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Research Article

Arbala Qanāt-Driven Mill, Meymeh, Isfahan Province, Iran: A Reassessment of its Architecture and Hydraulic System

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Abstract: Water-powered mills in Iran have long played a key role in producing flour and sustaining the livelihoods of traditional communities. One such historic structure is the Arbala mill in the city of Meymeh (Isfahan Province), which was fed by the UNESCO World Heritage-listed Mazdābād Qanāt and is regarded as one of the major hydraulic structures of the city. Despite its significance, no comprehensive historical, technical, or architectural documentation has previously been undertaken for this mill. The building has suffered extensive damage, with several parts destroyed or lost, and it is currently abandoned. This study aims to reconstruct the architectural and technical features of the mill before its deterioration and to identify the indigenous knowledge embedded in its construction and operation. To this end, a descriptive–analytical approach was adopted, drawing on multiple sources including library research, interviews with knowledgeable locals and experts, field surveys, and oral history. Semi-structured interviews were conducted with nine informed residents of Meymeh. In addition to presenting historical information and spatial analysis, particularly in relation to other historic hydraulic structures in Meymeh, the study reconstructs technical drawings of the mill based on its pre-destruction condition and identifies its key functional components. These findings provide a basis for future conservation and restoration planning. Furthermore, considering the tourism potential of the Mazdābād World Heritage Qanāt and other nearby hydraulic structures, as well as the broader historical and cultural assets of Meymeh, the study proposes strategies for the functional revitalization of the mill within a tourism-oriented framework.

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1. Introduction

The city of Meymeh, the administrative center of Meymeh County in Isfahan Province and located 90 km north of Isfahan, is one of Iran's historic settlements whose cultural development has long been dependent on the Mazdābād Qanāt. The Mazdābād Qanāt, referred to by local inhabitants as an "underground river" due to its continuous water flow, is one of the oldest qanāts in the Central Iranian Plateau. Extending 18 km along the foothills of Mount Karkas and the margins of the Joshaqan-Qāli River, it has historically contributed to the prosperity and economic stability of Meymeh, facilitating the establishment of sedentary life in the region (Moeinian, 2021).

In addition to providing drinking water and supporting agriculture and animal husbandry, this qanāt also supplied the mechanical energy needed to operate the mills of Meymeh. The constant flow of water enabled the construction of several watermills downstream of its outlet, allowing the community to maximize the utility of this vital resource. Historically, four mills operated using the

qanāt's water, the most important of which was the Arbala mill. Although now abandoned, the mill remained fully functional until the 1970s and played a significant role in the local economy and subsistence system.

Despite its historical importance, the site has never been subjected to a systematic scholarly investigation, and existing information is limited to oral narratives and scattered observations. This article aims to revisit the Arbala mill of Meymeh from historical, architectural, and functional perspectives and to analyze its environmental and spatial context. To achieve this, the study first reviews previous research on watermills in Iran and introduces the mills associated with the Mazdābād Qanāt. It then examines the historical background of the Arbala mill and describes its spatial setting within the urban fabric of Meymeh. The system of water supply to the mill is also outlined. Subsequently, the current physical condition of the mill is described, and the interventions and alterations of the past decades are addressed. Finally, the architectural configuration of the mill before recent damage is reconstructed, and recommendations for its conservation and revitalization are proposed.

2. Methodology

This study adopts a descriptive–analytical approach. A review of available library and archival sources revealed that very limited information exists regarding the Arbala mill; therefore, most of the data for this research were obtained through field surveys and interviews with knowledgeable local informants. To this end, multiple site visits were conducted, during which comprehensive documentation, including photographs and measured drawings of the current condition, was collected. Historical information and the reconstruction of the mill's earlier condition were acquired through interviews with local residents and by comparing and drawing parallels with other qanāt-driven mills.

Semi-structured interviews were conducted with nine participants (eight men and one woman), with an average age of 69 and an age range of 65 to 91 years. All participants were originally from Meymeh, though some resided within the city while others lived elsewhere. Data were collected and recorded through both in-person and telephone interviews.

