-Based Solutions (NBS), it establishes new concepts. Additionally, the study innovatively employs drone 3D modeling for water landscapes, utilizing these models for data measurement and analysis.

Furthermore, the research is committed to offering landscape architectural solutions to address climate anomalies. It involves analyzing precipitation data to predict future rainfall trends and providing landscape design strategies based on these trends. The effectiveness of these strategies is validated through data analysis.

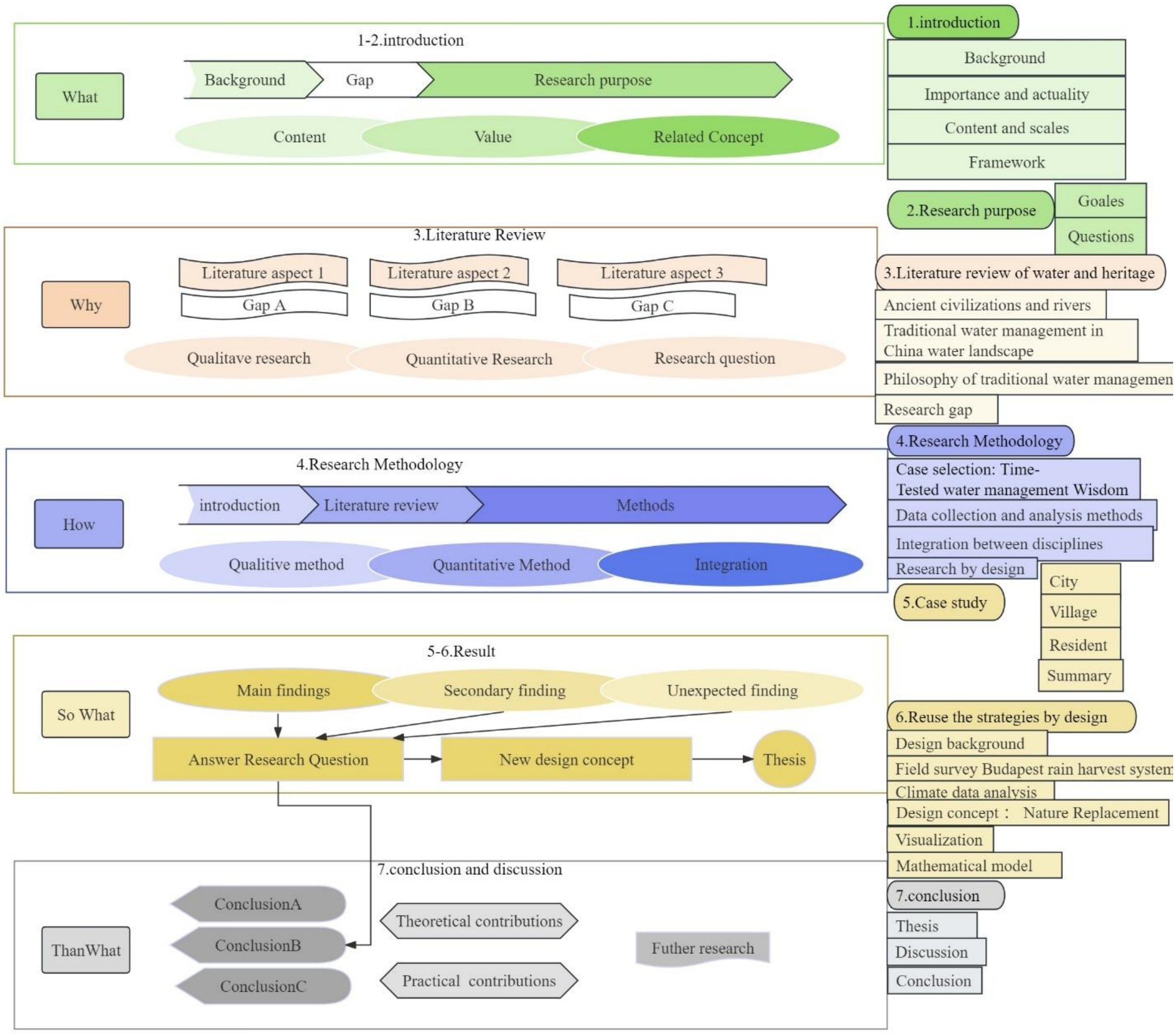

Figure 1. Research Framework

2. MATERIALS AND METHODS

The primary research methods employed are literature review and field research, analyzing and integrating traditional water management knowledge and techniques to further identify general water management strategies applicable across different environments. The relationship between local communities and their cultural heritage related to water management will also be examined.

