

Hydraulic Heritage and Community Identity: Examining Socio-Ecological Resilience and Heritage Transformation in Huaibei Area, China

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Abstract

This study explores the interrelations among socio-ecological resilience, identity construction, and hydraulic heritage through a case study of the Xiangyang Irrigation System in Huaibei, China. Tracing the system's transformation from a functional irrigation network to a fragmented cultural landscape, the research employs oral history, ethnographic observation, and semi-structured interviews to assess local perceptions. Findings reveal divergent community narratives shaped by varying levels of engagement and benefit. While some residents derive identity from the system's historical and cultural significance, others remain indifferent. The study concludes that hydraulic heritage contributes both to socio-ecological recovery and community identity, positioning it as a vital asset for sustainable regional development.

Keywords: Hydraulic heritage, Socio-ecological resilience, Identity construction, Sustainable development

1 Introduction

At present, the concept of resilience has an increasing impact on the concept of heritage, especially in the discussion of cultural landscapes and social-ecological systems, to explain the adaptive and sufficient capabilities of these complex systems in the face of external disturbances and changes (Rapaport *et al.*, 2018; Mrozek and Mrozek, 2021; Niu *et al.*, 2024) much attention had been given to defining, measuring and enhancing resilience at the community level. In this study we examine if and to what extent does resilience vary among communities of different types. We use type of community as a proxy for social ties in the community, to examine variances in the perceived community resilience. We utilize an innovative measurement of community resilience, Conjoint Community Resilience Assessment Measure (CCRAM. The concept of resilience includes the ability to buffer, adaptability and transformation (Figure 1), emphasising how ecology and society are deeply connected in the built environment (Folke *et al.*, 2002) evidence that has been accumulating in diverse regions all over the world suggests that natural and social systems behave in nonlinear ways, exhibit marked thresholds in their dynamics, and that social-ecological systems act as strongly coupled, complex and evolving integrated systems. This article is a summary of a report prepared on behalf of the Environmental Advisory Council to the Swedish Government, as input to the process of the World Summit on Sustainable Development (WSSD. For heritage landscapes, this concept can reflect the long-term interactive relationship between heritage communities and the surrounding environment temporarily.

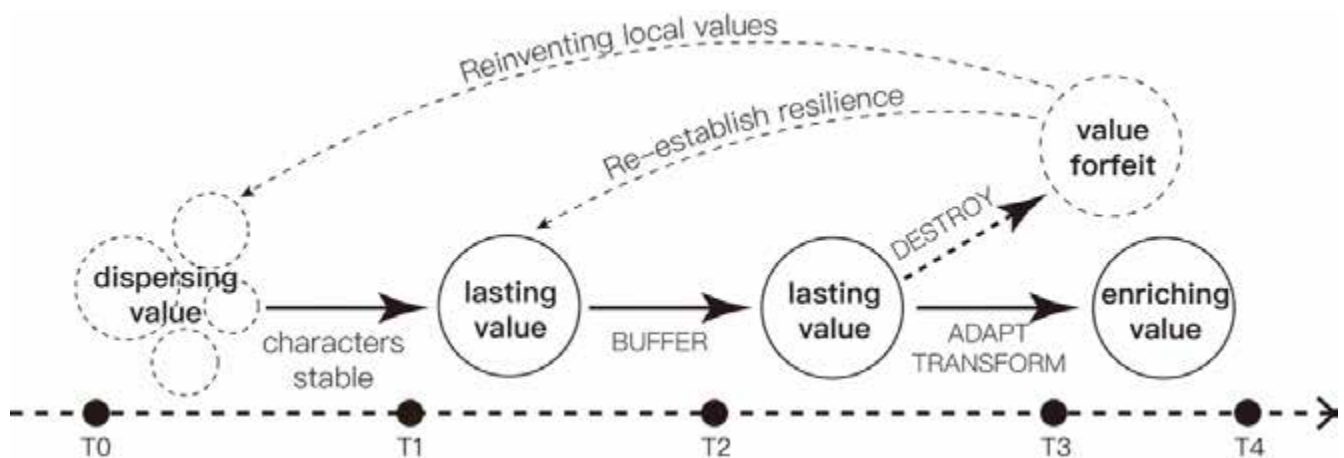


Figure 1 Evolutionary resilience model.

Hydraulic heritage refers to the historical systems designed and built for water management, including aqueducts, irrigation facilities, dams and traditional water use experience (Hermosilla Pla and Mayordomo Maya, 2016). It is a microcosm of the close co-evolution of natural resource management and society. These systems have played an essential role in the fragile environment and ecology, the allocation of water resources, the control of floods, and the improvement of agricultural production levels. Recent studies have found that in addition to the original engineering functions, hydraulic systems are often deeply bound to the cultural structure of the community and shape the community identity and collective memory (Durán-Suárez and Sáez-Pérez, 2019; Wei *et al.*, no date). As can be seen from the inclusion of China's Dujiangyan Irrigation System in the World Heritage List by UNESCO, this type of heritage is not only important as a historical project, but also as a lasting cultural landmark that provides contemporary functions.