3. Literature Review

The review of previous research on Iranian watermills provides not only the theoretical and empirical foundation required to analyze the Arbala mill as a case study but also enables comparative assessments with similar regional and national examples. Over recent decades, numerous studies with architectural, technical, historical, social, and environmental perspectives have examined various aspects of watermills across the country. These investigations range from architectural typology and technical analysis to evaluations of the social, economic, and ecological significance of such structures.

Examining the existing literature allows for the identification of comparable examples and facilitates the use of earlier scholarly findings to develop an appropriate framework for studying lesser-known cases. Among the earliest studies dedicated to watermills are those by Papoli (1985) and Reza et al. (1971). Several researchers have conducted general studies on Iranian watermills, including Salehi (2011), Harverson (1993), and Pourjafar et al. (2010).

Others, such as Ghobadi Hafshajani & Mohammadzadeh (2013), Poya (2019), Mehrdadian et al. (2022), and Afzali et al. (2021), have focused on individual watermills, examining their historical and technical dimensions in detail. Another group of scholars has studied watermills within

specific geographic regions, including Omranipour et al. (2020), Soltani et al. (2016), Farahza & Abbasi (2012), Mas'oudi et al. (2007), Sharifinia (2020), and Karagari et al. (2018).

Some studies have examined watermills within a defined historical period. For instance, Bahramzadeh and Alaei Bakhsh (2014) analyzed Sasanian-period watermills along the Persian Gulf coast, while Ahmadzadeh et al. (2023) investigated the socio-economic structure of watermills in the mountainous region of Hawraman during the Qajar and Pahlavi eras.

A review of existing research on qanāt-driven mills in Iran indicates that no prior study has examined the mills of Meymeh. Thus, the present research constitutes the first systematic scholarly investigation of the mills associated with the Mazdābād World Heritage Qanāt, with a particular focus on the Arbala mill.

4. Qanāt-Driven Mills in Meymeh and the Status of the Arbala Mill

The emergence point (Maz-har) of the Mazdābād qanāt is located approximately 2 km north of the historical core of Meymeh. After emerging from its outlet, the qanāt water flows along several channels, irrigates the downstream agricultural lands, enters the urban area, and then passes by the Jāmeh Mosque before reaching the farmlands situated south of the city.

Taking advantage of the natural elevation drop along the watercourse, the inhabitants of Meymeh constructed several mills to maximize the use of hydraulic energy for their subsistence needs. The most significant and northernmost of these structures was the Arbala mill, which stood closest to the qanāt outlet. In addition to Arbala, three other mills operated along the Mazdābād qanāt channel, listed in order of proximity to the outlet: the Nāserkhān Gerānmāyeh mill in the lower Latiān plain; the Mohammad-Aqā Sāberi mill opposite the Jamshid (Mousa Sadr) School; and the Arpele (Mādar-e Arbāb) mill near the Jāmeh Mosque. Moreover, the Rouyeh mill, located in the Sarār plains south of Meymeh, functioned using the water of the Rouyeh qanāt (Fig. 1).