Adopting an interdisciplinary perspective, the study analyzes case studies in China and Europe to understand the common logic behind local communities' water management strategies under varying natural and cultural contexts, ensuring the cross-regional applicability of water management strategies.

The study also presents case studies of traditional water management at three scales in the same cultural landscape area: Southeast China (including urban, rural and residential scales). Traditional water management strategies at these different scales are summarized and a general integrated water management framework is derived. Finally, through research by design, the framework is applied to the redesign of water management facilities in Budapest to enhance local community participation, landscape sustainability, and cultural heritage conservation and reuse.

In summary, the aim of this study is to attempt to establish a harmonious coexistence between human and natural environments by analyzing and justifying data on traditional water management (derived from cultural heritage). This study also explores sustainable water management strategies that combine modern needs with traditional wisdom in order to preserve cultural landscapes. It explores case studies from different backgrounds and at different scales, developing widely used strategies and their application in Budapest, demonstrating a future where heritage and sustainability combine.

2.1 Case Selection: Time-Tested Water Management Wisdom

This research delves into the enduring practices of traditional water management in China, emphasizing its significant role in shaping landscapes and civilizations. The Xiangjiang River Basin has been selected as the primary site due to its independent environmental context and comparable hydrological characteristics across traditional settlements, which are the focal points of study. An additional case study from Ganzhou in the Yangtze River Basin supplements this, providing a broader perspective on urban adaptation of ancient water management practices obscured by modern development.

2.2 Data Collection and Analysis Methods

2.2.1 Landscape Historical Survey

The methodological framework integrates both qualitative and quantitative approaches, using interdisciplinary research principles. Data collection involves extensive archival research, literature reviews focusing on traditional ecological strategies, and a robust examination of cultural heritage and settlement landscapes. Key institutions like Hengyang Normal University and the National - Local Joint Engineering Laboratory provide critical references and digital resources. This phase also includes an in-depth exploration of various source types, including textual, visual, and material sources.

2.2.2 Site Survey and Data Processing

Field investigations were conducted across different scales—from dwellings and villages to urban settings—within the Yangtze River Basin. This empirical research involved mapping, photogrammetric analysis using drones, and direct engagement with local communities through interviews. The survey aimed at collecting quantifiable data to analyze water management strategies while integrating qualitative insights from historical usage and local experiences. Notable techniques included the use of GIS for spatial analysis and predictive modeling to analyze climate and hydrological data, enhancing the understanding of traditional water management within contemporary applications.

2.3 Integration Between Disciplines

This study applies Jack Ahern's abiotic-biotic-cultural model, which emphasizes a multidisciplinary approach aligning water resources, biodiversity, and cultural goals. The research integrates environmental science, landscape architecture, and local heritage to devise sustainable water management strategies that resonate with both ecological and cultural dimensions of the study areas.

2.4 Research by Design

Adopting a research by design methodology, the study emphasizes creative, iterative processes in planning and design, inspired by Scandinavian participatory approaches. This method fosters continuous interaction with the community, ensuring that the developed solutions are viable and tailored to local needs. The design principles derived from this approach are tested and refined through case studies, enhancing the practical application of traditional water management strategies in modern settings.

