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Unveiling water legacy: an interdisciplinary exploration for comprehending Siraf's historical water landscape

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ABSTRACT

In the heart of southern Iran's arid expanse lies Siraf, a testament to the enduring bond between water and civilisation. This port city flourished in the 9th and 10th centuries, sustained by ingenious water management. Exploring Siraf's water heritage reveals a cultural landscape shaped by the symbiotic relationship between water and human innovation. Through meticulous analysis of technical reports, excavation records, interviews, and historical accounts, this research aims to understand Siraf's water heritage landscape using an interdisciplinary landscape-based approach. This approach integrates insights from archaeology, geology, geohydrology, and agriculture to provide a holistic view of the interconnectedness of natural and cultural elements. These dynamic systems inspire sustainable practices through landscape-based solutions considering natural and cultural landscape features to address urban challenges. As we face climate change and urbanisation, understanding and preserving Siraf's water heritage landscapes through an interdisciplinary approach provide a roadmap for a more resilient future.

KEYWORDS

Water heritage landscapes; cultural landscapes; sustainable water practices; landscape-based solutions; landscape conservation; Siraf

Introduction

Water has played a pivotal role in sustaining societies, shaping settlement, and driving the development of civilisation. These endeavours have given rise to structures, narratives, laws, and practices, collectively called 'water heritage' (Hein et al., 2020). When considering landscapes as areas characterised by the interaction of natural and/or human factors[1] (Déjeant-Pons, 2001), water heritage landscapes emerge as distinct regions shaped by historical interactions between water as a natural element and/or human factors. These landscapes stand as a testament to the unique relationship between water and humanity.

In the heart of southern Iran's arid expanse lies Siraf, a testament to the enduring bond between water and civilisation. Flourishing during the 9th and 10th centuries, Siraf had a strategic maritime location between Tang China and Iraq (George, 2015) (Figure 1). This ancient port city earned admiration for its large population and thriving agriculture (Hawqal, 1984; Istakhri, 1961), despite being situated in a semi-arid region known for scorching heat, erratic rainfall, and sparse vegetation (Mohajeri, 2010). Remarkably, Siraf fulfilled the water needs of its residents and agriculture. It also served as a vital water supply hub for visiting ships, earning

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Figure 1. This map shows Siraf's strategic location in maritime trade between Tang China and early Islamic Iraq, in the seventh to tenth centuries (The base map adopted from (George, 2015).

its evocative name 'Sirab,' symbolising the abundance of water (Jafari, 2016). Given these challenging environmental conditions, the most fascinating aspect of this historic port city is how residents ensured access to potable water and the unique relationship between water and humans in this historic landscape.

Studies highlight the critical role of preserving and valuing water heritage landscapes (Freitas, Cea, & Valdivieso, 2017; Hein, Mager, & Rocco, 2019; Olmo & Jiménez, 2013). Efforts to recognise and preserve cultural landscapes contribute to safeguarding cultural lifestyles and promoting the sustainable coexistence of humanity and nature in each region (Tahmasbi & Haghighatbin, 2022). Despite limited research in Siraf's urban landscape, significant knowledge gaps exist, including the need for a comprehensive regional perspective, integration of socio-cultural and ecological aspects, and sustainable strategies. Bridging these gaps requires a profound understanding of the landscape, as this foundation supports effective planning, assessment, and preservation efforts. This understanding and analysis of the relationship between water and heritage can also contribute to a more refined comprehension of tangible and intangible heritage on a broader scale (Hein et al., 2020). Comprehending a landscape is the foundation upon which effective planning, assessment, and preservation efforts are built.

This research aims to understand Siraf's water heritage landscape using an interdisciplinary landscape-based approach. This involves integrating insights and methodologies from various disciplines, including archaeology, geology, geohydrology, and agriculture. By leveraging this multidisciplinary framework, we aim to provide a comprehensive understanding of the water heritage landscape of Siraf. This approach is crucial for comprehending and conserving cultural landscapes as it allows for a holistic view that considers the interconnectedness of natural and cultural elements (Septini & Pramukanto, 2022). Furthermore, this approach helps bridge the gap between the conservation field's focus on the past and the planning and design field's orientation towards the future, offering a comprehensive framework for sustainable heritage management and decision-making (Massenberg, Schiller, & Schröter-Schlaack, 2023; Nijhuis, Storms-Smeets, & Thissen, 2023).

Data source and methods

The investigation of the Siraf water heritage landscape employed a comprehensive and multi-faceted approach, incorporating on-site visits, extensive fieldwork, and the examination of a wide range of materials, including technical reports, excavation records, maps, historical travelogue, and interviews.

The initial phase involved an in-depth examination of the historical development of rainwater management landscapes and their role in the formation of Siraf port cities. This phase utilised archaeological excavation reports, historical documents, and travelogues, alongside an analysis of the transformations that have occurred over time.

In the following phase, a thorough analysis of Siraf's spatial dynamics was undertaken using a landscape-based approach, categorising them into natural, urban, infrastructure, and water heritage layers to offer a holistic understanding of the operational dynamics of this cultural landscape system. Mapping these landscape systems unveils the spatial conditions crucial for adaptive planning strategies and design principles. Breaking the urban landscape into layers based on their change dynamics is a recognised approach to comprehending the urban landscape system (Nijhuis & Pouderoijen, 2014).

Also, understanding cultural landscapes through 'layer-by-layer' analysis necessitates reading them through 'landscape elements' to grasp the interconnectedness of the system, people, and the landscape itself for a comprehensive understanding (Maes, 2022; Martokusomo, 2022). So, the various elements constituting the landscape and their respective applications were then identified. Due to the limited availability of sources, extensive fieldwork was employed in this phase to gather comprehensive data.