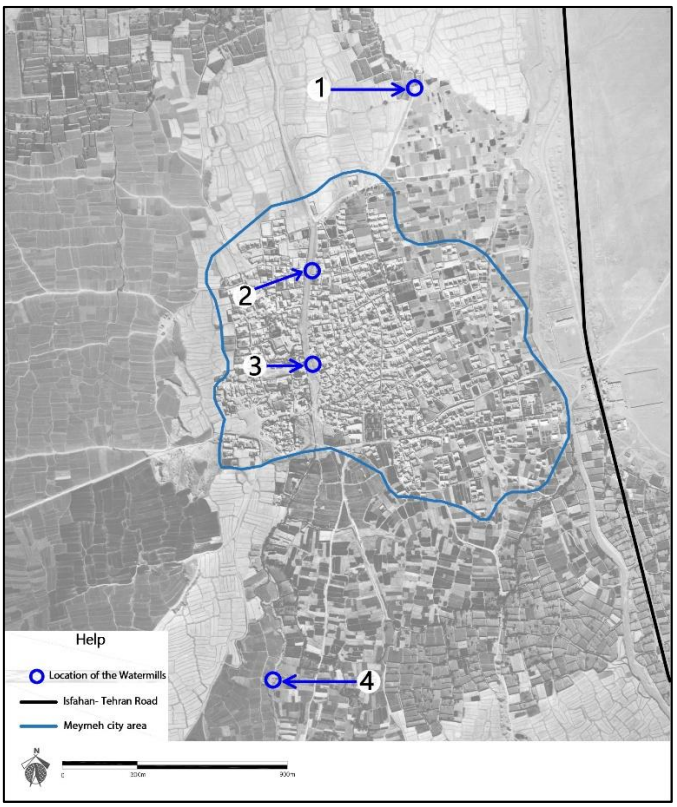

Figure 1. Location of the four downstream mills of the Arbalā Watermill in the 1956 aerial photograph of Meymeh: 1) Nāserkhān Gerānmāyeh Mill; 2) Mohammad-Aqa Saberi Mill; 3) Madar-e Arbāb Mill; 4) Rouyeh Mill.

Unfortunately, the Mohammad-Aqā Sāberi and Arpele mills were completely demolished during the street-widening and urban development works of the Pahlavi period. The Nāserkhān Gerānmāyeh mill (Fig. 2) and the Rouyeh mill (Fig. 3) also deteriorated due to a lack of maintenance, leaving only remnants of their vertical water shafts (Tanūreh) behind. Since the Arbala mill has preserved substantial portions of its original architectural fabric, its remaining structure serves as a symbolic feature within the natural and agricultural landscape of Meymeh, thereby conferring particular significance upon it.

The name “Arbala” clearly reflects the mill’s geographical location. The building is situated at a higher elevation than other mills along the qanāt, upstream of the watercourse, so that water from the Mazdābād qanāt initially entered this mill. The term “Ar” in the local dialect means “mill,” hence the name “Asiyāb-e Bālā” or “Arbala.” This position ensured that the mill received priority in water supply over downstream mills, allowing it to operate even during low-water seasons. Unlike many mills in Meymeh, which were only functional during periods when irrigation of gardens and farmland was not required (typically autumn and winter), Arbala mill benefited from a continuous and stable water flow throughout the year due to its superior location.

Figure 2. Remains of the Nāserkhān Gerānmāyeh Mill (photograph taken in 2024).

Figure 3. Remains of the Rouyeh Mill (photograph taken in 2024).

5. Location, Historical Background, Ownership, and Water Supply System of the Arbala Mill

The Arbala mill is located approximately 900 m south of the Mazdābād qanāt outlet. Key features upstream of the mill include the Mazdābād Park, the qanāt channel, and nearby poultry units. The mill is bordered on the east, west, and south by the Mazdābād qanāt cultivation area (Fig. 4).

According to interviews with elderly and knowledgeable local residents, the Arbala mill dates back several centuries. Oral accounts from multiple generations confirm the mill's long-standing presence, indicating that its origins can be traced at least to the Qajar period. The mill is registered under property record number 540/1. It is privately owned, with ownership divided into 72 shares allocated to the residents of Meymeh. The majority of shareholders are heirs of Mirza Mahmoud Saeidian, Mirza Bozorg Khordmand, and Asadkhāneh Gerānmāyeh (as cited by Mahmoud Saeidian).