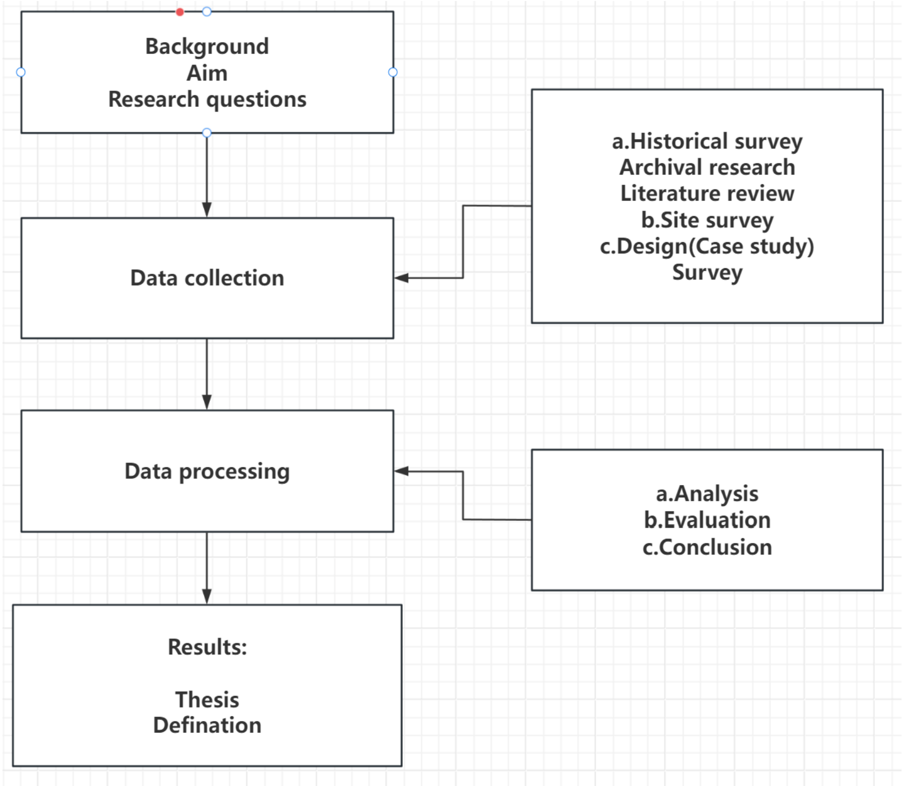

Figure 2 Research by design process

3. RESULTS AND DISCUSSION

Result of theorical research

Time Dimension:

Taking into account the temporal patterns of precipitation in Budapest, this design integrates a piece of Hungarian intangible cultural heritage: "Ártéri fokgazdálkodás/ floodplain agriculture, (Kohán, 2003) " which involves utilizing vertical water level differences created by seasonal variations of the rivers for fishing and agricultural activities(Bryan, 1929). This design exploits the height differences within the courtyards and seasonal variations in rainfall. During the summer, rainwater is collected from rooftops and channels into an extended drainage system—consisting of horizontal pipes at each floor level -for irrigating courtyard vegetation or replenishing pond water. This storage structure extends the retention time of rainwater, thereby alleviating the pressure on street drainage systems during flood-prone periods. It also utilizes natural water pressure to facilitate flow.

Spatial Dimension:

Through the redesign of water facilities, water elements are used to extend blue-green infrastructure horizontally across originally vertical courtyard spaces. The design aligns with the concepts of vertical gardens and "pocket parks," thus achieving protective development within limited heritage spaces.

Human Dimension:

While offering public spaces for local residents—like pocket parks situated in the courtyards—this design also aims to enhance community engagement. The selection and cultivation of plants in different floor corridors are left to the community, offering choices ranging from ornamental to medicinal and edible plants. This selection process can also serve as an opportunity for ecological education among local residents Chen et al., 2016) .

Result of case study

I conducted a linear regression analysis of the catchment volumes of two types of courtyards (patios) within the Xiangjiang River Basin and those within the architectural heritage area of Budapest (V'th district), comparing their similarities and differences, and analysing the results. Through Budapest Rain Harvest equation，I determined the applicability of traditional water management strategies based on courtyard structures across different regions.The regression formula:

$R1=6.336P1+86.63$

$R2=3.466P2+21.23$

$R3=1.224P3+1156.2$ (1)

Roof 1: Zhang Gu Ying village roof rain water harvest area

Roof2: ShangGanTang villages roof rain water harvest area

Roof3: Budapest roof rain water harvest area

Patio1: ZhangGuYing village patio area

Patio2： ShangGanTang village patio area

Patio3: Budapest patio area

Slope Interpretation:

The slopes of the lines (6.336, 3.466, and 1.224) are measures of how much the roof area changes for a unit change in the patio area.