In the last phase, the collected data were meticulously analysed and discussed, supported by specially designed diagrams to elucidate key findings. The results and diagrams were then validated through 10 semi-structured interviews conducted in April and May 2024 with local experts from diverse fields including 3 archaeologists, 2 geologists, 2 geohydrologists, and 3 agricultural specialists. This process ensured the reliability and credibility of the conclusions drawn.

Siraf's urban landscape is an ongoing history

The documentary evidence for the history of Siraf is summarised in David Whitehouse's report (Whitehouse, 1968) as follows:

> 'By the time Siraf was mentioned first[2] (c.850), it was already a flourishing port with merchants dealing with India and Southeast Asia. During the next hundred years, the city continued to prosper and Sirafi merchants traded with the Red Sea, East Africa, and Madagascar in the West and with India, the Malay peninsula, and China in the East. In the early tenth century, more than 2.5 million dinars' worth of goods passed through Siraf annually. In 977 the city was damaged by an earthquake and thereafter declined. After the fall of Buyids[3] (c.1055) most of the trade was diverted to Qais and by 1218 Siraf was in ruins.'

While historical records preceding the 9th century are scant, there are occasional references associating Siraf's origins with the legendary Iranian King Kai Kavus.[4] However, scholarly discourse suggests that Siraf's establishment may be attributed to Ardeshir Papakan) (Ardashir I), the founder of the Sasanian dynasty. Semsar (1978) supports this view, noting that Ardeshir paid significant attention to water supply in the cities he founded, ensuring that water management structures were scaled according to the expansion and needs of these cities. This is particularly evident in Siraf, where the rainwater management landscape expanded significantly during the 9th and 10th centuries.

Furthermore, Malekandathil (2002) indicates that King Ardashir I, who established Sassanid rule by overthrowing the Parthians in 224 AD, set the stage for transoceanic trade with India. He founded or re-founded several key ports in the Persian Gulf, including Siraf, Rew Ardashir, and Kharg Island, making them important maritime bases for the Sassanids.

The Sassanian period witnessed significant advancements in centralised administrative systems, facilitating progress across various domains, including water management technology. innovative water management techniques implemented by the Sassanians played a crucial role in transforming the arid landscapes of Iran into habitable zones (Noruzzadeh Chegini, Salehi Kakhki, & Ahmadi, 2015).

Documentary evidence provides insights into Siraf's flourishing trade activities until it was damaged by an earthquake in 977 CE (Pourhasan Darabi & Alamolhodaei 2017). After the decline of the Buyid dynasty, trade routes shifted, diverting commerce away from Siraf, ultimately leading to its abandonment and subsequent ruin by 1218 CE. Siraf's historical narrative underwent a resurgence in the 19th century following its rediscovery by archaeologists.

The rediscovery of Siraf by Western archaeologists in the 18th century (Stein, Andrews, & Hobson, 1937) catalysed significant excavations and research endeavours. Pioneering archaeological digs led by scholars such as David Whitehouse (Whitehouse, 1968, 1969, 1970a, 1971, 1972, 1974), alongside investigations by Iranian archaeologists (Jelodar & Esmaeil, 2021; Zarei, 2021), have yielded invaluable insights into Siraf's urban morphology and architectural heritage. Furthermore, surveys focusing on underwater, and shoreline remains (Khakzad, 2012; Tofighian, 2014) have enriched our understanding of this ancient port city.

Siraf's cultural landscape, akin to a palimpsest, bears evidence of sequential development over time, reflecting its multifaceted historical significance and enduring legacy in the region (Figure 2).

Results

Mapping landscape system

The spatial relationships between environmental conditions and human responses and interventions can be examined through cartographic explorations or mapping. This approach helps identify significant conditions, key driving forces, and the effects of various dynamics, as it is centred on understanding spatial relationships and the nature of change (Nijhuis, Xiong, & Cannatella, 2019). Spatial relationships play a crucial role in understanding cultural landscapes as they reflect the intricate connections between society, space, and culture (Jakaitis & Zukas, 2020). By considering spatial relationships, we can delve deeper into the layers of meaning and symbolism embedded in cultural landscapes, enriching our understanding of their significance and evolution over time.

Recognising the layers and interrelationships within landscapes is essential, as highlighted by Nijhuis, Sun, et al. (2023). Water heritage landscapes are viewed as systems spanning various scales, necessitating an analysis of positional, conditional, and operational factors and their complex interactions. Positional factors relate to the geographical placement of the water heritage

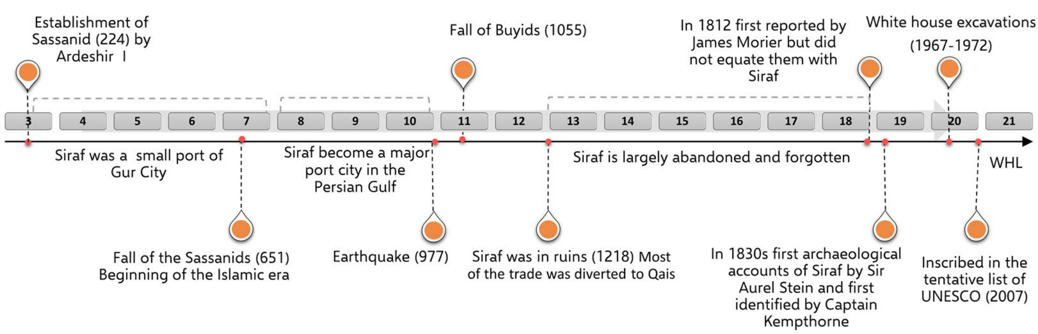

Figure 2. Siraf as an ongoing history (Design: Marziyeh Tahmasbi).

landscape within broader natural and urban contexts, including proximity to water sources and strategic locations. Conditional factors encompass climate patterns, hydrological regimes, and ecological dynamics that impact the landscape's evolution and interactions with other ecosystems. Operational factors involve site-specific conditions like cultural-historical features and land use practices, which directly affect the historical water landscape. Analysing these factors helps in comprehending the development and sequential relationships of the systems over time.