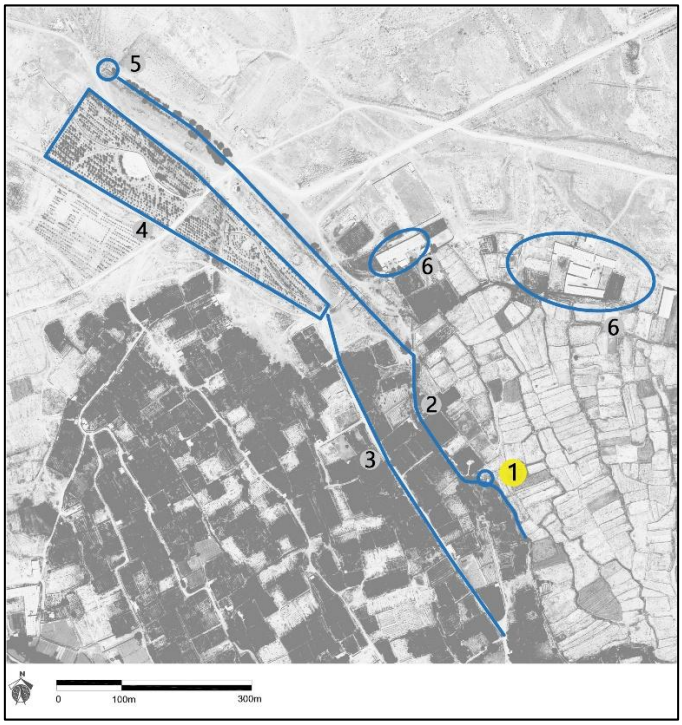

Figure 4. Spatial position of the Arbalā Watermill in relation to the Mazdābād Qanat and identification of key elements in its immediate surroundings: 1) Arbalā Watermill; 2) Water channel of the Mazdābād Qanat; 3) Rashid Alley; 4) Mazdābād Park; 5) Mazdābād Qanat outlet; 6) Poultry farm (Authors, based on Google Earth imagery, 2024).

Regarding the water supply system of the mill, after emerging from the Mazdābād qanāt outlet, a portion of the water flows into a channel leading to the mill's sluice gate (Takhte-band). The sluice gate regulates the direction and flow of water toward the mill. When the mill is operational, water is directed from the sluice gate to the vertical water shaft (Tanūreh). After being used in the milling process, it is discharged via an overflow channel and utilized for irrigating downstream farmland (Fig. 5). Unfortunately, due to the abandonment of the mill, the overflow channel has also been lost.

The open-air watercourse from the sluice gate to the vertical water shaft constitutes a distinctive and notable feature of this mill (Fig. 6). The sluice gate functions to block water entry when the mill is not in operation or requires maintenance, preventing water from entering this section.

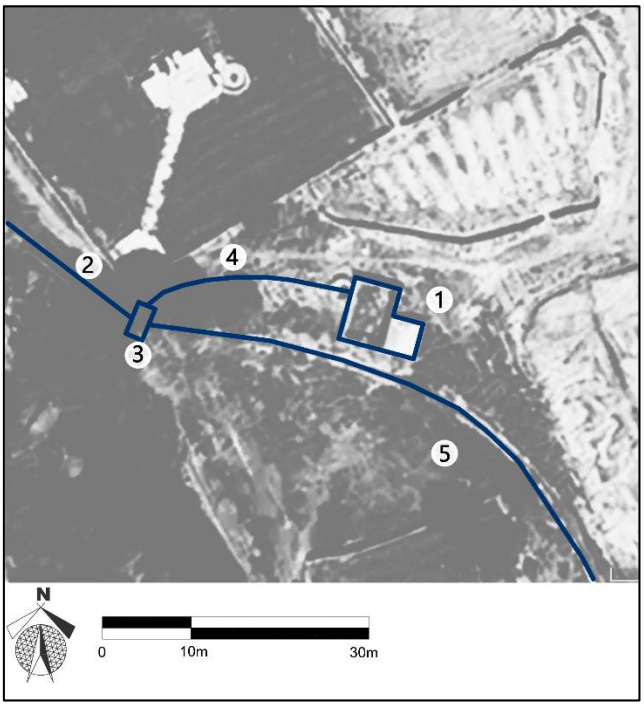

Figure 5. Environmental elements surrounding the watermill: 1) Arbalā Watermill; 2) Channel leading to the sluice gate; 3) Sluice gate; 4) Channel leading to the hydraulic tower; 5) Current watercourse (Authors, based on Google Earth imagery, 2024).

Figure 6. Sluice gate of the Arbalā Watermill (photograph taken in 2024).

6. Current Condition and Architectural Features of the Arbala Mill

The Arbala mill occupies an area of approximately 55 m^2. Its walls are constructed of brick and coated with a layer of mud plaster (Kāhgel). The building consists of two main rooms.

The eastern room contains a well approximately 3 to 5 m deep, locally referred to as “Chadi” or in the Meymeh dialect, “Chah Jeh.” This room was originally roofed, but the roof collapsed. In the 2000s, it was partially reconstructed using brick in a flat-arch (Filpūsh) style. The roof surface remains unfinished and lacks adequate plastering to protect against precipitation.

The eastern room housed the millstone and served as the main entrance. Currently, it is open to the air, though according to elderly and knowledgeable local residents, it was originally roofed. The

ceiling structure of the eastern room and the underground passage have been destroyed. Key functional components of the mill, including the millstone, paddles, dol, and Ākhureh, have been lost, and no evidence remains regarding their technical specifications, dimensions, or materials. Doors and windows have also disappeared (Fig. 7).