For Zhang Gu Ying village, a unit increase in patio area results in a 6.336 unit increase in the roof area.

For ShangGanTang village, the corresponding increase is 3.466 units.

For Budapest, the increase is much smaller, at 1.224 units.

The slope values suggest that this correlation is stronger in Zhang Gu Ying and ShangGanTang villages compared to Budapest. This could be attributed to local communities' practices, climate, or cultural heritage factors that prioritize larger roof areas relative to patios for rainwater harvesting.

Result of research by design

Rain water amount collection
S village year average perception（roof）：1426mm/㎡ *1251 ㎡=1783.93L
August（max） ：255 mm/㎡ =319L
Z village year average perception（roof）：1353mm/㎡ *4242 ㎡=5739.4L
August（max） ：172.9 mm/㎡ =733.44L
Budapest year average perception（roof）:500mm/㎡* 144824 ㎡=72412L
August（max） ：70 mm/㎡ =10137.6L
The evaporation: in Budapest：86%
The water amount be storage(processed):10138L
The Budapest Rain Harvest equation:

$M(R)=(1.224R+115.6) \times a \times b$

M(R) is the amount of water that roof should be processed, in units of mm or L.
1.224R+115.6 represents the roof area for rainwater harvesting and storage, presumably in square meters.

"a" is a dimensionless constant, replacing the specific precipitation value of 500 mm per square meter.

"b" is another dimensionless constant, representing the Effective Precipitation rate, replacing the specific value of 0.14.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

By examining traditional water management practices through a blend of historical analysis, field surveys, and interdisciplinary design, this research highlights the potential for ancient wisdom to inform contemporary strategies in water management. It demonstrates a sophisticated integration of qualitative and quantitative data, drawing on extensive resources and collaborative approaches to address challenges posed by climate change and urban development. The methodology outlined supports a holistic understanding of the subject matter, contributing to sustainable development and heritage conservation.

4.1 Summary of Theory and Practical Research

The dissertation presents a comprehensive exploration of traditional water management within the context of sustainable heritage. It underscores the significance of these practices in promoting sustainable development, cultural preservation, and advancements in landscape architecture. By navigating through historical, philosophical, geographical, and technical perspectives, the research highlights the essential role of traditional water management in fostering a balance among economic, societal, and environmental facets. These practices are depicted as a fusion of tangible and intangible heritage, deeply embedded in the principles of environmental adaptation and the symbiotic relationship between humans and nature.

The findings span across different cultures and geographical regions, demonstrating the global applicability and versatility of traditional water management strategies to tackle modern environmental challenges. A notable emphasis is placed on the influence of traditional Chinese philosophies in shaping water-related cultural landscapes, advocating for a design ethos that marries spiritual and physical aspects to foster sustainable interaction with the natural environment.

The interdisciplinary methodology enriches our understanding of water landscapes as dynamic entities that transcend time and cultural boundaries. The dissertation posits water management as a cornerstone in human civilization, integral to the nexus of people, their environments, and their cultural legacies.

A multi-scaled approach to traditional water management is elaborated, addressing regional, settlement, and individual levels, each crucial for accommodating diverse ecological and societal needs. The concept of patios is discussed as micro-level architectural elements crucial for sustainable water practices.

Innovatively, the dissertation introduces Nature Replace Solutions (NRS), blending traditional insights with modern engineering to enhance water management systems. The Budapest Rain Harvest equation and the modeling of a roof-patio system in Budapest exemplify the application of traditional strategies in contemporary settings, providing a quantitative framework for future implementations.

In essence, this dissertation reinforces the indispensable role of traditional water management in contemporary sustainable development and heritage conservation. It advocates for the integration of these age-old practices into current water management strategies to ensure their perpetuation and relevance for future generations, offering a vital contribution to global sustainable development and landscape architecture discourse.