Based on available knowledge and expert input, a comprehensive map was developed to illustrate the dynamics of Siraf's urban landscape (Figure 3). This map consists of four distinct layers: the natural layer, the urban layer, the infrastructure layer, and the water heritage layer, detailing their interactions within the port city of Siraf.

Natural layer

This layer is rooted in factors such as climate, landforms, water sources, and rock types. These physical factors play a pivotal role in shaping soil formation, hydrology, ecosystem distribution, agricultural land use, and historical development of settlements and cities (Nijhuis et al., 2019). Siraf extends along a narrow coastal area,[5] bordered by the foothills of the Zagros Mountains, which run parallel to the coastline (Khakzad, Trakadas, Harpster, & Wittig, 2015). The region experiences erratic rains during winter and autumn[6] (Jafari, 2016), resulting in flash floods during these months (Pourkerman et al., 2020). Three dry rivers, or wadis, channel these flash floods from the highlands to the sea.

Geologically, the landscape is divided into two parts: the southern part, including the urban area, is built on coastal sandy sediments containing shell fragments, while the northern part comprises steeper hillside slopes made of sandstone with interlayers of conglomerates (Pourkerman et al., 2020). These sandstone and conglomerates provide a porous foundation for the movement of freshwater. Additionally, Siraf's coastal morphology, characterised by a narrow coastal plain and steep coastal bathymetry, provided relative coastal stability with low vertical movements, making it an ideal location for maritime activities. The amplified summertime Shamal winds from 550 CE onwards, combined with a fall in Relative Sea Level (RSL), led to a shift in the importance of harbours in the Persian Gulf, making Siraf a preferred alternative for seafarers (Pourkerman et al., 2018). These natural factors collectively established Siraf as a significant maritime hub in the Persian Gulf, facilitating trade and settlement development throughout history.

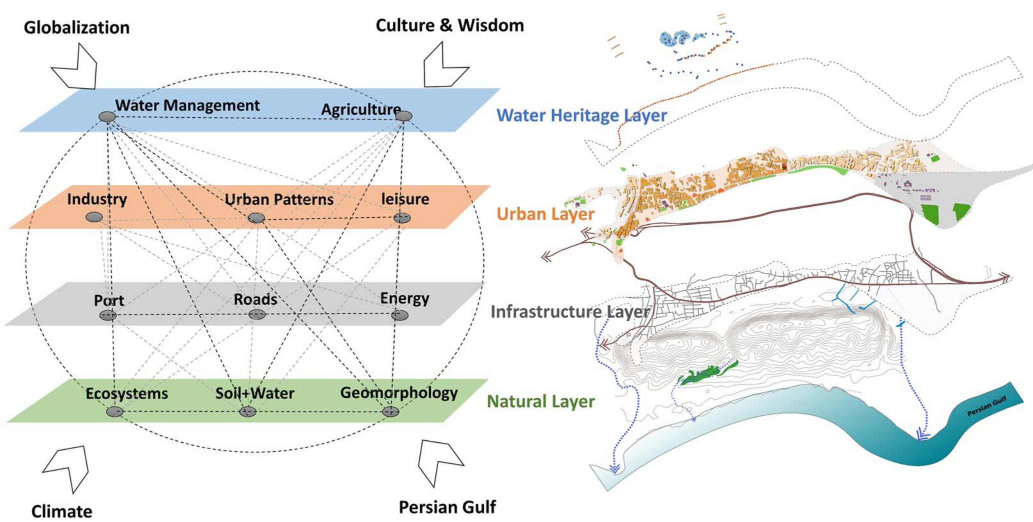

Figure 3. Multilayered structure of Siraf's water heritage landscapes (Design: Marziyeh Tahmasbi).

Urban layer

Influenced by the mountains to the north and the sea to the south (Khakzad et al., 2015), the city of Siraf follows a linear development pattern. This layer is divided into two sections. The ancient urban area includes significant cultural heritage sites such as the Great Mosque, Bazaar, and Noble Houses. In contrast, the new urban area formed mostly in the last two decades. The eastern and western regions of Siraf have experienced significant development due to a population increase, particularly in the recent two decades. This population surge is attributed to Siraf's proximity to the South Pars oil and gas industrial area of Asalouye, which has spurred immigration. However, this development has been unplanned, resulting in a lack of essential services and causing chaos and a loss of coherence in the city's physical character, both in the historical and newly developed parts (Sardari & Kiani, 2018). Consequently, the unstructured expansion poses significant challenges to the sustainable development and preservation of Siraf's unique urban identity.

Infrastructure layer

This layer includes both port and road infrastructures. The port infrastructure is divided into two distinct sections. The eastern section features a beachfront area with a dock serving various industrial activities, particularly the transportation of gas condensate. In contrast, the western coast has small fishing piers catering to smaller boats (Afshari Esfidvajani, Suzanchi, & Lagayi, 2014). The road infrastructure within Siraf consists of a network of local roads within urban areas and a freeway to the north. A critical road running parallel to the coastline connects the Asaluyeh port, one of Iran's major oil ports located east of Siraf, with the Bushehr port in the west. This road serves as the city's main street, around which residential areas have developed. A freeway in the north connects the Asaluyeh port to Shiraz, serving as the primary access point to Siraf and playing a pivotal role in facilitating transportation and connectivity in the region.

