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Original Research Article

A Comparative Analysis of the Role of Traditional Water Infrastructures in Place-Based Development (Case Study: Qanats of Dezful and Madis of Isfahan)*

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ABSTRACT

Water, as the most essential human need and a vital component of life, has always been a primary concern in establishing both permanent and temporary settlements. Water supply networks are among the earliest forms of urban infrastructure, playing a critical role in sustaining human environments. In historical Iranian cities, traditional water infrastructures have gone beyond their functional purpose of providing water, contributing significantly to shaping spatial organization, strengthening place identity, and facilitating social interactions. However, in the context of contemporary urban transformations and disconnection from local foundations, their role has often been marginalized. This study aims to identify the physical, functional, and symbolic capacities of traditional water infrastructures and to examine their role as identity-forming elements in urban spatial organization. By conducting a comparative analysis of two notable examples the underground qanats of Dezful and the surface madis of Isfahan the research highlights their importance in supporting place-based urban development. The study employed a qualitative approach, using field data and documentary sources to analyze three dimensions: physical, functional, and symbolic. A conceptual model was then proposed to explain the relationship between indigenous infrastructures and urban development. The case studies included Dezful's qanats and Isfahan's madis, which were examined through four stages: theoretical component extraction, historical source analysis, semi-structured interviews with residents and experts, and field observations. The findings reveal that, despite morphological differences caused by climatic conditions, both systems have functioned as multifunctional structures, contributing to spatial organization, meaning-making, and collective memory. The study emphasizes that creatively revitalizing these infrastructures can enhance climate resilience and sustainable water management while also promoting a stronger sense of place, social cohesion, and sustainable urban development.

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Introduction

In contemporary urban development in Iran, particularly within historic districts, a clear gap has emerged between indigenous traditions and modern urban planning practices. This gap has impacted not only the spatial organization of cities but also their cultural and symbolic foundations (Salih, 2006; Relph, 1976). Urban renewal programs, instead of maintaining a logical continuity between urban space and historical memory, have predominantly relied on modernist design models and imitative policies (Nourikia & Zivdar, 2020). As a result, life-centered landmarks and local values have gradually been eroded, creating a "semantic disconnection" between people, urban spaces, and the natural environment in Iran's historic cities.

Traditional water infrastructures, such as the qanats of Dezful and the madis of Isfahan, which historically functioned as vital drivers of urban and social life, have been pushed to the margins. Beyond their role in supplying water, these systems structured social relations, preserved collective memory, and reinforced place identity (Saatsaz & Rezaie, 2023; Jamshidian, 2023). However, contemporary urban development often overlooks the systematic reinterpretation of this spatial heritage, leading to a breakdown in the intrinsic connection between form, function, and meaning (Attarian & Safari Najar, 2019).

These cultural and spatial assets have largely been left unexamined in modern planning. New development approaches have not only failed to restore their internal logic but have sometimes disrupted patterns of life rooted in local practices. This reflects a broader disjunction between traditional knowledge and contemporary urban policies, weakening the organic links between humans, space, and nature in historic Iranian cities. Such a context highlights the urgent need to reconsider the relationship between "infrastructure" and "place." Accordingly, the central question of this study is: How can traditional water infrastructures, such as the qanats of Dezful and the madis of Isfahan, be recognized and employed as active agents in place-based urban development in contemporary Iranian cities?

Research Method

This study adopted a qualitative approach and employs comparative analysis to explore the role of traditional water infrastructures namely the qanats of Dezful and the madis of Isfahan in place-based urban development. Data were collected from three sources: documentary materials, field observations, and semi-structured interviews, and were analyzed within a conceptual framework developed specifically for place-based development.

In the initial stage, theoretical sources related to place-based development, indigenous infrastructures, and the concept of "place" were reviewed to establish the study's conceptual foundation. This review identified three key dimensions of place-based development in relation to traditional water infrastructures: the physical dimension, the functional dimension, and the symbolic dimension. These three dimensions formed the basis for the comparative analysis of the two case studies.

Next, historical and documentary sources including old maps, architectural documents, and previous research were analyzed to provide a detailed understanding of the historical, spatial, and functional roles of these systems within the urban context. This analysis helped uncover the relationships between water infrastructures and the organization of public spaces, urban neighborhoods, and identity-defining elements in both cities.

Field observations were then conducted along the qanats and madis to examine their ongoing role in daily life, current usage patterns, and social interactions. Simultaneously, eighteen semi-structured interviews were conducted with local residents to gather perspectives on how these infrastructures continue to influence community life.