This study attempts to answer the role of hydraulic heritage in social ecological resilience by analysing the Xuzhou Xiangyang Irrigation System in the Huaibei region of China. Historically, the Huaibei Plain has been deeply affected by many large-scale hydrological interventions, especially the diversion of the Yellow River into the Huaihe River Basin during the Song Dynasty (1128 AD) (Junya and Wright, 2013). This move was intended to strategically protect the Jiangnan region but caused widespread ecological damage and agricultural degradation in the Huaibei region. Over the next nine centuries, the region's ecological and social resilience was systematically compromised. Villagers struggled with flooding, salinised land, and agricultural stagnation for a long time, earning an unfortunate reputation as "sacrificial locals". In response to Huaibei's complex ecological and social problems, the 30-kilometre Xiangyang irrigation system was built in the context of social mobilisation in the 1970s, covering facilities such as channels, sluices, and pumping stations. It improved agricultural productivity by providing stable fresh water and reducing soil salinisation. In the new century, with the introduction of more advanced regional water resource management technologies, the irrigation function of the Xiangyang system gradually weakened, and the various facility elements lost their spatial associations, but their role in local cultural and historical identity became increasingly evident. The transformation of the meaning of hydraulic heritage highlights the contemporary value of social-ecological resilience.

This study examines the transformation of landscapes, heritage narratives, and social perceptions through a qualitative method, which integrates literature research, semi-structured interviews, participatory observation, and spatial analysis. The purpose is to understand how hydraulic heritage can promote social cohesion, and increase the resilience of eco-social systems while protecting ecological integrity. By understanding how historical infrastructure can adaptively integrate cultural and ecological elements and become a lasting resource for the development of heritage communities, this paper makes theoretical and empirical contributions to the intersection of heritage conservation, resilience theory and sustainable development.

2 Method

2.1 Literature and Archive Review

First, the academic literature and archives on eco-social resilience, cultural landscape, hydraulic heritage and historical hydrology in Huaibei, Jiangsu Province were studied, with a focus on the historical records of "taking the Huai River into the sea" and the subsequent ecological degradation. At the same time, the county annals of the former Tongshan County (now Tongshan District, Xuzhou City), hydrological engineering reports from the 1950s to the 1970s and provincial planning documents were consulted to understand the development timeline of the Xiangyang irrigation system and the positioning of the state-led hydraulic project construction in the Huaibei region under the background of the "Red Flag Aqueduct" spirit. In addition, the relevant international adaptation and resilience theoretical frameworks were sorted out, and combined with UNESCO's papers on cultural landscapes and community identity development to lay the cognitive foundation for this study.

2.2 Semi-structured interviews and participatory observations.

From 2023 to 2024, 21 semi-structured interviews were conducted in Liuquan Town, Xuzhou and neighbouring villages. Interviewees were selected by snowball sampling to ensure that a wide range of ages and social identities were covered, and the diversity of the interviewees' participation in the irrigation system was obtained as much as possible. Interviewees included the following four categories: (1) farmers who participated in the construction and early use; (2) village committee/party and mass workers who participated in village political management and hydraulic heritage maintenance; local cultural researchers and teachers who incorporated the history of the water system into the teaching system; and (3) community residents engaged in related rural

tourism. At the same time, the interviews included open-ended questions on the following topics: (1) personal or collective experience of using the Xiangyang irrigation system; (2) perceived benefits and challenges of the Xiangyang irrigation system in the past and present; (3) emotional and cultural connections to the irrigation system; (4) attitudes towards heritage commercialisation and tourism development; and (5) views on changes in the local ecological environment. All interviews were recorded, transcribed, and coded with knowledge and anonymity.

At the same time, the research team formed an ethnography of the local community by observing the interaction between local residents and the remains of the irrigation system, recording their emotional responses to water-related landmarks, and the stories they told while accompanying observers on walking tours. This record not only took their daily lives related to water as historical objects, but also analysed their current social and spatial structures.

2.3 Landscape Analysis and Spatial Mapping Framework

In order to make the above qualitative data, which are mainly based on oral and observational data, more objective, this study also used GIS tools to conduct a spatial analysis of the local built environment, including: (1) the original layout of the Xiangyang irrigation system based on engineering records and field measurements built in the 1970s; (2) the current local land use patterns and visible remains of hydraulic facilities; (3) recent development activities on related heritage, such as signboards and visiting walkways; (4) satellite images from 1970 to 2024 to record changes in land cover, vegetation and water bodies. This spatial information will be combined with the qualitative content obtained from interviews and observations to track the material state of changes in the irrigation system and explain how specific heritage sites are remembered, used or forgotten. Data analysis will be tested using triangulation methods to understand how hydraulic heritage is interpreted and how it is deconstructed and materially transformed in the context of resilience.

3. Case Study: Xiangyang Irrigation System in Huaibei

3.1 Historical Context: From Floods to Social Marginalisation

The socio-ecological trajectory of Huaibei is highly relevant to one of China's most important water events. During the Northern Song Dynasty, the Yellow River was artificially diverted into the Huai River system. In 1128 AD, under siege by the invading Jurchen army, the Song army broke through the dikes in present-day Kaifeng and released the Yellow River floodwaters southward to form a defensive barrier. Large areas of northern Anhui and Jiangsu provinces were flooded by this river change. However, the long-term ecological and socio-political consequences were much more serious. The wartime strategic shift had a significant impact on the local hydrology. The Yellow River, which previously flowed into the Bohai Sea, then usurped the Huai River channel further south and entered the Huai River basin. This diversion exacerbated local flooding problems due to changes in the river's capacity, leading to chronic waterlogging. At the same time, the large amount of sediment carried by the Yellow River led to local soil salinisation, agricultural abandonment, and large-scale displacement. Historical records show that large tracts of arable land in northern Huaibei became unusable, forming what Qing officials later called "poor mountains and bad waters."