Water heritage layer

This layer is divided into five zones based on different functions (Figure 4). Each zone features distinct spatial-visual characteristics and elements:

1. Nourishing the underground water table zone: Located in the mountains to the north and outside of urban areas. This zone features landscape elements such as recharging pools, wells, and stairs.
2. Storing zone: Situated in the foothills and on the outskirts of the city, this zone is characterised by cisterns.
3. Harvesting zone: Found within urban areas, this zone primarily consists of pumping wells.
4. Farming zone: Observable on the hillside and in the foothills of the mountain, this zone includes farming wells and brick walls.
5. Crisis protection zone: Positioned to protect the city against water crises, such as floods in the north and stormy sea waves in the south. This zone features elements like percolation[7] and barrier dams.

Analysing the water heritage landscape as a complex system involves categorising its functional and structural aspects into distinct layers, avoiding a deterministic approach that might overlook other essential considerations. The goal is to understand the individual layers, their interconnected influences, and the potential for their relationships to evolve. This relationship illustrates how the water heritage landscape functions as an integrated system, influenced by geographical conditions, the natural environment, and their location within the port city (Figure 5).

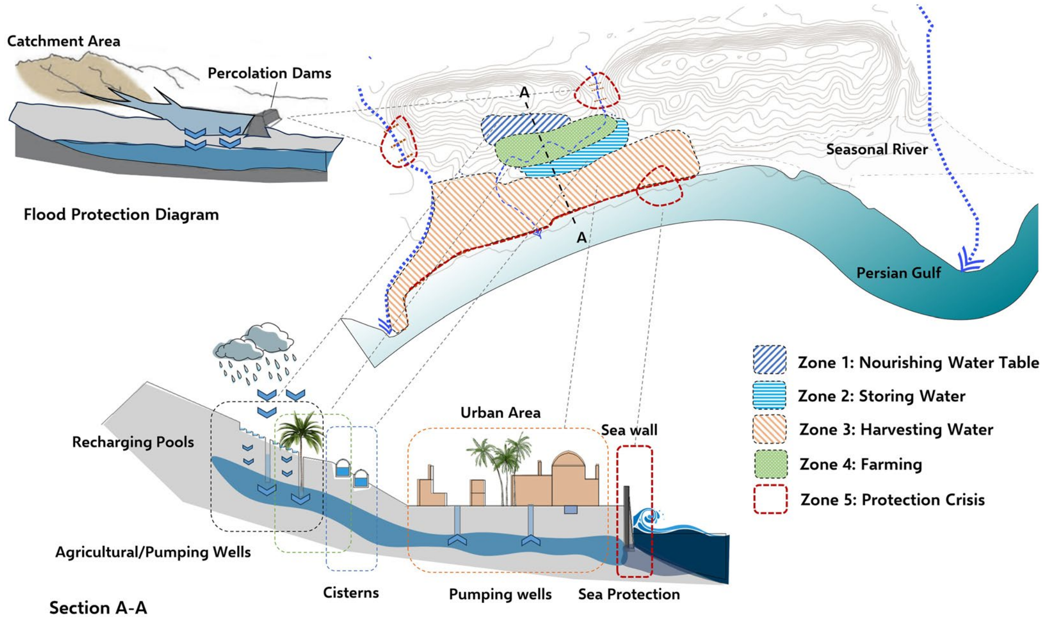

Figure 4. Different zones of water heritage landscape based on functions (Design: Marziyeh Tahmasbi).

Rainwater, as the primary water source, combined with extremely hot weather and geological conditions, has significantly shaped the form of the city and its well gardens. The need to manage and utilise rainwater efficiently led to the development of specific infrastructure and settlement patterns aligned with water management zones. Consequently, aligning these water heritage layers with the city's expansion highlights their crucial role in Siraf's sustainable urban development. Therefore, understanding and preserving these water heritage layers is essential for maintaining Siraf's historical integrity and ensuring its future resilience.

Landscape elements

Analysing cultural landscapes through 'landscape elements' is crucial after a 'layer-by-layer' analysis to effectively understand the historical and cultural values, functions, and land use methods (Jelen, Šantrůčková, & Komárek, 2021). Understanding the water heritage landscape of Siraf involves examining its visual and symbolic elements and their attributes (Figure 6). Recharge pools, wells, cisterns, percolation dams, barrier dams, brick walls, and access stairs each play a crucial role in the system. By studying these elements, we can gain insights into the historical and contemporary water management practices and the intricate relationships within this landscape. This approach allows for a comprehensive understanding of how these elements have shaped and sustained the region over time.

Recharge pools

In the highlands of the mountain overlooking Siraf, there are over 7,400 recharge pools. These rectangular basins play a vital role in collecting rainwater along the southern slope of the mountain. They come in three shapes (see Figure 6, column 1): aligned with the slope, perpendicular to it, or irregular (Jafari, 2016). Typically, they follow the topographic slope, with uniform and parallel excavation in wide, even slopes. In more diverse terrains, the pools vary in direction but maintain alignment with the slope. Dimensions vary, averaging 1.4 metres in length, 0.5 metres in width, and approximately one metre in depth.