4.2 Future Research

The dissertation outlines several potential directions for future research that could further our understanding of sustainable landscape practices and architectural heritage:

Thermal Environment Research of Patio Systems:

- Quantitative Assessment: Investigate the cooling effects of patio systems through empirical measurements comparing temperatures in environments with and without patio features.
- Material and Design Factors: Analyze how different materials and designs contribute to thermal comfort and efficiency.
- Modeling and Simulation: Employ simulation tools to assess the impact of patio systems on urban temperature profiles, potentially addressing urban heat islands.

Comparative Research of Patios between Pompeii and Southeast China:

- Historical and Cultural Contexts: Delve into how differing historical and cultural backgrounds have influenced patio designs and functions.
- Design and Functionality: Compare the architectural and functional aspects of patios, focusing on water management and thermal properties.
- Sustainability and Modern Applications: Explore ancient patio designs for insights into modern sustainable architecture challenges.

Broader Implications for Sustainable Development and Cultural Heritage Preservation:

- Policy Frameworks and Community Engagement: Develop policies that incorporate traditional water management into modern urban planning and heritage conservation. Engage communities in the preservation and revitalization of these practices.
- Research and Development Support: Increase support for interdisciplinary research and pilot projects that integrate traditional and modern water management strategies.

4.3 Policy Recommendations

To effectively integrate traditional water management into contemporary contexts, several policy recommendations are proposed:

Integration into Urban Planning: Encourage the incorporation of traditional water management principles into urban development policies, emphasizing water-sensitive designs.

Promotion of Traditional Practices: Advocate for the use of traditional methods in sustainable landscape development through incentives.

Cultural Heritage Preservation: Enhance efforts to document and promote traditional water management systems as cultural heritage.

Educational Programs: Implement educational initiatives to raise awareness about the benefits of traditional water management.

Support for Research and International Collaboration: Boost funding for research and promote international cooperation on traditional water management studies.

Policy Development for Nature Replace Solutions (NRS): Foster policies that support the application of NRS in enhancing water management infrastructure.

Climate Adaptation Strategies: Integrate traditional water management into climate adaptation strategies to improve resilience to climate variability.

These recommendations and future research directions underscore a commitment to blending historical wisdom with contemporary technological and ecological advances, aiming to craft a sustainable future that respects and revitalizes our rich cultural and environmental heritage.

5. NEW SCIENTIFIC RESULTS

THESIS 1 - Sustainable Heritage: Traditional water management

<u>I found, that traditional water management is one of the basic conditions to achieve the harmony and balance between economy, society and environment. I found, that the theory and practice of the traditional water management worldwide can be considered as tangible and intangible Landscape Heritage, and this is an organic and indispensable component of the concept of sustainable landscape development.</u>

I summarized the knowledge, techniques, and experiences related to traditional water management, highlighting the strategies and application of water management across different cultures and regions.

Through a literature review that organizes the relationship between ancient civilizations and rivers, I concluded that water management plays a crucial role in the origin and development of human civilization. By examining ancient China's historical documents and case studies in conjunction with the definition of cultural heritage, I discovered that traditional water management constitutes a sustainable form of cultural heritage and has three principles: circulation (flow), adaptation to the environment, and harmony of man and nature.

Through historical review and field investigations I identified key similarities and differences in traditional water management strategies in vernacular settlements located in Xiangjiangg River basin, providing a rich comparative analysis and proving the versatile applicability of traditional water management practices under different environmental conditions.

Further investigation through field research, interviews and archival studies revealed that six traditional villages in the Xiangjiang River basin have inherited and continuously employed traditional water management methods for site selection, settlement planning, and residential landscape design. The history of these water management and landscape design practices can be traced back to the Ming Dynasty (1371AD) and have persisted to the present days. Actual cases demonstrate the sustainability of water cultural heritage, namely: these water management strategies have exhibited continuity and resilience historically, spatially, and socially.

THESIS 2 - Design strategy: Philosophical background

In my exploration of the philosophical underpinnings of traditional water-related cultural landscapes in China, I have discovered that the traditional Chinese philosophies (Confucianism, Buddhism, Taoism) have had an important influence on the design of traditional water management. I established, that the traditional design strategies are driven by internal (spiritual) elements and influenced by external (physical) ones, together forming a harmonious design philosophy system.