After the 19th century, the Huaibei Plain was widely referred to as "sacrificial locality" (Ma, 2023). This was a marginal territory that was neglected in the allocation of national resources by the entire central government. The fragile ecology brought poverty, food shortages, and social exclusion, and also caused the loss of rural population. Although the Yellow River changed its course again in the 19th century, making the Huaihe River system the main water system in the Huaibei Plain, the ecological resilience was still not ready to be restored, and the salinised plains, broken waterways, and complex social environment still existed. This state also laid the foundation for a series of hydraulic projects in the Huaibei area. Because major infrastructure, including the Xiangyang Aqueduct, is not only an ecological resilience restoration project, but also an initiative to reintegrate this land into social politics.

3.2 Construction of Xiangyang Irrigation System: Engineering Hope and Collective Memory

Despite the long-term instability of the hydrological environment and the marginalisation of geographical conditions, the country launched a nationwide modernisation movement of large-scale hydraulic facilities under the leadership of the Taihang Mountain Red Flag Aqueduct Hydraulic Project in the 1970s (Figure 2).

This type of rural infrastructure project is usually initiated by large-scale mobilisation and has a significant impact on the local agricultural environment.



Figure 2 The fundamental status of the Xiangyang irrigation system.

The Xiangyang system is a set of irrigation hydraulic networks with self-weight water supply and mechanical pump assistance. Its purpose is to introduce fresh water resources from Weishan Lake in the north and newly built small and medium-sized reservoirs to Liuquan Town and surrounding villages to solve the problems of farmland salinisation and poor drainage. According to county-level archives, the system was completed in 1976, with a length of about 33.6 kilometres, including five medium-sized water transfer stations, five large aqueducts, 369 bridges and culverts, five tunnels, and 25 kilometres of high-voltage lines. It is worth noting that this facility was not implemented by a professional engineering corps, but through the labour model dominated by the people's commune, mobilising thousands of villagers and educated youth. Oral histories recorded on the ground testify to the intensity and symbolism of the work. One interviewee, 74-year-old Ms. Zhang, who worked on the project, recalled:

"There were no large machines, and we dug with our hands and shovels. Each household sent a labourer; my husband worked for 38 consecutive days. It was hard to get enough food, but free meals were provided at the construction site, and they said they were "building water (water diversion)" for the village. The work was hard, but we were all proud. The project was our own business."

This participatory practice not only achieved the construction of infrastructure, but also created a sense of "ownership" of public property. Between the 1970s and 1990s, calligraphy and paintings on the facilities, murals in the village, and local songs recorded the entire construction process. Although villagers were not clear about the role of each part of the system, for example, a vital aqueduct was called the "38-hole bridge" by the locals because of the 38 arches that supported the aqueduct. The aqueduct is certainly not a transportation facility, but due to the similarity of the image, the use of "bridge" as an alternative word can better spread the name of the project (Figure 3). The Mao Zedong quotations inscribed on the aqueduct also highlight the complex emotions of the locals, showing the embedding of emotional meaning in the material structure.



Figure 3 "38-hole bridge"

On the other hand, the hydraulic system attains ecological resilience by connecting the originally broken water bodies and providing drainage outlets. This has significantly improved local productivity. The salinity of cultivated land has dropped by more than 30% in five years, and the areas controlled by the Xiangyang Project have gone from being difficult to plant to being able to harvest twice a year. According to villagers, the yield of some lands has doubled compared to before the project was used.

More importantly, the Xiangyang hydraulic system has also reshaped the village settlement model. Due to long-term flooding, the original villages could only be built on high ground. Now the hydraulic system has become an organisational axis, and housing, markets and community centres have been repositioned around these axes. In some villages, bridges and public washing platforms are built near irrigation facilities, which have become their new infrastructure and social space. As a local retired teacher said:

"Hydraulic facilities not only bring fresh water, but also bring intimacy between people. It runs through our lives: irrigating farmland, swimming, washing clothes. It is part of our lives..."

Today, although most of the facilities still retain the integrity of their physical state, they have lost their original irrigation function. Due to the restoration of ecological resilience and new water diversion technology, the Xiangyang system has begun to transform from infrastructure to landscape, and has become an intersection of culture and emotion. It is precisely by capturing this shift that the interpretation becomes a transformation of its function and meaning.

3.3 Decline of Function and Rise of Symbolism

Since the early 2000s, the state of water resources and hydrological conditions in the Huaibei region has changed significantly. With central government investment in large water facilities, the construction of deep well systems, and the expansion of municipal water supply facilities, the region has gradually reduced its reliance on the Xiangyang system. However, unlike most infrastructure that has taken off, the Xiangyang irrigation system has begun a soft evolution, from functional infrastructure to symbolic landscape. This shift was not achieved through formal renaming, but rather through a combination of spatial intervention, community memory, and tourism development. In 2016, Liuquan Town began to promote the "Water Channel Memory Walk", installing interpretive signs along the main waterway, which is about 4.5 kilometres long. These signs include photos of the past, oral texts, and QR codes linking to students' related documentary works. Some local celebrations, such as the Spring Plowing Ceremony and the Mid-Autumn Water Lantern Ceremony, are also held near the key facilities of the waterway to strengthen the symbolic connection.

Many elderly people still describe the water system as a “gift from the past.” An 82-year-old villager claimed:

“It may not be carrying water, but it carries our pride. I often go there because it’s my old time.” The intervention of collective art also adds to this spiritual transformation.