In the final stage, the data from all sources were synthesized into a comparative analysis of Dezful's qanats and Isfahan's madis. This analysis highlighted both the similarities and differences across physical, functional, and symbolic dimensions and provided the basis for a three-dimensional conceptual model. This model, a key theoretical contribution of the study, has potential applicability to other Iranian cities with arid climates and traditional water infrastructures.

Theoretical Foundations

• Place-based development

The concept of "place" has long been a fundamental concern across various disciplines, drawing sustained theoretical attention. In the literature, place has been referred to using terms such as "location," "site," "space," and "environment." However, in contemporary approaches, place is no longer seen merely as a point or geographic area; rather, it represents a dynamic arena where social, economic, political, and environmental forces intersect, providing meaning and direction to human actions and historical patterns (Jonas, 2013; Allen & Cochrane, 2007).

Understanding place depends on the intricate connections between space and time and arises from a process in which place is continuously produced, reproduced, and transformed. This dynamic process, interacting with physical elements, lived experiences, human activities, and identity structures, generates a rhythm and vitality of meaning within a place (Farjallahzadeh & Salehinia, 2021; Moore, 1997). Within this framework, place is not merely a backdrop for habitation but an active field of social action.

Scholars have generally classified conceptions of place into two approaches: the first considers place as an objective, physical location, while the second emphasizes the roles of meaning, experience, memory, and identity in its formation (Amdur & Epstein-Pliouchtch, 2009). From the second perspective, place emerges from the subjective and emotional engagement of individuals with their environment, making it a complex, multi-layered socio-cultural construct (Cuba & Hummon, 1993; Stedman, 2002; Cheng & Daniels, 2003).

Numerous researchers, including Canter (1997), Relph (1976), Tuan (1977), and Lynch (1987), focusing on lived experience and mental perception, argue that place arises when individuals or groups establish an emotional and conceptual connection with space through processes of meaning-making and cultural determination. Places carry memory, identity, a sense of belonging, and ideals, maintaining inseparable links with everyday life, human activities, and cultural symbols (Rapaport, 1982; Gustafson, 2001; Gieryn, 2000).

Building on this perspective, place-based approaches to policy and development have emerged, emphasizing the

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critical role of geographical context, local knowledge, and social action in shaping development pathways. Unlike top-down, standardized development strategies, these approaches prioritize bottom-up processes, localized policy adaptation, and the recognition of each place's unique capacities (Barca et al., 2012; Bachtler, 2010).

Place-based development rests on the fundamental assumption that residents' knowledge, experiences, and values are key to the success of development policies. Accordingly, place is not a passive backdrop but an active agent through which a deeper understanding of social, economic, and cultural transformations can be achieved (Werlen, 1993). Place-based policies, by emphasizing belonging, spatial justice, and social inclusion, contribute to addressing territorial inequalities (Beer et al., 2020; Wills, 2016).

At the regional scale, the place-based paradigm emphasizes analyzing overlapping institutional, physical, and functional layers. Through tools such as local assessments, social mapping, and participatory consultation, it enables the formulation of strategies tailored to the distinctive characteristics of each place (Potschin & Haines-Young, 2014; Pugalis & Bentley, 2014). Simultaneous analysis of the physical, functional, and symbolic dimensions of place not only enhances the understanding of local challenges but also informs the redefinition of development policies at national and regional scales.

Consequently, as emphasized in previous theoretical and empirical studies, what transforms space into place is not merely its physical presence but a complex combination of lived experience, social functions, and cultural meanings. Following this conceptual framework, this study identifies place-based indicators across three dimensions functional, physical, and symbolic through document analysis (Table 1).

It is noteworthy that within the framework of a place-based development approach, a deep understanding of the natural context and infrastructure of each location forms the foundation for comprehending how urban spaces are shaped and transformed. In this regard, traditional water infrastructures, as tangible symbols of sustainable human interaction with the natural environment, play a key role. These systems are not only essential for the supply and distribution of water resources but also contribute fundamentally to the spatial organization of urban areas, the reinforcement of collective identity, and the reproduction of cultural meanings. From this perspective, examining traditional water infrastructures within a place-based development framework provides a unique opportunity to identify the historical and environmental capacities of cities and establishes a solid foundation for designing sustainable, identity-driven development patterns that align with the characteristics of each location.

• Traditional water infrastructure

In the place-based development approach, infrastructures, as complex human-made structures, play a fundamental and multifaceted role in shaping communities, economies, and urban environments. Beyond fulfilling operational functions, these systems possess physical, aesthetic, and symbolic dimensions that contribute to place identity and enhance urban environmental quality. Among these, traditional water infrastructures stand out as prime examples of indigenous systems historical structures adapted to the climatic and cultural conditions of each region, evolved over centuries, and characterized by significant sustainability and resilience.