Intentional damage has been observed in the well, likely due to unauthorized excavations in search of treasure. At present, the primary heritage buffer zone (first-degree protection area) around the site has been preserved (Figs. 8, 9, 10).

Figure 7. Southern façade of the watermill: 1) Main entrance (photograph taken in 2024).

Figure 8. Water inlet path to the watermill: 1) Vertical water shaft (Tanūreh); 2) Channel leading to the hydraulic tower; 3) New water channel (photograph taken in 2024).

Figure 9. Interior of the western section of the watermill: 1) Door connecting the main room and the storage room; 2) Main entrance; 3) Location of the millstone (photograph taken in 2024).

Figure 10. Interior of the eastern section and the well excavated at its center (photograph taken in 2024).

7. Transformations of the Watermill Over Time

Since its construction, the Arbalā Watermill has played a significant role in the economic and subsistence systems of Meymeh. Historically, it functioned as an integral component of the region's traditional production network, providing the flour required by the local community. Over time, particularly following technological advancements in milling and the widespread adoption of electric mills, the functional importance of the mill gradually diminished, leading to its reduced relevance within the local economy.

The mill continued to operate until the 1970s; however, due to a series of events during that decade, it ceased functioning. With electric mills becoming increasingly common, the traditional mill was never restored to operation and eventually fell into disuse. Among the last millers who worked at the Arbalā Watermill were Gholamhossein Ebram, Abbas Varkāni (Kāmouei), Abbas-Ali Heydariyan, and Ebrahim Sojoudi from the village of Vandādeh.

Following its abandonment, the mill was temporarily reactivated in the late 2000s to accommodate the filming of the movie Tofang-e Sarpor, after which it once again became inactive. During the same decade, the roof of the eastern room, formerly used for storing wheat and flour, was repaired and reconstructed as a dome-vault (Fig. 11).

The absence of effective conservation measures and the lack of continuous maintenance gradually contributed to the deterioration of the physical fabric of the structure, resulting in the progressive loss of several functional components. During this period, in addition to natural weathering, human-induced factors, such as illicit excavations and the theft of architectural elements, intensified the degradation process and accelerated the destruction of various parts of the mill.

Figure 11. The arch restored in the 2000s (photograph taken in 2024).

8. Architectural and Functional Reassessment

Figures 12 and 13 present an overall view of the mill's architecture before the destruction and loss of the original water flow system. During the mill's operational period, water from the Mazdābād qanāt was directed into the vertical water shaft through a dedicated channel. As the vertical water shaft filled, the pressure generated by the water's height caused rapid discharge from its base.

This high-pressure water struck the wooden paddles, causing them to rotate. The motion of the paddles was transmitted via a vertical shaft to the upper millstone, setting it in motion. The upper stone, positioned atop the lower stone, used the generated force to gradually grind wheat or barley, which was fed to the center of the stones through a funnel called the "dol." The milled flour was then directed outward through a channel known as the "Ākhureh" and collected in containers or a designated storage area.

The "Chah Jeh" well and the underground passage called "Chadi" provided access to technical sections for maintenance and repairs. The resulting overflow water was channeled outside the mill and utilized to irrigate agricultural lands, exemplifying the complete use of water resources in traditional systems. The precise design of the mill components and their seamless coordination with natural water power reflect the technical skill and indigenous knowledge embedded in pre-modern industrial architecture.

Figures 14, 15, 16, and 17 present comprehensive architectural documentation that reconstructs the mill's condition before its destruction.

Figure 12. Representation of the overall appearance of the mill from the southern façade.

Figure 13. Aerial view representing the mill structure and the water inflow/outflow paths.