In 2021, a mural project organised by college student village officials (a way for the Chinese government to train grassroots officials) repainted the text on the sluice facilities, emphasising the spiritual role of the great mobilisation project in the 1970s by highlighting some of the political slogans written at the time, which also made these facilities a “red heritage.” Although the scale of these practices seems small, they show a spiritual transformation: the old hydraulic infrastructure has become an anchor of rural identity. And this emotion is deeply reflected in the post-agricultural society and semi-urbanised landscape (Figure 4).



Figure 4 Political slogans that have been repaired in the structures

3.4 Landscape transformation: from aqueduct to cultural corridor

In addition to oral accounts and observations, spatial analysis also reveals how the material space of the Xiangyang irrigation system has gradually been integrated into contemporary culture and eco-society. Comparison of satellite images from 1990, 2005, and 2024 shows the following trends:

(1) **Physical form:** Although some river channels have disappeared due to land development, the main water channels remain intact and have become green corridors or channels between fields; the sides of the river channels have also become vegetation buffers, with native vegetation growing on the edge of concrete, becoming an ecological plate for amphibians and butterflies.

(2) **Social form:** In the 13 villages surveyed, administrative buildings, primary schools, public squares and other facilities in five villages have spatial intersections with the remains of the irrigation system;

(3) **Industrial form:** The 2020 tourism plan includes two theme hotels, a hydraulic cultural centre, and a souvenir shop related to hydraulic knowledge. Although the final implementation is different from the plan, it can still capture the symbolic role of the Shuili heritage in the local space.

3.5 The aqueduct as a multi-scalar heritage

The role of the Xiangyang irrigation system in terms of function and meaning can be analysed at different levels: at the micro level (village), it constructs rural neighborhood identity and spatial positioning, such as residents often point to specific landmarks, "the bridge my father built", "above the sluice", "where we played with paper boats", which shows the continued role of heritage as a spatial location marker; at the same time, it is also an aesthetic and social node, promoting the birth of local tourism and public art through narratives of events and memories. At the meso level (township), the hydraulic system has been incorporated into the strategic planning of rural revitalisation. Although it is still lacking in funding, a planning document for 2022 describes it as a heritage system that connects ecological restoration areas, rural cooperatives, and heritage clusters. At the macro level (region), scholars and planners regard this system as a typical example of hydraulic landscape heritage in the Huaibei region.

Thus, the evolution of the meaning of the Xiangyang irrigation system reflects the process of spatial heritage stratification, from functional infrastructure (1970-2000), to post-industrial memory sites (2000-2010), and to polysemic cultural landscapes (2010). This transformation of resilience is reflected not only in the ecology but also in the politics, economy and collective identity of a community. As summarised in an interview with the village party secretary:

"We used to worry about whether there was water in the aqueduct. Now we ask: does it still have meaning? Yes. It flows differently now, but it still connects us."

4. Results

This chapter presents the main empirical findings from the fieldwork. Based on 23 semi-structured interviews and participatory observations, subjects were coded. The analysis revealed that people's perceptions of the transformation of the Xiangyang irrigation system varied across generations, occupations, and geographies, leading to different interpretive patterns.

4.1 Typology of local narratives: four community positions

The subject coding of the semi-structured interviews yielded four different community positions, which we categorise as (1) governors; (2) cultural transmitters; (3) pragmatists; and (4) tool innovators.

(1) Stewards of the aqueduct

This group is mainly composed of older villagers (over 60 years old) .they either directly participated in the construction of the aqueduct or actively used it during its operation. For this group, the irrigation system is not just an infrastructure, but also a moral story of resilience and sacrifice. They see themselves as stewards of the aqueduct's memory. As one 72-year-old woman said:

"This is not just a aqueduct, it is what we built with our youth. If you tear it down, you end our lives."

This group often uses emotional terms, such as calling the irrigation system "our blood vessels," "common works," or "the backbone of the village." They prefer low-tourism, high-ritual space utilisation methods, such as worshiping ancestors by the water.

(2) Cultural disseminators

This group is more composed of middle-aged villagers (40-60 years old), teachers, local cultural researchers, and village cadres. They act as intermediaries between old memories and new interpretations. Many of them did not directly participate in the construction and irrigation work, but grew up listening to the story of the aqueduct. They noticed the material and intangible heritage value of the irrigation system. Local teacher He, 43, said:

"Our students may not know the principles of the irrigation system, but they can understand the meaning behind it. This is the result of the efforts of the Party (CCP) and the collective, and it is also a lesson for us on how to change nature."

This group actively supports heritage education, painting projects, and oral history collections. They are moderately open to tourism development, provided that it conforms to "local values" and "mainstream narratives."

(3) Pragmatists

This group is usually composed of young residents under 35 years old and those who have recently returned to the village. They show ignorance and indifference to the irrigation system and its original function. As a generation living in the context of mechanised agriculture and urban water supply, for them, it lacks direct relevance to daily life. A 27-year-old driver said:

"I cross the bridge (the 38-hole aqueduct) when I deliver to the store, and that's it. It's not part of my life."

It is worth noting that this group is not against heritage, but just thinks it is not a priority in their lives. They focus on reuse projects that can generate short-term benefits, such as whether some facilities can be converted into cafes.

(4) Tool Innovators

This group is small but growing, including local entrepreneurs, tourism planners and youth cooperatives. They see heritage as a tool for economic and social development and propose "adaptive use" of hydraulic facilities. For example, it can be integrated into agricultural tourism experiences, create VR experiences of using hydraulic facilities, or hold seasonal rituals related to them. A 34-year-old B&B owner said;

"If we only view the hydraulic facilities as history, they will disappear sooner or later. But if we view it as a resource, it can play a positive role in the economy, culture and society."