These water systems have not only been central to the supply and management of water resources but also embody social, cultural, and ecological values. In essence, traditional water infrastructures establish a deep connection between humans and nature and reflect the political, economic, and environmental dynamics of local communities. In Iran, especially in historical cities located in arid and semi-arid regions, these systems have gained particular significance. They have met critical agricultural and urban water needs while playing a decisive role in the social, cultural, and spatial development of these cities (Salih, 2006; Nourikia & Zivdar, 2020).

From a structural and spatial perspective, traditional water infrastructures are an inseparable part of the cultural and urban fabric, influencing urban settlement patterns and neighborhood organization

Table 1. Place-centered indicators in three functional, physical, and semantic domains. Source: Authors.

	Dimension	Component	Source
Place-oriented components	Functional	Activity	(Canter, 1997)
		Flexibility	(Gieryn, 2000)
		Self-sufficiency and Adaptability	(Wills, 2016)
		Eventfulness	(Falahat, 2006)
		Presence	(Relph, 1976)
	Structural	Urban Spatial Structure	(Barca et al., 2012)
		Wayfinding and Legibility	(Barca et al., 2012)
		Visual Richness	(Hillier & Hanson, 1984)
	Semantic	Connectivity	(Moore, 1997)
		Identity	(Relph, 1976)
		Enjoyment of Place	(Beer et al., 2020)
		Satisfaction	(Rapaport, 1982)
		Memorability	(Cuba & Hummon, 1993; Stedman, 2002)
		Human Interaction	(Madani-Pour, 2005)
		Emotional and Affective Attachment	(Cuba & Hummon, 1993; Stedman, 2002)

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(Marathe, 2019; Saatsaz & Rezaie, 2023). Numerous studies have shown that these infrastructures, in addition to managing water resources and controlling floods, play a key role in improving urban environmental quality and enhancing city resilience. In this context, research by Jamshidian (2023), Attarian & Safar Ali Najar (2022), and others clearly confirms the role of these systems in preserving urban ecosystems and sustainably managing water resources.

Therefore, a comparative study of traditional water infrastructures, such as the Madi systems of Isfahan and the Qamsh systems of Dezful, offers a unique opportunity to uncover latent capacities in the interaction between technical, cultural, and social structures. This research lays the groundwork for developing sustainable, place-specific, and identity-driven development patterns.

Findings

• Qamsh systems: manifestation of traditional water infrastructure in Dezful

The Qamsh systems of Dezful can be regarded as a vivid and clear embodiment of traditional water infrastructures within the city's historical fabric. This system has evolved and persisted through an intricate connection between the natural environment, indigenous technology, and socio-cultural structures. Dezful's location on a conglomerate natural base along the Dez River has provided a setting in which water resources, as a fundamental factor, have played a shaping role in spatial organization, livelihoods, and social life (Imam Ahwazi, 2003). In fact, the Qamsh systems, as a distinctive example of indigenous water transfer technology, not only addressed the challenge of water access but also became one of the organizing elements of urban structure and social interactions.

Unlike qanats, which are fed by underground aquifers, Qamsh systems consist of hybrid underground tunnels that channel water from the Dez River, relying on the natural slope of the land, from upstream points to downstream areas of the city (Montazeri, 2008) (Fig. 1). Utilizing the natural stability of the conglomerate soils, this system has been resistant to collapse, and its structural durability has ensured continuous operation over centuries. Moreover, the routes of the Qamsh gradually became key indicators for settlement location; many houses, residential buildings, and even alleys were established along the Qamsh paths, making this infrastructure an integral part of the city's framework (Latifpour, 2009). One of the city's elders recounts: "A house that was not beside a Qamsh was like a tree with its roots dried up."

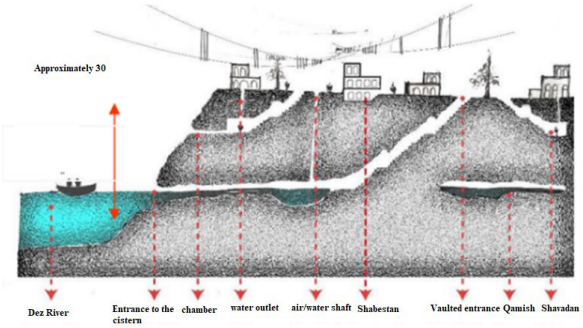


Fig. 1. Schematic cross-section of hand-carved architectural structures in the city of Dezful. Source: Mohibian et al., 2022.