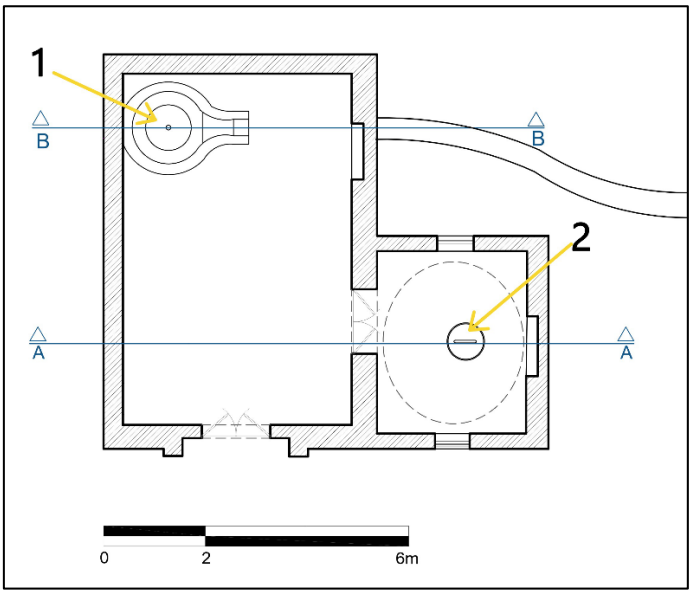

Figure 14. Ground-floor plan representation: 1) Millstone placement; 2) Chah Jeh well.

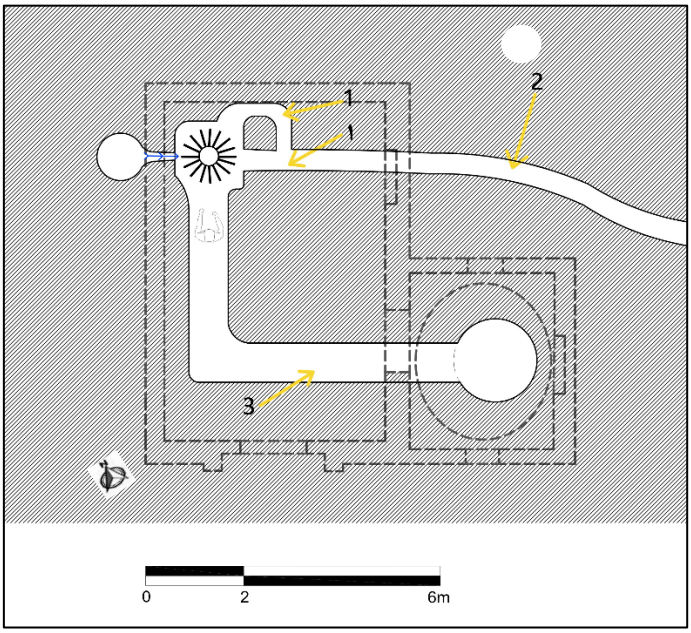

Figure 15. Basement plan representation: 1) Water escape channel; 2) Chadi (underground passage leading to the turbine); 3) Outflow path toward agricultural fields.

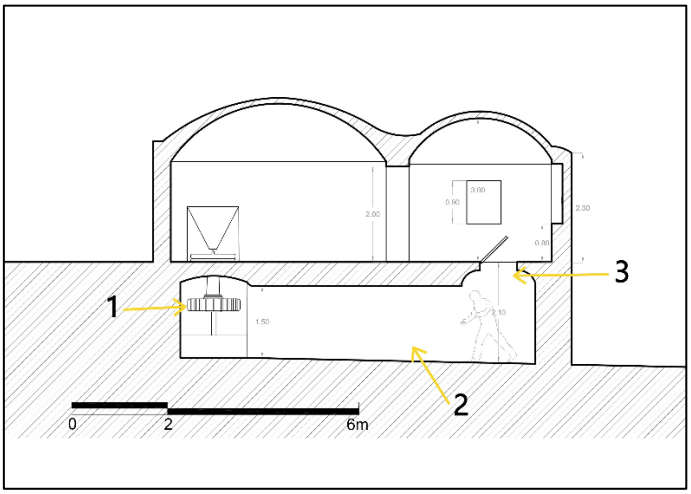

Figure 16. Section A–A: 1) Turbine; 2) Chadi; 3) Jeh well.