This group tends to prioritise strategic action storytelling and brand creation. Their activities are similar to other heritage-led rural development models in China and are often supported by higher-level governments.

4.2 Intergenerational friction and intra-village dialogue

The positions of these four narrative subjects together reveal a landscape of negotiated governance of heritage rather than shared memory. Multiple interviewees expressed tensions between different generations, especially in the understanding of the symbolic and economic value of the irrigation system. In several villages, intergenerational conflicts arose over the use of heritage for tourism development. In Xixiang Village, the elderly opposed the establishment of a night market near the historic sluice gate, believing that it was "interference with a place of memory." Meanwhile, young entrepreneurs saw it as an opportunity to "revitalise a corner of the village." Similar disagreements occurred in the design of rituals, such as whether the Spring Water Festival should include only traditional rituals or contemporary music performances and webcasts.

To resolve these contested opinions, there were at least four coordination meetings held in different villages. The meetings bring together village elders, youth representatives, local officials, and teachers.

They negotiate the content of facility-related activities and how they should be governed. In Dongma Village, for example, the meeting agreed to limit commercial stalls to one side of the facility, while reserving the other side for ceremonial purposes.

These hybrid governance mechanisms are still being refined, but they represent a grassroots effort to manage in a participatory way. During the interviews, both sides expressed cautious optimism.

"They are listening more now," said one elder. "At least we have a seat at the table."

"It's not about agreement," said a youth representative, "but about recognising what is important to different people."

4.3 Heritage as emotional infrastructure

In addition to its physical infrastructure and cultural brand, the Xiangyang Irrigation System functions as an “emotional infrastructure” that serves as a site for processing individual and collective feelings of loss and belonging. This becomes evident in many of the narratives associated with the aqueduct. For example, five widows whose husbands died during the construction of the aqueduct in the 1970s maintain a memorial corner next to an abandoned hydroelectric station (Figure 5), and every Qingming Festival, they perform rituals such as burning incense and chanting names, and become “aqueduct sisters”. A 75-year-old woman, Ms. He, explained: *“When my husband died, I started walking along the aqueduct every morning. It’s quiet, but it listens. It remembers.”*



Figure 5 Memorial corner by “aqueduct sisters.”

Elsewhere, a teenage boy talked about running along the aqueduct when he failed an exam, and an older man described bringing his grandson here to share family stories. In these narratives, heritage is less a structure than a space for reconnection. This emotional significance is not aligned with economic or ecological values, but it is central to the lived relevance of this place. Therefore, when assessing rural heritage frameworks, its role as emotional infrastructure should be included, recognising not only its role but also what it possesses and evokes.

4.4 Spatialized heritage visibility

Using GIS data derived from low-altitude drones and historical satellite maps, we categorise the physical remains of the Xiangyang irrigation system into three levels of visibility.

(1) Structural visibility

Includes intact and readable structures, such as water diversion channels, sluices, or pump houses, which are still clearly identifiable in shape and location. These structures are mainly distributed in Wangma Village and Dongma Village near Weishan Lake. Their integration into the agricultural space has preserved their identity.

(2) Symbolic visibility

This category includes original structures that have been completely or partially demolished, but elements of signs and murals have been retained. For example, the Red Flag Cave in Xipu Village, although the original structure is no longer visible, still retains the Red Flag Cave painting, which tells the story of political propaganda in the 1970s.

(3) Latent or forgotten visibility

In peripheral villages such as Laoquan Village, the material traces of the irrigation system are almost non-existent. Interview results also show the loss of memory. Many young people in the village could not identify the location of previous facilities. However, the landforms and water behaviour still hint at past hydraulic functions. This spatial typology reveals that visibility is not just a peripheral material condition, but also a function of cultural gain and empirical investment.

Villages that are used for investment or receive development plans often maintain material and narrative visibility.

4.5 Functional differentiation between villages

In the 13 villages where field research was conducted, three different development patterns emerged:

(1) Functional heritage villages

In these villages, the remains of the irrigation system still play a certain degree of hydraulic function. In Dongma Village, a water transfer station is used to direct runoff and seasonally irrigate collective vegetable plots, and heritage is embedded in ongoing use (Figure 6).



Figure 6 Desalination plant still in use.

(2) Cultural and tourism villages

Villages such as Wangma Village and Xinjia Village reposition heritage as heritage assets. They install signage, hold annual festivals, and transform abandoned houses into cafes (Figure 7). These villages often receive township-level development funds and appear in development plans.



Figure 7 The house planned to be transformed into a coffee shop.

(3) Marginalised villages

In Xipu Village and Laoquan Village, heritage elements were mostly removed and damaged. These villages often lack official documentation, external investment, or young returnees. Some expressed dissatisfaction in interviews, stating that

“Our facilities are equally historic, but no one promotes us.”

This reflects spatial inequalities in heritage valorisation and its connection to economic opportunities.

This phenomenon suggests that the aqueduct heritage is not a unified regional asset, but a diverse landscape, which is shaped by governance priorities, local capacities, and symbolic frameworks.