Within the city, structures known as Sarbāṭāq were constructed at points where the Qamsh systems intersected with the ground surface. These spaces not only provided public access to water but also became social and cultural hubs. Particularly due to their location at the center of neighborhoods (Fig. 2), they played a pivotal role in shaping spaces for conversation, religious gatherings, and even local rituals. One local woman recalls: "The Sarbāṭāq were places to meet and talk, where we not only collected water but also shared daily news, joys, and sorrows." Thus, the physical structure of the Qamsh systems provided a framework for a network of social relationships, where water functioned not merely as a natural resource but as a unifying and socially cohesive element. Field observations and interviews with residents further confirm that Sarbāṭāq, as behavioral anchors, had a tangible and active presence in people's daily lives (Montazeri, 2008; Imam Ahwazi, 2003).

In neighborhoods located farther from the river, water was supplied through Saqqāhs (water carriers) and the transport of water bags a practice that, beyond its functional role in providing water, was recognized as a sustainable occupation and part of the local economy (Sajadi, 2009). This situation indicates that the traditional water distribution system in Dezful was not merely a technical system but a social and economic



Fig. 2. Map showing the city's structural dependence on Sarbāṭāq. Source: Mohibian et al., 2022.

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network in which infrastructure, employment, and cultural interaction were intricately connected.

From a functional perspective, the role of the Qamsh systems in providing drinking water, supporting agriculture, and maintaining public hygiene was vital and multifunctional. According to local farmers, these water transfer systems enabled optimal utilization of surface water from the Dez River across extensive agricultural lands, and the sustainable development of agriculture in the city's peripheries relied heavily on the continuity of these structures (Rahimiyeh & Raboubi, 1974). This demonstrates a form of environmentally adaptive engineering that innovatively leveraged the region's ecological capacities.

Beyond their obvious livelihood functions, the Qamsh systems also performed a dual role in interacting with the region's hot climate. Field observations during the warm months indicate that the cool, underground water flow provided a pleasant environment for residents and, particularly for vulnerable groups, offered a space for climatic comfort and social interaction (Fig. 3). This climatic function represents a subtle yet effective dimension of urban liveability.

At a deeper, more symbolic level, Qamsh systems are integral to the collective memory and historical identity of Dezful. Narratives from older generations and lived experiences indicate that these infrastructures were not only present in daily life but also reflected a distinctive perspective on nature, engineering, and urban living. As markers of indigenous intelligence and human-nature interaction, Qamsh systems have played a role in shaping place memory and are perceived by residents not merely as water transfer structures but as integral elements of the city's narrative.

Thus, Qamsh systems have played a fundamental role not only at the physical level as engineered structures, and at the functional level as systems for water distribution and urban liveability, but also at the symbolic level as cultural and social icons, contributing to the formation of place and the continuity of urban life in Dezful. This historical experience provides a clear model of the interconnection between infrastructure, place, and community, which can inspire contemporary place-based urban development policies. The preservation and revival of these systems represent not merely a return to the past but a forward-looking approach to strengthening identity, spatial equity, and urban resilience.

- **Madi systems of Isfahan: a water infrastructure with cultural and social roles in urban structure**

The Madi systems of Isfahan represent a clear manifestation of traditional surface water infrastructures within the city's historical fabric. This system has endured for centuries through an intricate connection between the natural environment, climate-adaptive technology, and socio-cultural structures. Isfahan's location on the central Iranian plateau along the Zayandeh Rud River created conditions in which water was not merely a life-sustaining factor but also a structuring element in urban spatial organization and life (Majedi & Ahmadi, 2008).

The Madi systems, as branches derived from the Zayandeh Rud, were initially designed to irrigate gardens and peripheral lands, but over time, they became key elements in the city's spatial order, social life, and cultural identity (Jenab, 1997) (Fig. 4).

In comparison with qanats or Qamsh systems, the Madi systems are surface structures that visibly channel water from the river to neighborhoods and agricultural lands. The paths of the Madi systems have shaped the urban fabric in such a way that many historical neighborhoods, bazaars, gardens, and even Naqsh-e Jahan Square are located along or adjacent to them (Namdarian et al., 2022). Field observations in the Jooybareh, Lenban, and Abbasabad neighborhoods also show that the Madi systems continue to act as influential physical elements, shaping pathways and defining the spatial identity of neighborhoods.