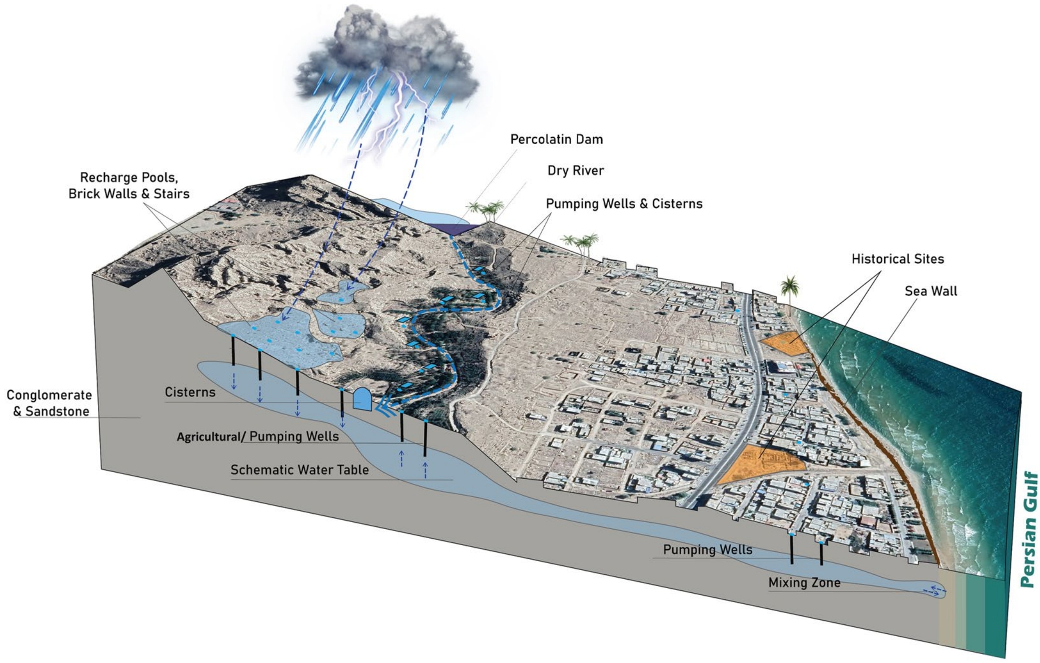

Figure 5. Conditional relationships of Siraf's water heritage landscapes (Design: Marziyeh Tahmasbi).

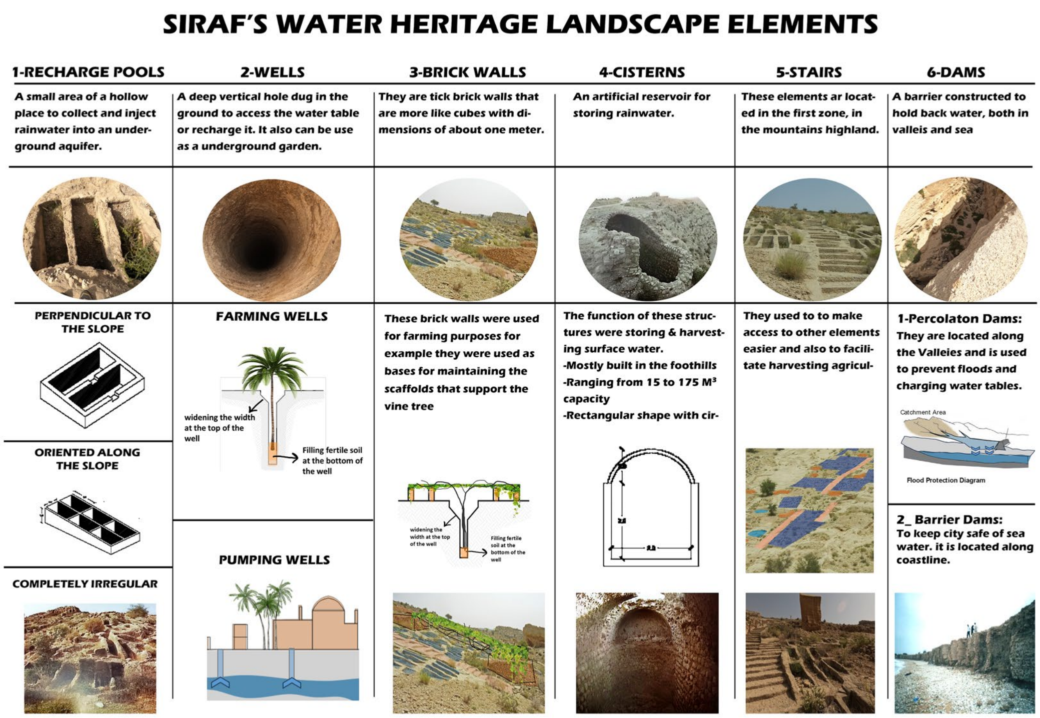

Figure 6. Siraf's water heritage landscape elements (Design: Marziyeh Tahmasbi).

In certain sections, like the eastern Lir Valley, pools appear perpendicular to the slope, integrating water channels or grooves for overflow into lower wells. In this area, dimensions may reach up to 2.2 metres in length, 0.7 metres in width, and about one metre in depth. Conversely, in the western Lir Valley, rainwater collection pools differ in size and slope orientation, suggesting a less organised approach influenced by a longer historical context with less emphasis on strict order.

Wells

Wells play a significant role in the Siraf's water heritage landscape, with approximately 170 well rings identified within this landscape. Most of wells have a circular cross-sectional shape and can extend to depths exceeding 60 metres underground. Their diameters typically range from 70 centimetres to 1 metre, with the widest ones measuring about 2 metres (Jafari, 2016). These wells serve distinct functions and can categorised into two groups (see Figure 6, column 2).

The first category consists of farming wells used for planting fruit trees, such as grapes (Khorsandi & Movaghatian, 2022) and dates (Jafari, 2016). These farming wells are primarily located in the foothills, with some also found in the highlands. The second category encompasses pumping wells, situated in both mountain slopes and residential areas for water harvesting purposes. Historical maps (Whitehouse, 1970b), indicate a linear arrangement of these wells in the Lir Valley, suggesting they are integral components of a qanat system designed for water extraction.

Brick walls

This element can be seen in the farming zone in considerable numbers. They are thick brick walls that are more like cubes with dimensions of about one metre (see Figure 6, column 3). In some archaeological reports, they are mentioned as building ruins (Whitehouse, 1968). However, considering the similarities in landscape elements and the unique grape cultivation methods in a village in Bushehr province, it seems that these brick walls were used as scaffolds to support the grapevines planted in the wells (Tahmasebi, 2009).