I find how cultural, societal, religious beliefs, and traditional philosophies profoundly influence the formation and sustainability of water cultural landscapes. This aspect illustrates the multifaceted impact of non-physical factors on the practical applications of traditional water management strategies.

Taking as case study the cultural landscape formed along the Xiangjiang River's basin, we can observe, that the traditional Chinese philosophies of Confucianism, Buddhism, and Taoism have had an important influence on the values, customs, and beliefs of the Chinese people, which in turn has helped form a solid and sustainable concept of landscape planning. This is of great value for the promotion of sustainable development.

By proposing the perspective of "*internal elements driven, external elements influenced*" I introduced a multi-layered analytical framework that aids in deepening the understanding of the design philosophy behind traditional water-related cultural landscapes. Providing specific examples, historical document support, to demonstrate how internal and external elements collaboratively influence the design philosophy of traditional water management. Moreover, exploring how these elements specifically impact the design outcomes and the details of the socio-cultural environment further enhance the depth and breadth of the argument.

THESIS 3 - Water related landscape interpretation

Through an interdisciplinary approach I discussed the significance of historic water management from the perspective of the landscape, on the basis of which water management is a landscape that transcends time, space and culture. The interpretation “the landscape transcends time, space and culture" is not attributed to my proposal, but has gradually formed through the fusion of multiple disciplines such as landscape studies, geography, history and cultural studies. This concept reflects a deep understanding of water-related landscapes from a multidisciplinary perspective, emphasizing water landscapes as a product of the interaction between humans and nature, representing both the physical environment and a carrier of culture and social history. (picture43 Appendix A)

Several academic backgrounds are related to the development of this concept.

Landscape ecology emphasizes the relationship between ecological processes at different scales and landscape patterns. Early works (Forman and Gordon (1986)) initiated systematic studies on the spatial structure and functions of landscapes. This research draws on landscape ecology's definition of different scales.

Cultural geographers focus on cultural expressions and identity within space and place, such as Yi-Fu Tuan's "Topophilia" (1974) and Edward Relph's "Place and Placelessness" (1976), which explore the deep connection between place and cultural identity. I have drawn on this concept to enhance the connection between water management and local communities for the traditional water management reuse in design.

Historical geography studies highlight how the geographical environment affects historical processes and how historical events shape geographical spaces, emphasizing the role of time in the formation of landscapes.

Environmental historians like William Cronon in "Changes in the Land" (1983), explore how human activities have transformed the natural landscapes of North America. I have drawn on this theory of the interaction between humans and nature and the historical dimension of landscapes.

Combining the above academic backgrounds, I found that water management holds significant value throughout the development of human civilization. It reflects not only the regularity expressed by water management in spatial and temporal differentiation but also a common logic and core of water management across different cultural contexts.

My study summarizes the logic and core of traditional water management as continuity in time, space, and society, that is a landscape that transcends time, space and culture.

THESIS 4 – ‘Three-levels’ water management

I established, that traditional (sustainable) water management as Landscape Heritage can be modelized in three different levels or scales:

a. Regional scale;
b. Settlement scale;
c. Dwelling/object scale,

and these levels are strongly interconnected.

This result draws on landscape ecology's approach to scaling, a discipline that studies the impact of landscape structure, function, and changes on ecological processes, and ecosystem services. In landscape ecology, scale is a core concept, encompassing multiple levels from micro to macro. These scales include: micro scale, regional scale and global scale.

This result categorizes traditional water management heritage according to the level of the research cases into: urban and rural areas, and residences, that is, regional, settlement, and objects scales.

At the urban/regional scale, water management practices are often designed to address the needs of extensive geographical areas, incorporating large-scale infrastructures such as dams, canals, and reservoirs. This level emphasizes the strategic allocation and distribution of water resources across diverse ecological zones, ensuring the sustainability of water supply for agricultural, industrial, and domestic purposes. The planning and implementation of such systems necessitate a deep understanding of hydrological cycles, regional climate patterns, and the socio-economic dynamics of the area, highlighting the importance of an integrated approach to landscape and water management.