This network has long defined the city's structural framework, with its routes functioning as guiding lines for spatial orientation (Fig. 5). The presence of flowing water, the shade of trees, and the sound of moving water

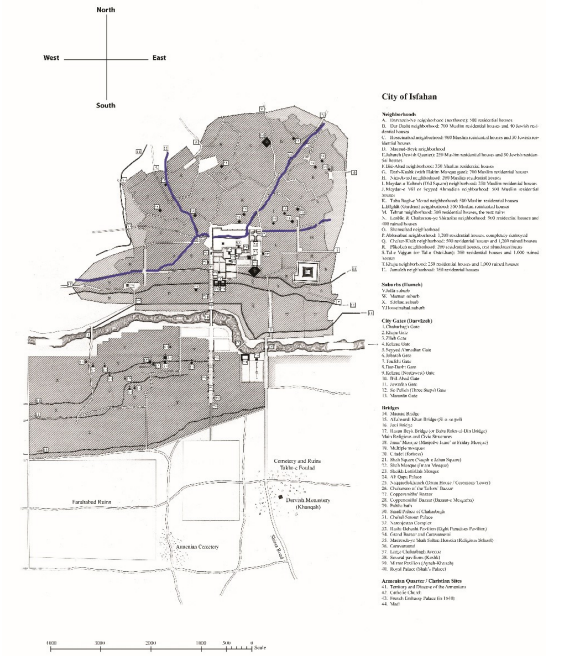


Fig. 4. Isfahan and the role of Madi systems in the city. Coust, 1867. Source: Shafaghi, 2002.



Fig. 3. Qamsh sculptures by Choqabaftan, a vivid testament to the history of people's interaction with Qamsh systems. Source: https://www.yjc.ir/fa/news/7543469

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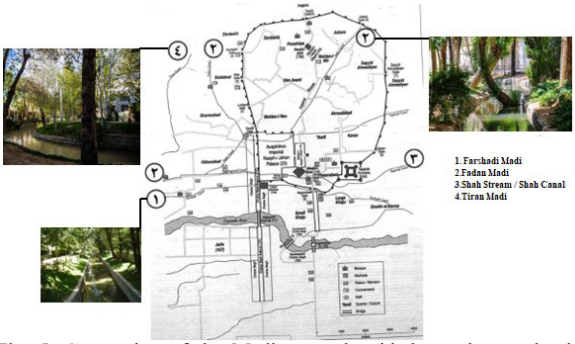


Fig. 5. Connection of the Madi network with key urban nodes in Isfahan. Source: Blake, 1999/2009.

tangibly enhanced the perceptual richness and aesthetic quality of these spaces. One longtime resident remarked in an interview: "For us, the Madi systems were like streets with trees, shade, and the sound of water."

Within the city, many bridges, Saqqakhānehs, Houshkhānehs, and mills were constructed in direct relation to the Madi systems. These spaces not only enabled public access to water but also provided a framework for daily interactions and the formation of social behaviors. In some neighborhoods, Madi paths functioned as open urban spaces, serving as venues for conversation, children's play, and even local rituals. Field observations in Madi Fadan and Madi Shah Mirza II show that, even in recent years, despite reduced water flow, these spaces continue to serve as areas of passage and gathering for residents. These characteristics have transformed the Madi systems from a simple water supply network into a platform for social interaction and local cohesion.

From a functional perspective, the Madi systems were multifunctional networks that addressed both daily and essential needs of the city's residents. They supplied water not only to gardens, agricultural lands, and homes but also to ablution facilities, Saqqakhānehs, and mills. Historical and documentary sources, especially from the Safavid period, indicate that the placement of religious and governmental spaces, such as the Shah Mosque and the Dolatkhaneh, was planned with access to the Madi system in mind (Ayatollahzadeh Shirazi, 2002). Interviews with older residents in neighborhoods adjacent to the Madi systems further confirm this role. One resident recalled: "My father used to say, if a Madi didn't pass through a place, they wouldn't choose it to build a house." This statement reflects the role of Madi systems in shaping settlement patterns and economic life.

Moreover, the climatic role of the Madi systems should not be overlooked. The surface flow of water in Isfahan's arid climate not only irrigated plants and trees but also increased soil moisture and reduced perceptible temperatures in surrounding streets. Some architectural experts believe that this surface moisture contributed to the stability and durability of earthen and gypsum materials used in historic buildings. Accordingly, it is argued that the enduring stability of structures like Imam Mosque owes in part to the continuous flow of the Madi systems (Ayatollahzadeh Shirazi, 2002).

At a deeper, symbolic level, the Madi systems occupy a special place in the collective memory of Isfahan's residents. Narratives from past generations show that daily life was intertwined with the Madi, from children's games to traditional rituals and evening conversations along the waterways. Terms such as "stream of life", used in local literature to describe the Madi, reflect their emotional and cultural significance (Fig. 6). One elderly woman from Abbasabad neighborhood remarked in an interview: "When its sound came, we knew spring had arrived. Now it's dry; it's as if the city has grown silent." This statement not only reflects the sorrow for the loss of past function but also underscores the role of the Madi in conveying a sense of place and collective memory.