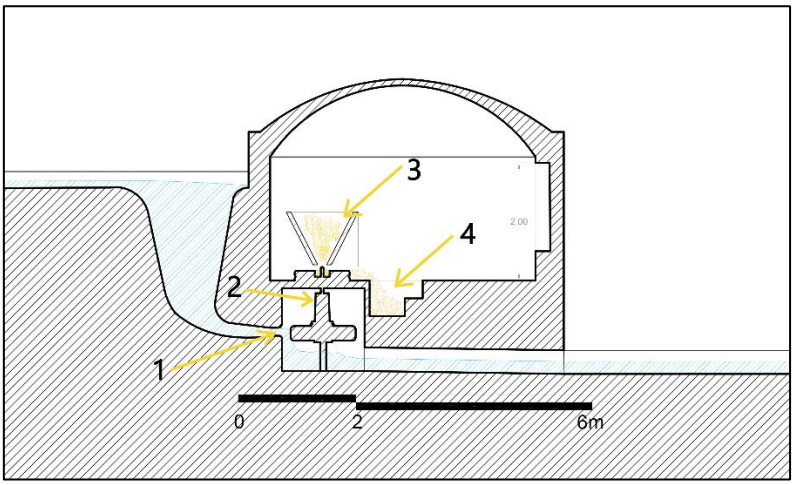

Figure 17. Section B–B: 1) Water outlet duct from the hydraulic tower; 2) Qapān; 3) Dol; 4) Ākhureh.

9. The Necessity of Conservation, Restoration, and Revitalization of the Arbalā Watermill

The progressive deterioration of key architectural spaces, visible traces of illicit excavations, and the absence of effective conservation or restoration interventions collectively pose a serious threat to the survival of the Arbalā Watermill. Under such circumstances, the need for greater attention from both the local community and relevant authorities becomes increasingly urgent. Ensuring the long-term preservation of this heritage structure requires the implementation of scientifically informed conservation practices based on historical and technical documentation.

However, the conservation and restoration of a historic structure, in the absence of functional revitalization, cannot guarantee its long-term physical stability or sustainability. Even restored heritage buildings are prone to gradual decay when left unused. Therefore, any effort to preserve and restore the Arbalā Watermill must necessarily be accompanied by measures to revive the site and ensure the continuity of its functional life.

Fortunately, the continued flow of the Mazdābād Qanat still provides the hydrological conditions necessary for the traditional reactivation of the mill. This potential is further strengthened by the growing contemporary demand for locally produced and traditional flour in Meymeh. In addition, the inherent hydraulic and mechanical capabilities of the mill could be utilized for innovative purposes, such as small-scale electricity generation, offering additional possibilities for adaptive reuse.

Nevertheless, the most significant potential for the revitalization of the Arbalā Watermill lies in the domain of cultural tourism. In this regard, the tourism capacities associated with the World Heritage Qanats of Mazdābād and Vazvān offer promising opportunities. Within the legal city limits of Meymeh, two of Iran's eleven World Heritage qanats, Mazdābād and Vazvān, are located. Furthermore, recent infrastructural developments around the Mazdābād Qanat, including the construction of its stairway-access (Pāyāb), have transformed it into one of the most frequently visited hydraulic heritage structures in the country. This creates a unique opportunity for the development of a cohesive tourism network centered on Meymeh's historic water architecture.

The presence of the remains of Meymeh's historic icehouse (Fig. 18), which historically functioned in relation to the Mazdābād Qanat, along with the surviving remains of two additional traditional mills (Nāserkhān Gerānmāyeh Mill and Rouyeh Mill), both of which are currently restorable, provides the necessary foundation for forming a connected tourism ensemble. This

ensemble can be structured along three linear heritage routes extending across the northern and southern boundaries of the legal city limits.

The primary route begins at the pāyāb of the Mazdābād Qanat and continues sequentially to the qanat outlet, the Arbalā Watermill, the former sites of the Mohammad-Aqa Saberi and Arpele mills, and finally the Rouyeh Mill. This route was previously proposed in the Comprehensive Tourism Plan of the Mazdābād Qanat in Meymeh (Shahabinejad & Talaei, 2022), although at that time the significance of the Rouyeh Mill had not yet been recognized, leading to its omission.

Additionally, a western branch of the tourism network can connect the main route to the historic icehouse of Meymeh, while the eastern branch can link the Nāserkhān Gerānmāyeh Mill and the pāyāb of the World Heritage Qanat of Vazvān to the main tourism axis (Fig. 19). Within this framework, the Arbalā Watermill, recognized as the most significant historic mill in Meymeh, holds a central position and could serve as a catalyst for its cultural revitalization and economic activation.