4.6 Heritage as a governance network

Heritage governance in Liuquan Town operates through a multi-level governance network, including village committees, township agencies, and ad hoc working groups. Spatial analysis of project funding, signage distribution, and festival rituals revealed a striking feature: villages with strong leadership or elite participation were more likely to mobilise external resources. According to interviews and constructed actor networks, Xinjia Village and Dongma Village acted as nodes, coordinating inter-village activities such as storytelling sessions and tour guide training. In contrast, villages with limited connections to the governance network showed a disconnect. A village committee member from Xipu Village said:

“We filled out two applications for heritage funding, but there was no response. Then we heard that other villages already had plaques and visitors.”

This suggests that while irrigation systems were once linear structures connecting villages through water flows, they now function as a meaningful governance network that creates spaces for unequal access driven by policy, capital, and culture.

5. Discussion

5.1 Infrastructure Construction of Heritage and Identity

The transformation of Xiangyang Irrigation System shows that infrastructure can be used not only for ecological restoration or economic development, but also as the cornerstone of collective identity. This is consistent with relevant research in the current heritage context. This scholarship believes that heritage is no longer a static, protected monument, but a dynamic process of social production. As shown in the study, hydraulic facilities are not only valued for their functions but also for actively absorbing narratives about production, sacrifice, and life continuation. Through the concept of lieux de mémoire proposed by Nora (1989), hydraulic heritage can be understood as a spatial place for collective memory and value narratives. Abukarki, Uzunahmet and Onur (2023) specifically, Byzantine mosaics in Jordan, where the Byzantine Empire left behind a rich mosaic heritage. Today, these mosaics are replicated in contemporary architectural environments. The purpose of this article is to explore the heritage discourse surrounding Byzantine mosaics in Jordanian contemporary places with a particular focus on the replication and interpretation of the mosaics in contemporary places. To do that, the relationship between the attachments to the Byzantine mosaic places, the community's level of awareness, and the replicated heritage discourse was examined. The research was conducted using several different methods, where structural equation modelling (SEM) claimed that when infrastructure is entangled with collective struggles, it becomes a "cultural production tool for self-expression." This study further points out that identity construction is spatially and temporally layered. For young people who have not experienced that history, this series of hydraulic facilities is not a living past, but more like a history that is born with them. Even so, the local look brought by this symbolism also implies the continuity of collective consciousness. Therefore, the term infrastructural identity is particularly appropriate to describe how large-scale technological systems drive the self-perception process of local communities in post-disaster reconstruction. In the case of the Huaibei Plain, this identity is not passively acquired, but actively negotiated through narrative, consciousness, and space and time.

5.2 From functional system to symbolic landscape

The case of the Xiangyang system further illustrates the transformation of infrastructure into landscape, not only in visual and functional terms, but also in ontological terms. The system was originally a modern hydraulic solution to address centuries of ecological fragility. Today, it operates more as a cultural landscape in the sense of UNESCO, a microcosm of human-nature interaction in history. This change is particularly evident in the discussion of the low-visibility typology of the system (Section 4.4) and the village differences (Section 4.5). Where the system's material form is highly visible and memorialised, it is not only a place of memory but also a spatial anchor for development and tourism planning; where it has disappeared, it presents a more fragmented memory with weaker community participation. This also confirms Tilley's (1994) proposition that landscape is not neutral, but is full of meaning, constituted by memory, and organised by politics. The "heritage density" displayed by the spatialisation of the material remains of the aqueduct system reflects the power differences of factors such as funding, social attention, and political discourse. In other words, heritage landscapes are contested even when they are produced.

On the other hand, the transformation from function to symbol does not mean obsolescence. As shown in the case of "Sisters of the Aqueduct" (Section 4.3), the landscape has become a stage for rituals and emotions, and even serves as an ecological facility. This kind of soft resilience allows the space to continue to maintain its social production capacity even if the system loses its original use value.

5.3 The multi-scalar politics of heritage

The recontextualisation of the Xiangyang hydraulic system is far more than the result of a grassroots movement. From the results of Section 4.6, this governance process is multi-party. From the local village committee to the township government, to the county brand planning, each institution has its own understanding of the use of heritage and competing strategies. This reflects memory selection, tourism economy and legitimacy. Ashworth, Ashworth, Graham and Tunbridge (2007) proposed "discordant heritage" and analysed how governance structures mediate or exacerbate conflicts. The emergence of mediation committees (Section 4.2) shows that local actors negotiate and create institutions to ease such disputes. However, from the spatial network analysis, it can be seen that different subjects have obtained disproportionate visibility, resulting in an imbalance in landscape value. This imbalance reflects the differential distribution of symbolic capital proposed by Bourdieu (1986). The visibility of the irrigation system, whether material or immaterial, is a form of capital. Different actors can obtain investment, facilities and status, which shows an asymmetric cultural economic control.

Therefore, post-functional infrastructure can serve as a field for governance experiments. Currently, we see bottom-up heritage planning, cross-village cooperation, and participatory governance, rather than top-down hydraulic projects. All of this has reshaped the imagination and practice of rural governance in China.

5.4 From engineered resilience to evolutionary resilience

The transformation of the Xiangyang irrigation system also demonstrates a paradigm shift in the concept of resilience. It means from engineered resilience that emphasises stability and resilience, to adaptability and identity transformation, to evolutionary resilience. In its original design and construction, the irrigation system embodied engineered resilience, creating a system that conformed to technical rationality to mitigate hydrological dysfunction and agricultural decline. It was linear, technical, and hierarchical, reflecting the modernist desire to control nature (Scott *et al.*, 2020). The results were expressed in terms of food production, water flow, and salinity. However, after the new century, the resilience of the irrigation system has changed. The system now supports community cohesion, educational participation, and tourism innovation. These uses are not residual, but an adaptive reshaping. In essence, it is a transformation of physical infrastructure into cultural and emotional assets. The elements of the irrigation system are reconnected through community values, making it a refunctionalized infrastructure. It is not about water itself, but about what water once meant and what it means again. This also corresponds to Pelling's (2010) resilience framework:

- (1) Sustainability: irrigation systems maintain their physical state and core symbols;
- (2) Adaptation: irrigation systems take on new uses and meanings;
- (3) Transformation: irrigation systems reposition local governance, identity and development goals.