Thus, the Madi systems of Isfahan have played an unparalleled role in shaping place and sustaining urban life, not only as engineered infrastructures at the physical level and multifunctional systems at the functional level, but also as carriers of meaning, memory, and identity at the symbolic level. This historical experience provides a vivid example of how infrastructure is intertwined with culture, society, and space, offering inspiration for contemporary approaches in urban regeneration, climate resilience, and place-based development.

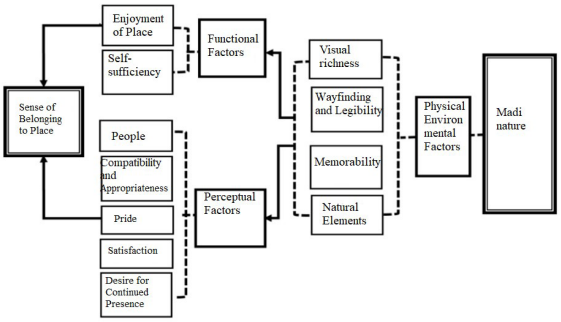


Fig. 6. Symbolic dimensions of the Madi systems. Source: Authors; Amjad et al., 2022.

Discussion

A comparative analysis of traditional water systems in two exemplary cases the Qamsh systems of Dezful and the Madi systems of Isfahan provides an opportunity to reassess the role of these infrastructures in place-based development. Despite differences in climate, geology, and urban form, these systems have simultaneously and intricately contributed at three levels physical, functional, and symbolic to spatial organization, facilitation of social life, and production of meaning. These findings indicate that traditional water infrastructures were not merely water conveyance systems but active agents in shaping urban experience, constructing space, and reproducing place identity (Table 2).

In the comparative analysis, distinct differences in the physical structure of these two systems are observed. The Madi systems, as surface networks, harness the flow of the Zayandeh Rud to create open structures that have influenced the spatial organization of neighborhoods, urban legibility, and visual richness. In contrast, the Qamsh systems, with their underground structure, have shaped spatial legibility through Sarbāṭāq, organizing the spatial structure of Dezful neighborhoods on a different basis. This structural distinction not only reflects the differing geological and climatic conditions of the two cities but also demonstrates the techno-ecological adaptability of these infrastructures to local needs. Thus, the physical differences reflect the precise

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Table 2. Comparative analysis of place-based development in the Qamsh systems of Dezful and the Madi systems of Isfahan. Source: Authors, 2024.

	Place-based Components	Dezful's Qamshs	Isfahan's Madis
Physical	Urban spatial structure	In the traditional era, due to supplying water to areas far from surface water, it played a structural role in forming neighborhoods and urban development.	In the traditional era, they played a significant role in locating neighborhoods, designing public buildings, and directing the city's expansion toward the southwest.
	Orientation and legibility	This system, with its underground nature, derived its orientation and legibility factor through the Sarbataq (entrance structures) present in the urban fabric.	This system had a substantial role in neighborhood placement and public building design to enhance urban legibility, such that Naqsh-e Jahan Square is a prominent example situated between two Madi channels.
	Visual richness	Due to its underground nature and reliance on Dez's conglomerate substrate, this factor has been less effective.	It had a profound influence on the creation of green spaces, to the extent that European travelogues described Isfahan as a "city within a forest" due to this feature.
Functional	Activity	It has lost its functional role.	Today, many of these channels are no longer used for water transfer, either because they are dry or blocked.
	Flexibility	It was a multi-purpose system supporting functional systems (services, irrigation, and related industries such as watermills), cultural systems (religious and cultural ceremonies), and recreational systems.	It is a multi-purpose and essential infrastructure in Isfahan for irrigation, supplying water to public facilities, and designing green spaces, affecting urban spatial organization, and serving as a venue for social interactions.
	Self-sufficiency and adaptability	Due to leveraging the Dez River and the conglomerate substrate of Dezful, this factor remains effective in the system.	By using the Zayandeh-Rud as the main water source, this factor remains effective in the system.
	Event receptivity	Hosting ceremonial, religious, and cultural events, as well as social interactions.	It is a structural and cultural element, contributing to the creation of public buildings for communal gatherings.
	Presence/ Accessibility	Its presence in the modern period has diminished due to the loss of identity and original nature in the system.	Presence in the modern era has diminished due to the loss of its identity and original nature.
Semantic	Frequency	The time factor in this water system has halted in later periods, and, with modern water supply systems, the system has been largely forgotten.	With climate changes, reduced flow of the Zayandeh-Rud, and the expansion of modern water supply systems, the functional role of Madi channels in water provision has decreased, and in recent historical periods, this factor's influence on the urban fabric has weakened.
	Identity	It is recognized as an identity component of Dezful city.	Madi channels are part of Isfahan's historical and cultural identity and have been preserved as symbols of urban heritage.
	Interaction with humans	Due to its multi-purpose activities, it facilitated these interactions.	The presence of water and vegetation along the Madi channels created spaces for human interaction with the environment.
	Emotional and sentimental attachment	Emotional attachment existed due to its functional, recreational, and cultural roles.	Due to their functional, recreational, and comfort-providing roles, they fostered emotional and sentimental attachment among residents.
	Memorability	As a place for gatherings and human interactions, it provided a memorable context.	They created spaces for social interactions and memory-making.
	Place enjoyment	Because of climatic conditions and limited access to surface water, this system played a role in recreation and social interaction within the urban fabric, which in turn created a sense of place enjoyment.	As offshoots of the Zayandeh-Rud, Madi channels brought water to areas far from surface sources and, in combination with greenery, provided spaces for place-based enjoyment.
	Satisfaction	Due to its service, recreational, functional, and economic roles, this aspect persisted at a satisfactory level until the advent of modern water supply systems, but in later periods, it has largely been forgotten in the urban context.	Due to their service, recreational, and functional roles, these channels offered high satisfaction in the city until the advent of modern water systems and climate changes; over time, drying and blockage of the channels have diminished this factor in residents' memories.