The village/settlement scale narrows down the focus to community-based practices that manage water resources at a more localized level. Here, the emphasis is on the collective efforts of communities to harness, distribute, and conserve water through communal wells, rainwater harvesting systems, and small-scale irrigation channels. This level showcases the vital role of communal solidarity and traditional knowledge in sustaining water management practices that are tailored to the specific needs and environmental conditions of individual settlements.

Finally, at the dwelling/object scale, water management becomes an intimate practice embedded within the daily lives of individuals and families. This scale focuses on the architectural and design elements that facilitate water conservation and efficient usage within homes and other structures. Features such as patios, roof gardens, and water storage units not only serve functional purposes but also reflect the cultural and aesthetic values of the community. This micro-level of water management underscores the adaptability of traditional practices to contemporary challenges, promoting sustainable living through the integration of heritage and innovation.

THESIS 5 - Patios: the basic units of traditional water management

Through historical and field research of 6 settlements, I have established a strong relationship between traditional water management, vernacular architectural structures (features) and sustainability in the Xianjiang River basin. Accordingly, I defined three different types of patios playing a crucial role in the water management, which can used as prototypes for future developments：

a. Village patio；

b. Large family patio；

c. Small family patio.

I also mapped their spatial distribution and characters.

By conducting on-site observations, photography, and mapping of the water landscapes in six settlements within the Xiangjiang River Basin, and through interviews with property owners, I identified and defined 3 main types of patios (Patio as the object level of water management), The classification of patios into three distinct types—village patios, large family patios, and small family patios—offers a nuanced understanding of how these architectural features serve not only as aesthetic and social centers but also as critical components of water sustainability. Village patios, often larger and centrally located, function as communal hubs where water is collected, stored, and distributed, embodying the collective effort in water management at the community level. Large family patios, on the other hand, cater to the needs of extended family units, incorporating more elaborate water collection and storage systems that reflect the economic and social status of the household. Lastly, small family patios represent the adaptability of this traditional practice to smaller, core family structures, showcasing the scalability and flexibility of patios in water management across different social units.

THESIS 6 - The dimensions of traditional water management

I established, that traditional water management strategies have three dimensions: the time dimension, the spatial dimension and the social dimension.

a. Time dimension：

Traditional water management focuses on the cycle of the four seasons, summarizing the rhythms and patterns of nature. Seasonal water retention measures extend the water cycle time. Traditional water management has accumulated a profound perception of the rhythms of nature through experience.

b. Spatial Dimension:

Balance between water and landscape structure. Managing water resources from both horizontal and vertical spatial angles with water as the axis.

c. Society Dimension: (Holism)

Humans are also part of nature, hence ethically follow nature’s metaphor. These dimensions showing the sustainability.

Time Dimension

The temporal aspect of traditional water management underscores a profound respect and attunement to the natural rhythms and cycles of the environment. By aligning water retention and utilization strategies with the seasonal variations, traditional societies demonstrate an advanced capability to enhance water availability and mitigate scarcity through the year. This cyclical approach reflects not only a deep-seated knowledge of local climatic patterns but also a long-term perspective on environmental management. It embodies the principle of sustainability by ensuring that water management practices do not exhaust resources but rather extend their viability across generations.

Spatial Dimension

The spatial dimension of traditional water management highlights the intricate relationship between water resources and the landscape's structural elements. By managing water in both horizontal (across the land) and vertical (through different elevations and depths) dimensions, with water serving as the central axis, traditional practices achieve a dynamic equilibrium within ecosystems. This approach demonstrates an intuitive understanding of hydrology, where the manipulation of water flows and storage is harmonized with the natural topography and landscape features. It showcases an advanced level of environmental design where water management is integrated seamlessly into the landscape, enhancing its resilience and productivity.