Cisterns

Other elements of this water heritage landscape are water reservoirs for storage and retention of surface water. These water reservoirs are mostly built in the foothills and are covered or enclosed structures (see Figure 6, column 4). Arnold Wilson,[8] mentions that he observed numerous ruined water reservoirs among the debris (Wilson, 1928). These structures are large rectangular pits dug into the ground and lined with lime and mortar. To prevent water evaporation, they had constructed a circular roof over them. However, all these roofs have collapsed and become dilapidated over time. The useful capacity of these water reservoirs differs from 15 to 20 cubic metres, with some of them having capacities of up to 60 cubic metres and occasionally even up to 175 cubic metres. One interesting aspect of these water reservoirs is the presence of handcrafted water channels designed to direct the runoff towards these reservoirs.

Access stairs

These elements are in the mountain highland, near recharge pools and brick walls (see Figure 6, column 5). They used to make access to other elements easier, for example, they could facilitate transportation of harvested grapes.

Dams

Dams in the area can be categorised into two distinct groups, each serving unique functions (see Figure 6, column 6).

The first category consists of percolation dams, designed to impound and control stormwater flow within gullies or valleys. According to the archaeological report (Whitehouse, 1972), such a dam in the western part of zone one obstructed water flow at three distinct points to create barriers, channelling water through a conduit to an aqueduct system leading to the Siraf region via the Kunarak gorge. This system included well-like structures functioning as settling tanks to separate sediment from the water before distribution, highlighting the engineering and water management techniques used in the landscape. The second category is barrier dams. Historical records, such as those by Lamb (1964), mention a 400-metre-long coastal wall serving as a shield for the city from waves. Currently, only a small part of this wall remains in the western part of the beach (Tofighian, 2014).

Discussion

Each landscape has its distinct characteristics and is distinguished by its characteristics, this distinction is defined as the authenticity of the landscape. Authenticity helps in understanding the evolution of the landscape, emphasising the importance of both physical and perceptual aspects in conservation efforts (Nijhuis, 2020). In other words, A landscape's authenticity enhances its legibility, making it easier for people to interpret and appreciate the spatial quality and historical context of the environment. Therefore, in landscape conservation and cultural heritage management, authenticity is crucial, bridging the past and future (Gustavsson & Peterson, 2003).

The water heritage landscape of Siraf possesses significant authenticity as it genuinely represents the landscape's past while acknowledging its continuous transformations over time. Due to the various landscape layers and historical elements, the landscape remains legible. However, rapid urban development and functional changes, especially in recent decades, can compromise the layering and legibility of the landscape, posing a danger to its cultural identity. Therefore, implementing a 'management of change' approach in conserving this authenticity is necessary to ensure the landscape's past continues to play a relevant role in the future.

In this regard, one important point to consider is that Siraf's water heritage landscape should be viewed as intricate networks of subsystems constantly adapting to natural processes, societal needs, and technological advancements, a characteristic of living landscapes emphasised by Nijhuis (Nijhuis, Storms-Smeets, et al., 2023). By recognising and embracing this dynamic nature, we can ensure the preservation of their authenticity.

Siraf's historical urban landscape demonstrates remarkable resilience and adaptability. The city's water management strategies, developed during the Sasanian dynasty under Ardeshir I, supported extensive trade networks and facilitated urban growth. The city's response to significant changes, such as the devastating earthquake in 977 CE and subsequent shifts in trade routes, highlights its adaptive capacity. The rediscovery and archaeological excavation of Siraf in the 19th and 20th centuries further underscore its dynamic nature and historical significance. These landscapes stand as a testament to the ongoing dialogue between human activities and the natural world, a dialogue that shapes the very essence of their cultural and historical significance. The water management strategies employed in Siraf offer a profound example of this dynamic interaction, illustrating how the landscape adapted and evolved while maintaining its authenticity.

Landscape-based solutions for water management

Studying the unique relationship between culture and nature in landscapes like Siraf enhances our understanding of past water systems and their relevance today. One key aspect of this knowledge is the strategies people used for centuries for water management, which are called landscape-based solutions (LBS). A landscape-based solution refers to an approach in spatial planning that considers natural and cultural landscape features to address urban challenges (García-Mayor & Nolasco-Cirugeda, 2023). These solutions are not only innovative but also deeply rooted in the specific environmental and cultural context of Siraf.

For instance, the methods employed by people to collect rainwater in aquifers and redirect water from aquifers to the surface demonstrate a sophisticated understanding of local geology and hydrology. These systems were crucial in sustaining agriculture (Wilkinson, 1974) and providing water to the city, showing how local knowledge was integrated into practical solutions.

Another significant aspect of Siraf's water management is the cultivation of trees and vegetation that are well-adapted to the arid climate (Figure 7). These practices not only supported agriculture and minimised evaporation but also fostered microclimates that enhanced biodiversity and bolstered the resilience of the local ecosystem. The use of indigenous plants and traditional agricultural techniques underscores the importance of cultural heritage in developing sustainable water management practices.

These landscape-based solutions provide valuable insights for addressing contemporary challenges such as climate change and urbanisation (Nijhuis, 2022; Ursino & Pozzato, 2019). They illustrate how blending natural processes with cultural wisdom can lead to effective and sustainable water management strategies. By learning from Siraf's heritage, we can develop modern approaches that are both innovative and respectful of local traditions and environmental conditions.