alignment of each system with the local ecology and technical adaptation to climate.

At the functional level, both systems were multifunctional. From water supply and irrigation to servicing public facilities, supporting rituals, enabling social interactions, and sustaining the local economy, these infrastructures functioned as living socio-economic systems. The Madi systems, with their continuous water flow, enhanced climatic quality and urban landscapes, while the Qamsh systems, with their extensive underground coverage particularly in central Dezful supported a wider range of services. Notably, both systems, despite differences in form and scale, successfully responded to daily needs and local sustainability.

At the symbolic level, both infrastructures carry cultural, mnemonic, and identity-forming significance. Oral histories, lived experiences, and the attachment of older generations to spaces such as Sarbāṭāq or beside the Madi demonstrate that these systems have been carriers of meaning in collective memory and urban perception. In Isfahan's local literature, terms such as "stream of life" and in Dezful, identity markers, indicate the role of these infrastructures in the cultural reproduction of the city.

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Despite notable similarities, structural differences are also significant (Table 3). The surface design of the Madi systems allowed direct human interaction with nature and urban space, whereas the Qamsh systems primarily operated underground, creating a more indirect form of presence. Furthermore, the Madi networks functioned largely as cultural-ecological systems within the urban fabric, while the Qamsh systems, in addition to their functional and cultural roles, contributed to the local economy and ensured the livelihood security of residents.

Based on this analysis, a three-layer conceptual model of place-based development centered on traditional water infrastructures is proposed. This model demonstrates that traditional water infrastructures are meaningful, multi-layered structures that simultaneously influence the city's physical form, social interactions, and residents' mental perception. In this model:

• **Physical Layer: Infrastructure as Spatial Organizer**

This layer addresses how the infrastructure shapes the city's spatial structure, the formation of neighborhoods, urban pathways, spatial legibility, and the visual richness of the environment.

• **Functional Layer: Infrastructure as a Support for Livability and Resilience**

At this level, the infrastructure acts as a living socio-economic system, meeting daily needs and providing a platform for social interactions, ritual practices, and multifunctional services.

• **Symbolic Layer: Infrastructure as a Carrier of Meaning, Memory, and Urban Identity**

This layer focuses on the cultural significance of the infrastructure, its role in shaping collective memory, emotional attachment, and the reproduction of place identity.

This model demonstrates that traditional water infrastructure is an integrative structure capable of simultaneously influencing urban form, spatial quality, citizen experience, and symbolic systems. Importantly, this analytical framework is generalizable to other Iranian and Islamic cities with similar infrastructures and can serve as a conceptual tool for place-based analysis and design. A key aspect of this model is that the layers do not operate in isolation; rather, they function in an interactive and synergistic relationship, with traditional water infrastructure acting as the central driving element within this three-layered network (Fig. 7).

Therefore, the logical pathway to answering the research question lies not merely in describing historical structures, but in translating the internal logic of these infrastructures into contemporary urban policy and design. The proposed conceptual model does not simply represent the three layers physical, functional, and symbolic but provides an operational framework for applying the principles of indigenous infrastructures in place-based urban development. Within this framework, the physical layer can serve as a basis for context-sensitive design and spatial legibility in modern water networks and public spaces; the functional layer can be translated into socio-ecological strategies and approaches to enhance urban resilience; and the symbolic layer has the capacity to revive collective memory and a sense of urban belonging in policies for historic fabric restoration. Thus, the comparative findings of the study advance from the level of "recognizing tradition" to "applying theory in practice", providing an explanatory and model-based answer to the central research question: how traditional water infrastructures can function as active agents in place-based urban development.