5.5 Emotional resilience

In addition to material and institutional transformations, the emotional role played by the Xiangyang system is arguably the most enduring. Although this is rarely reflected in planning documents, these functions are far-reaching. Emotional resilience refers to the ability of individuals and communities to adapt to social and psychological pressures by rooting themselves in meaningful places. The concept of "ordinary heritage" places everyday attachments on grand narratives. For example, for the aqueduct sisters, heritage is not carefully cultivated, but cultivated through rituals and storytelling. This practice is not commodified and does not require external validation. In this way, they maintain emotional stability in the rapid changes of rural modernisation.

This resilience is particularly important in China's post-rural society. Here, population hollowing out, land consolidation and other issues have caused deep emotional ruptures (Yan, 2010). The persistence and availability of the aqueduct act as a psychogeographical plaster. The results show that heritage management should not only focus on economic and cultural resilience, but also pay attention to the emotional needs of the community. This means that planning needs to support local rituals and uncommodified memory spaces. It also requires managers to realise that heritage management includes not only what is seen and sold, but also what is felt.

5.6 Facility memory and time negotiation

Finally, the transformation of the Xiangyang irrigation system also triggered a re-examination of heritage. The system itself is a product of state intervention in the local area, a machine for dealing with historical scars and political amnesia. The Huaibei Plain has long been considered a "sacrificial area", and its construction allows the region to re-enter the narrative of national development. Then, this facility also realises a bottom-up temporal agency. Narrating the process of recovery in their own way. They reposition loss, remains and the future. For example, villagers compare the state's past neglect with the attention it has received now. Therefore, the Xiangyang system becomes a narrative balance, from forgetting to revival, from hiding to visibility. In this process, it realises what (Tsing, 2015) called "revival in ruins", that is, the ability to construct the future from the destroyed past.

On the other hand, not all participants have the same narrative. As the results show, between the old and the young, between tourism and tradition, between visibility and hiding. These disputes are not the failure of heritage, but the embodiment of vitality. Heritage, like memory, is not fixed, but a negotiated temporality where meanings are layered, modified and activated.

6. Conclusion

This study aims to investigate how post-functional hydraulic heritage can serve as a spatial medium for socio-ecological resilience, identity construction, and place-making. By delving into the history of the historically marginalised Huaibei Plain and the Xuzhou Xiangyang Irrigation System as a hydraulic intervention, this study traces the complex transformation of the irrigation system from an engineering solution to an affective, symbolic, and political infrastructure in the 1970s. Drawing on a qualitative mixed-method approach, we explain how the legacy of the hydraulic system continues to shape the daily experiences, aspirations, and ideals of the local community. The Xiangyang Irrigation System, though almost dry, continues to flow through memory, ritual, imagination, and governance. In this sense, the system is not just a story of hydraulic history, but a living example. How rural landscapes absorb trauma, adapt to change, and find meaning again, not with scars, but through scars.

6.1 Theoretical Contribution

(1) Conceptual expansion. The study of hydraulic heritage as infrastructure extends the concept of facilities beyond the technical aspect. Technical facilities can also be called social-ecological infrastructure, which shapes landscape, culture, and emotions at the same time. As in the case of the Xiangyang system, even though the original hydraulic function has ended, the structure still produces ecological, emotional and institutional meanings. At the same time, this example also establishes two important concepts, namely infrastructure identity and emotional infrastructure. The former refers to how collective identity is engraved on the material of the architectural engineering system, especially under the conditions of common labour and struggle; the latter emphasises the non-economic role of heritage in promoting emotional stability and community cohesion, especially in areas with drastic demographic and cultural changes. These two concepts provide theoretical support for understanding the interaction between heritage memory and place.

(2) Evolutionary resilience of heritage landscapes. Resilience should not only be limited to engineering, but also extend to transformation and reinterpretation. The aqueduct was not only preserved after its elimination, but also became a medium for reconstructing the future of rural areas. This process goes beyond static heritage protection and forms a dynamic negotiation platform.

6.2 Empirical Contributions

(1) Case Extension. This study provides original empirical material for the exploration of post-functional rural infrastructure in China. Through 23 semi-structured interviews, participatory observation and spatial analysis, the study documents how local communities interpret, negotiate and use heritage systems through different methods. These stories highlight the diversity of the social value of heritage.

(2) Method Extension. This study provides a spatial method for evaluating heritage systems. By dividing the system into structural, symbolic and potentially visible components, the uneven typological significance of heritage systems can be understood. This set of methods can be applied to other linear infrastructure heritage.

6.3 Strategic Recommendations

(1) Establishing a post-functional governance framework. Local institutes should identify infrastructure, which is no longer serves its original function, but remains eco-social significance. Governance should include adaptive reuse, participatory place-making, and low-cost interventions.

(2) Putting emotional resilience into rural planning. As ecological resilience has become a requirement in environmental planning, emotional resilience should be admitted in heritage policy. Protect ritual or collective spaces, even if they lack direct economic output.