Harmonising natural and architectural techniques

Siraf's water management system was remarkably inventive, seamlessly blending natural and architectural techniques to capture and store rainwater (Figure 8). Utilising mountain wells, and

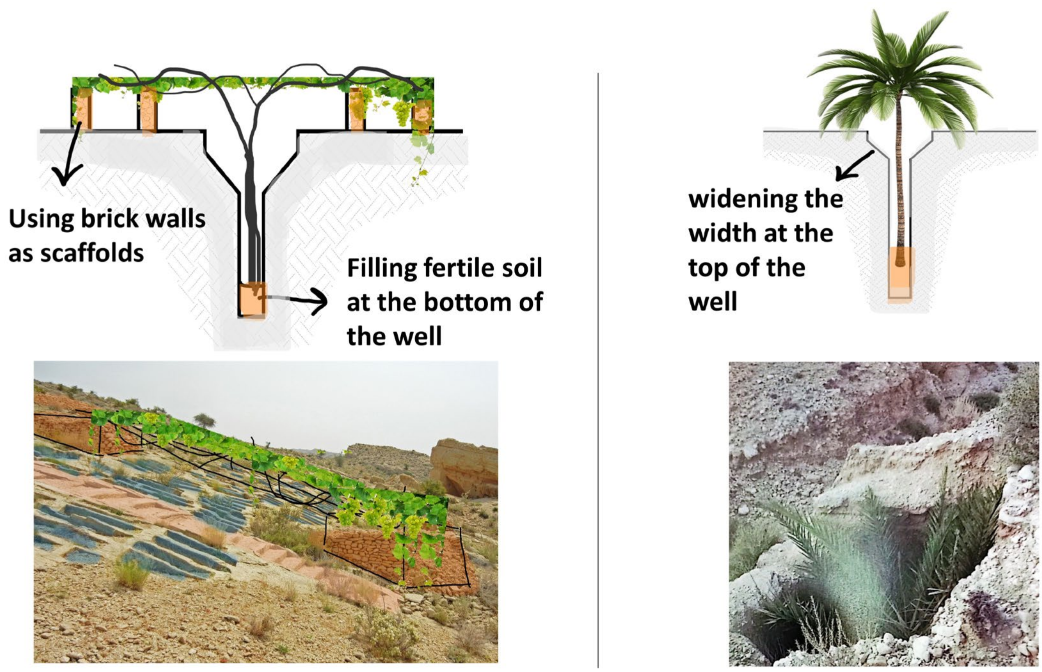

Figure 7. Details of the well garden and brick walls (Design: Marziyeh Tahmasbi).

cisterns, and incorporating rainwater storage within city structures, the system effectively harnessed rainwater for long-term use. The Whitehouse Report (1969) details this approach, noting the use of drains and earthenware pipes to channel rainwater into stone-lined pits at the base of outer walls, highlighting the smart design that protected against storm damage and facilitated water storage.

Additionally, Siraf's innovative water management extended to its religious structures, such as the great mosque. Within the mosque, a stone-lined well and a large cistern, along with a strategically placed platform for drawing water, demonstrated a sophisticated approach to water conservation. The cistern's design mirrored those found in the foothills, underscoring a consistent and effective water management strategy. Sir Arnold Wilson (1928), also noted the presence of a nearby qanat, further illustrating Siraf's comprehensive and integrated approach to water utilisation, even within its sacred spaces.