Table 3. Similarities and differences between two water infrastructures: Madi systems of Isfahan and Qamsh systems of Dezful. Source: Authors.

	Comparative components of two water infrastructures (Madis of Isfahan and Qamsh of Dezful)
Points of difference	Physical structure
	Role in urban legibility
	Source of water supply
	Role in urban landscape
	Flexibility and multifunctional use
Points of similarity	Role in urban development
	Identity and cultural dimensions
	Social and cultural interactions
	Impact on urban experience
	Decline of functional role in the contemporary period

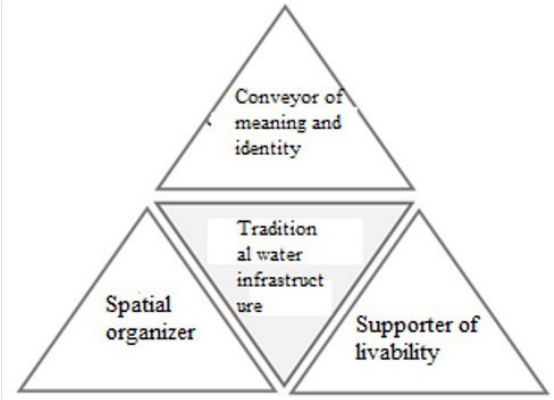


Fig. 7. Conceptual model of place-based development based on traditional water infrastructure. Source: Authors.

Conclusion

The present study, by posing the fundamental question of how traditional water infrastructures such as the Qamsh of Dezful and the Madi of Isfahan can be recognized and utilized as active agents in place-based development within contemporary Iranian cities, sought to clarify both the internal logic of these traditional water systems and their potential transfer to contemporary policy and design through a comparative analysis and the development of a three-layer conceptual model.

The findings indicate that traditional water infrastructures are inherently multidimensional structures that operate at the intersection of form, function, and meaning. Consequently, they can go beyond being merely technical systems and acquire an agentive role in urban development processes. According to the proposed model, revisiting and applying these infrastructures in contemporary contexts requires simultaneous attention to three interwoven layers:

• Physical layer: The water infrastructure acts as a "spatial organizer," defining the logic of urban form and spatial connectivity. Comparing the two water systems shows that Qamsheh, through underground channels and Serb-Taq nodes, structured Dezful's socio-spatial fabric, whereas Madi, with its surface presence and direct connection to the natural landscape, shaped the

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historical urban fabric of Isfahan. This understanding of internal spatial organization can be reproduced in contemporary urban design as a context-sensitive, networked model, in which local resources, form, and social life interact harmoniously.

• Functional layer: Traditional infrastructures not only addressed essential water supply and livelihood needs but also enhanced social interactions and provided the basis for urban ecological resilience. Qamshs, with natural airflow and underground cooling, and Madi, linking water, vegetation, and human movement at the urban scale, both demonstrate indigenous mechanisms for achieving sustainable urban livability and self-sufficiency. In contemporary cities, reinterpretation of these models could inform local green–blue infrastructure strategies aligned with climate and social needs.

• Symbolic layer: These systems carry layers of memory and meaning, reproduced through rituals, naming practices, and local narratives. Concepts like the "Living Stream" in Isfahan's collective consciousness, and the role of Qamshs in shaping Dezful's historic neighborhoods, are not merely memories of a technology but part of urban identity and lived experience. Understanding and reviving this symbolic layer can elevate contemporary development policies beyond the physical dimension, fostering belonging, social trust, and climatic memory.

Thus, the study's three-layer conceptual model moves beyond the mere recognition of tradition to the application of theory in practice. It demonstrates that transferring the logic of traditional water infrastructures to place-based development is possible through the integration of three interrelated dimensions:

• Physical connection between traditional structures and context-sensitive contemporary urban design;

• Functional connection between indigenous systems and resilience strategies;

• Symbolic connection between collective memory and identity-driven urban policies.

Consequently, the study argues that answering the central research question how to utilize traditional water infrastructures lies not in mere reconstruction of historical structures but in reproducing their internal logic and the synergistic interplay of form, function, and meaning in urban management and design. From this perspective, traditional water infrastructures, as "living spatial knowledge," possess the capacity to generate practical strategies for context-sensitive design, enhancing climatic resilience, and revitalizing urban identity in other Iranian cities.

Reviving these infrastructures, therefore, is not a regressive act, but a forward-looking step toward rethinking the relationship between humans, space, and nature within the framework of Iranian urban development a step that can lay the foundation for a new generation of place-based, ecologically sustainable, and meaning-rich cities.

Conflict of Interest

The authors declare that there was no conflict for them in conducting this research.

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