Social Dimension (Holism)

The social dimension emphasizes the ethical and holistic perspective that humans are integral components of nature, bound to follow its laws and rhythms. This view fosters a culture of respect for natural resources, promoting sustainable practices that go beyond mere utility to encompass moral and ethical considerations. The recognition of humanity's place within the natural world encourages practices that are not only environmentally sound but also socially equitable, ensuring the fair distribution and responsible use of water resources. This dimension highlights the role of traditional water management in fostering community solidarity, intergenerational equity, and a deep-seated sense of stewardship over natural resources.

THESIS 7 - Nature Replace Solutions (NRS)

I proposed a new design concept exploring the potential for integrating traditional and modern water management practices：the Nature Replace Solutions (NRS), utilizing Budapest patios as prototypes for NRS applications.

The literature review on NBS reveals a gap in deeply integrating traditional knowledge and practices with modern engineering solutions. While both approaches emphasize the use of natural processes to manage water resources and mitigate environmental challenges, there often remains a disconnect between these modern strategies and the rich heritage of traditional water management techniques. This gap can result in missed opportunities to harness the full potential of historically informed, culturally sensitive, and ecologically harmonious water management strategies.

Finally, through research by design apply the NRS concept and emphasizing the value and potential application of traditional knowledge in contemporary water management practices.

THESIS 8 - The rain harvest equation

I modelled, measured and calculated the correlation coefficient between the rooftop and courtyard (patio) catchment areas. I conducted a linear regression analysis of the catchment volumes of two types of courtyards (patios) within the Xiangjiang River Basin and those within the architectural heritage area of Budapest (Vth district), comparing their similarities and differences, and analysing the results. Through Budapest Rain Harvest equation， I determined the applicability of traditional water management strategies based on courtyard structures across different regions.

The regression formula:

$R1=6.336P1+86.63$

$R2=3.466P2+21.23$

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Roof 1: Zhang Gu Ying village roof rain water harvest area

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Roof3: Budapest roof rain water harvest area
Patio1: ZhangGuYing village patio area
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Slope Interpretation:
The slopes of the lines (6.336, 3.466, and 1.224) are measures of how much the roof area changes for a unit change in the patio area.
For Zhang Gu Ying village, a unit increase in patio area results in a 6.336 unit increase in the roof area.
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a is a dimensionless constant, replacing the specific precipitation value of 500 mm per square meter.
b is another dimensionless constant, representing the Effective Precipitation rate, replacing the specific value of 0.14.

THESIS 9 - Budapest roof-patio water management system model

Based on my research and analysis I formulated the mathematical model of traditional water management at object level

Step 1: Data Preprocessing and Analysis

Calculate Average Precipitation: First, compute the average precipitation for each month throughout the year. This step aids in understanding the seasonal variations and long-term trends of the data.

Identify Patterns and Trends: In addition to calculating averages, analyze fluctuations in precipitation data, the frequency of extreme events, seasonal patterns, and potential long-term changes (those caused by climate change).

Step 2: Constructing an Annual Precipitation Model

Determine Model Type: Based on the analysis of historical data, identify a model suitable for predicting annual precipitation. This could be a simple statistical model or a more complex time series analysis model.

Estimate Model Parameters: Use historical precipitation data to estimate model parameters. This include fitting curves, determining periodic components, and assessing trends.

Step 3: Prediction Using Markov Chains

Define States: Divide annual or monthly precipitation into different states based on precipitation amounts (, "drought," "normal," "wet").

Calculate Transition Probabilities: Analysis historical data to calculate the probability of transitioning from one state to another. This requires statistics on the frequency of various states following each state.

Construct Markov Chain: Based on calculated transition probabilities, construct a Markov chain model describing changes in precipitation states.

Step 4: Model Validation and Prediction

Model Validation: Before using the model for future predictions, validate it using a subset of historical data to check its predictive performance.

Make Predictions: Use the validated model and Markov chain to predict future precipitation patterns. Predictions made for the coming months, a year, or longer, including precipitation trends and potential state transitions.

6. LIST OF PUBLICATIONS

Journal paper

1. Ning, D. G, Yan, J., Liu, P., Van den Toorn, M. & Fekete, A. (2022). Historical Water Management Strategies - Case Study of Traditional Villages in Southern China, Hunan Province. Land, 11(12), 2107.

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