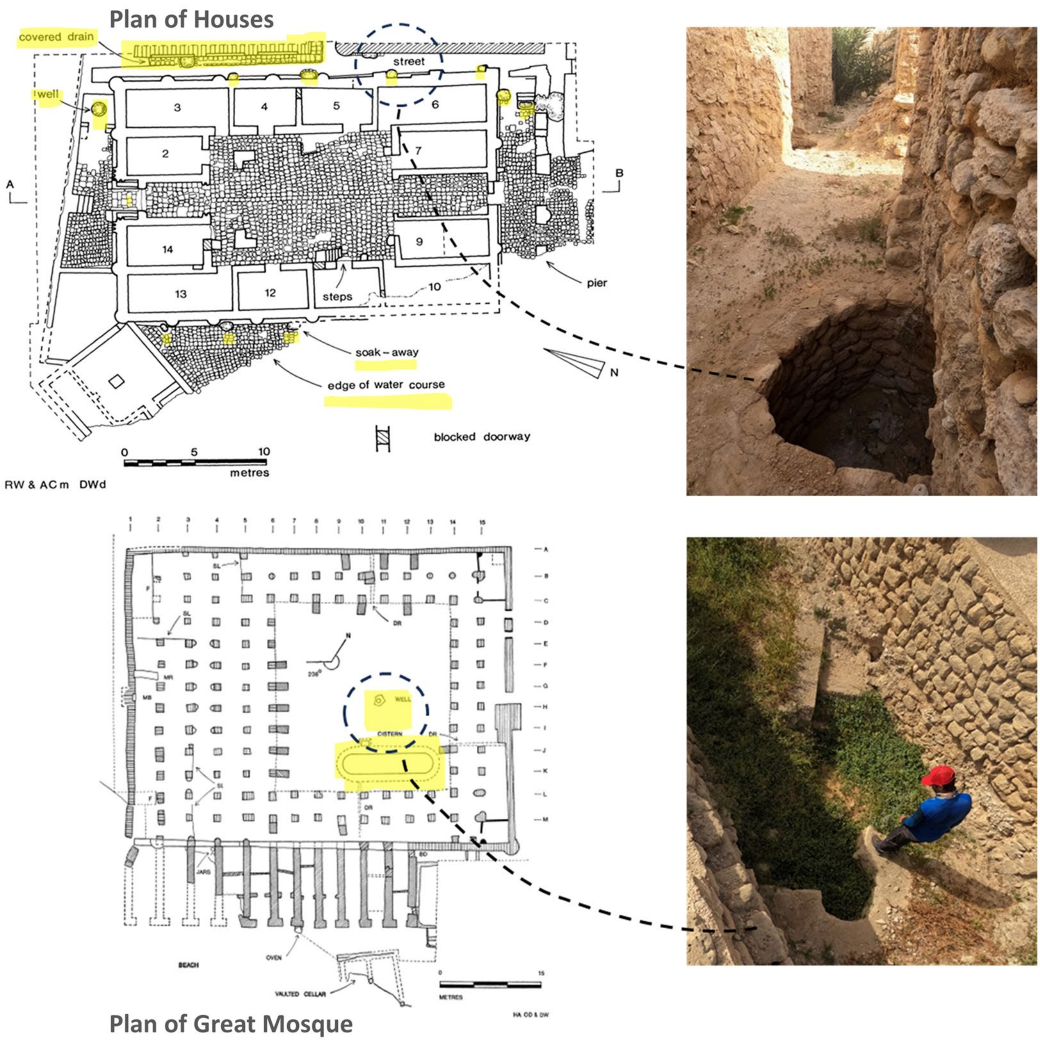

Figure 8. Architectural elements of the water management system, such as wells, rainwater collection pools, and cisterns, are evident in the 10th or 11th-century house and mosque plans, as documented in the Whitehouse Report (1969). The accompanying photo illustrates these features (Photograph by Marziyeh Tahmasbi).

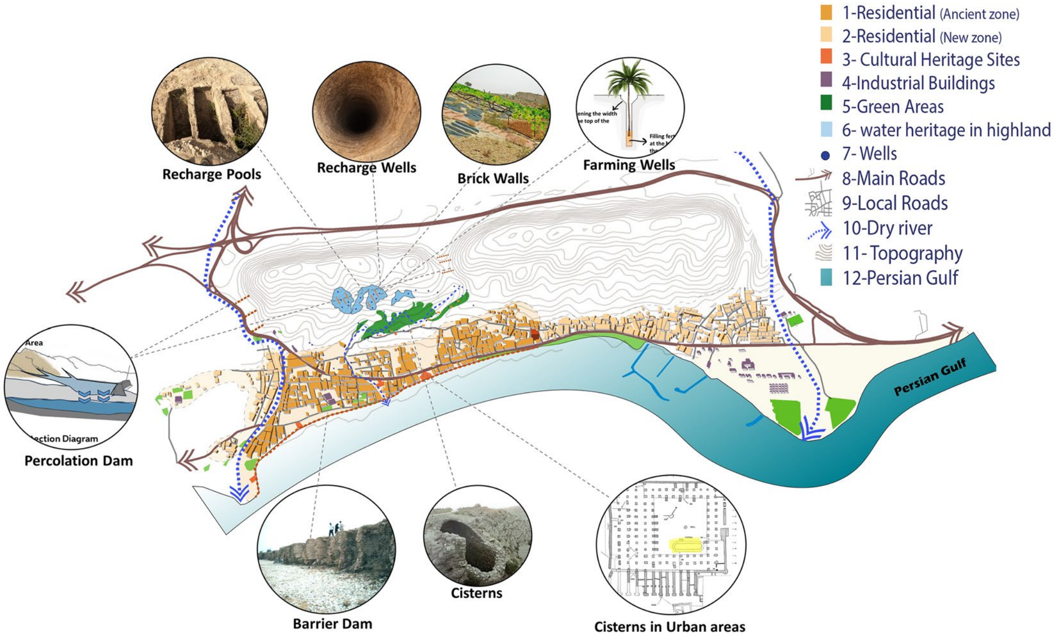

Figure 9. Siraf's water heritage landscape (Design: Marziyeh Tahmasbi).

Conclusion

Siraf's water heritage landscapes (Figure 9) exemplify a convergence of historical, cultural, and environmental significance, offering dynamic systems that inspire sustainable practices. By preserving their authenticity, we establish a vital link between the past and future, drawing lessons from comprehensive water management systems integrating natural and architectural features.

The landscape-based solutions demonstrated in Siraf, such as advanced rainwater harvesting techniques and innovative methods of tree cultivation, hold valuable implications for contemporary challenges like climate adaptation and biodiversity enhancement. These ancient practices not only sustained urban life and agriculture in the past but also provided a framework for modern sustainable development strategies.

Siraf's spatial dynamics, categorised into natural, urban, infrastructure, and water heritage layers, underscore the holistic understanding necessary for effective landscape management. Integrating cultural heritage with environmental science in Siraf's water management strategies offers a blueprint for resilient urban design. Techniques such as integrating cisterns into city structures and leveraging indigenous plant species highlight adaptive strategies that remain relevant today.

In conclusion, Siraf is a testament to the harmonious coexistence between human activities and nature, fostering a dialogue essential for sustainable solutions to contemporary challenges. By embracing and adapting Siraf's historical practices, we can pave the way for urban resilience, environmental stewardship, and cultural preservation in the face of evolving global pressures.

Notes

1. The definition presented by the European Landscape Convention.
2. The earliest reference to Siraf occurs in the writing of Ibn al-Faqih (Whitehouse, 1968).
3. Islamic dynasty that ruled in Iran and Iraq from 932 to 1062 (https://www.oxfordreference.com/display/10.1093/oi/authority.20110803095539247 access: 27/10/2023).

4. Kai-Káús or Kai-Kaus, is a mythological King of Greater Iran and a character in the Shahnameh.
5. Spanning approximately 0.5 to 1 kilometre in width.
6. Average annual rainfall in this area is approximately 230 mm (Pourkerman et al., 2020).
7. Percolation dams serve three purposes: (a) to reduce the speed of surface flow; (b) increase percolation for the recharge of shallow aquifers; and (c) obstruct the flow of sediments. They are constructed across riverbeds and are made of natural materials that are locally available such as rocks, logs, bamboo, sticks and branches (Mekdaschi Studer & Liniger, 2013).
8. The author of the book "The Persian Gulf" who visited Siraf in 1911.

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Disclosure statement

All authors declare that they have no conflicts of interest.

Research ethics and consent

All participants in the validating process have been verbally informed that they participated in a research project, and that information and data from the process would later be published.

Data availability statement

All the data have been published in the paper.

Notes on contributors

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