(3) Promoting multi-scale heritage governance platforms. Mediation conferences mentioned before provide a model for democratic consultation. This heritage should be supported by local governments with funding and training resources, to strengthen grassroots capacity building.

(4) Solving inequalities in heritage visibility. Regional heritage policies should proactively identify marginalised villages and provide targeted support for related initiatives, in order to avoid exacerbating spatial disparities.

6.4 Limitations and Future Directions

(1) Time constraints. This study provides a rapid ethnography of heritage. The meaning and function of the Xiangyang system are constantly evolving, and long-term longitudinal research will help understand how current practices have an impact over time.

(2) Data coverage and sample representativeness. Although 13 villages and 23 interviews were included, the sample cannot guarantee the heterogeneity of Liuquan Town and even the Huaibei Plain. In particular, the views of migrant workers, women under 30 years old, and township-level planners are underrepresented.

(3) Horizontal comparison. Comparison with rural irrigation systems in other contexts can enrich the research depth and test the applicability of my theoretical model in different ecological and cultural regions.

Reference

Abukarki, H.J., Uzunahmet, H.A. and Onur, Z. (2023) 'The Influence of Place Attachment on Heritage Discourse in Contemporary Places: A Case Study of Jordanian Byzantine Mosaics', *Sustainability*, 15(10), p. 8395. Available at: <https://doi.org/10.3390/su15108395>.

Ashworth, G.J., Graham, B. and Tunbridge, J.E. (2007) *Pluralising Pasts: Heritage, Identity and Place in Multicultural Societies*. Pluto Press. Available at: <https://doi.org/10.2307/j.ctt18mvnhw>.

Bourdieu, P. (1986) 'The Forms of Capital', in *Handbook of Theory and Research for the Sociology of Education*. New York: Greenwood, pp. 241-258. Available at: <https://www.marxists.org/reference/subject/philosophy/works/fr/bourdieu-forms-capital.htm> (Accessed: 25 May 2025).

Durán-Suárez, J.A. and Sáez-Pérez, M.P. (2019) 'Characterization of Classical Construction Materials used in Ethiopian Architecture for the Restoration of their Historic and Artistic Heritage', *International Journal of Architectural Heritage*, 13(6), pp. 855-869. Available at: <https://doi.org/10.1080/15583058.2018.1489014>.

Folke, C. et al. (2002) 'Resilience and sustainable development: Building adaptive capacity in a world of transformations', *Ambio*, 31(5), pp. 437-440. Available at: [https://doi.org/10.1639/0044-7447\(2002\)031\[0437:RASD BA\]2.0.CO;2](https://doi.org/10.1639/0044-7447(2002)031[0437:RASD BA]2.0.CO;2).

Hermosilla Pla, J. and Mayordomo Maya, S. (2016) 'A methodological system for hydraulic heritage assessment: a management tool', *Water Supply*, 17(3), pp. 879-888. Available at: <https://doi.org/10.2166/ws.2016.186>.

Junya, M. and Wright, T. (2013) 'Sacrificing Local Interests: Water control policies of the Ming and Qing governments and the local economy of Huaibei, 1495-1949', *Modern Asian Studies*, 47(4), pp. 1348-1376. Available at: <https://doi.org/10.1017/S0026749X12000583>.

Ma J. (2023) *Sacrificed 'Locality': A Study on Social-Ecological Changes in Northern Huai River Basin*. Chengdu: Sichuan People's Publishing House.

Mrozek, D. and Mrozek, M. (2021) 'The Specificity of Dynamic Resistance of Existing Bridge Structures in Mining Areas', *International Journal of Civil Engineering*, 19(4), pp. 463-480. Available at: <https://doi.org/10.1007/s40999-020-00571-y>.

Niu, S. et al. (2024) 'Evaluation of smart community resilience: empirical evidence from Heilongjiang province, China', *Environment Development and Sustainability* [Preprint]. Available at: <https://doi.org/10.1007/s10668-024-04514-8>.

Nora, P. (1989) 'Between Memory and History: Les Lieux de Mémoire', *Representations*, 26, pp. 7–24. Available at: <https://doi.org/10.2307/2928520>.

Pelling, M. (2010) *Adaptation to Climate Change: From Resilience to Transformation*. London: Routledge. Available at: <https://doi.org/10.4324/9780203889046>.

Rapaport, C. et al. (2018) 'The relationship between community type and community resilience', *International Journal of Disaster Risk Reduction*, 31, pp. 470–477. Available at: <https://doi.org/10.1016/j.ijdr.2018.05.020>.

Scott, M. et al. (2020) 'Planning for historic urban environments under austerity conditions: Insights from post-crash Ireland', *Cities*, 103, p. 102788. Available at: <https://doi.org/10.1016/j.cities.2020.102788>.

Tilley, C.Y. (1994) *A phenomenology of landscape: places, paths, and monuments*. Oxford, UK ; Berg (Explorations in anthropology).

Tsing, A.L. (2015) *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton University Press. Available at: <https://doi.org/10.2307/j.ctvc77bcc>.

Wei, X. et al. (no date) 'New Discovery of Diethyl Carbonate Modified Natural Hydraulic Lime in Heritage Conservation', *International Journal of Architectural Heritage*, 0(0), pp. 1–13. Available at: <https://doi.org/10.1080/15583058.2024.2375040>.

Yan, Y. (2010) 'The Chinese path to individualization', *The British Journal of Sociology*, 61(3), pp. 489–512. Available at: <https://doi.org/10.1111/j.1468-4446.2010.01323.x>.