Figure 18. Remains of the historical icehouse of Meymeh (photograph taken in 2024).

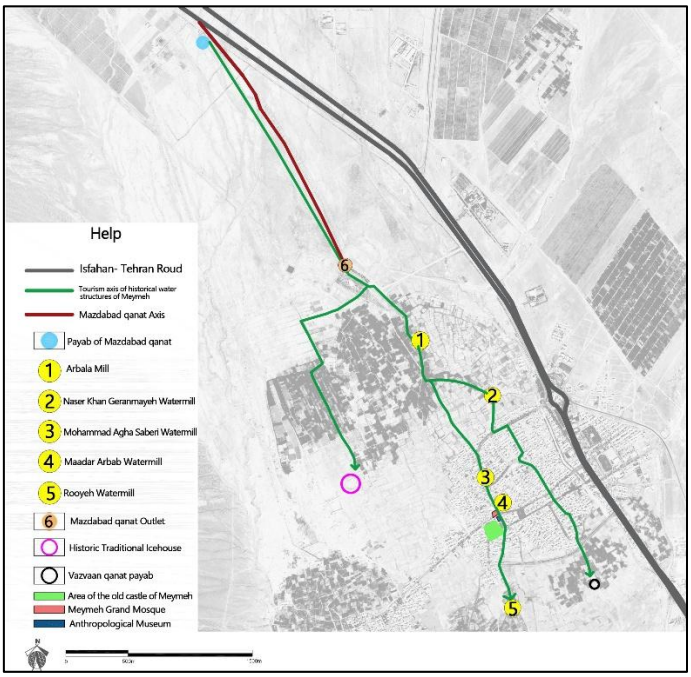

Figure 19. Proposed tourism routes associated with the ensemble of historical hydraulic structures in Meymeh (Authors, based on Google Earth imagery, 2024).

10. Conclusion

The Mazdābād qanāt is one of Iran's eleven UNESCO World Heritage qanāts and is among the most significant in the Central Plateau. Featuring unique characteristics, including an underground dam within its main structure, this qanāt historically supported several downstream hydraulic structures, including four mills and a traditional icehouse, all relying on its water. Additionally, the Rouyeh watermill, connected to the Rouyeh qanāt in southern Meymeh, can also be observed.

Unfortunately, due to diminished functional demand, all these historical structures are now abandoned and in ruins, with two mills destroyed during the expansion of streets during the Pahlavi era. This study aimed to identify all mills associated with the Mazdābād qanāt and to locate them precisely using aerial imagery from 1956 and contemporary aerial photographs. These mills include Arbala, Nāserkhān Gerānmāyeh, Mohammad-Aqā Sāberi, Arpele, and Rouyeh. Images of the remains of two ruined mills (Nāserkhān Gerānmāyeh and Rouyeh) were also provided.

The historical icehouse of Meymeh was introduced as a water-dependent structure, and its location was documented. As this study focuses on Arbala mill, the most significant mill associated with the Mazdābād qanat, field surveys and interviews with local informants were employed to gather data on its age, water supply system, current architectural condition, and historical-functional evolution. The architectural and functional reconstruction was further contextualized through comparison with other Iranian mills.

Findings indicate that the mill dates back at least to the Qajar period. Its local name, "Arbala," means "upper mill," denoting its position upstream of other mills. Pre-destruction plans of the mill were prepared, illustrating its components, including the vertical water shaft (Tanūreh), well (Chah Jeh), underground passage (Chadi), sluice (Qapān), grain funnel (dol), and flour chute (Ākhureh). These plans can serve as a basis for future conservation and restoration projects.

In recent decades, neglect and deliberate damage have accelerated the physical deterioration of the mill. Given the Mazdābād qanāt's World Heritage status and the mill's dependence on it, understanding, preserving, and restoring the Arbala mill is of critical importance. The study also proposes strategies for the functional revival of the mill, emphasizing the tourism potential of the Mazdābād qanāt.

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Name	Year of Birth	Name	Year of Birth
Haji Ali Shahabinejad	1930	Gholamhossein Heydarian	1949
Isa Jafari	1934	Mohammadreza Shahabinejad	1955
Haji Mohammad Beykian	1941	Abdolreza Sheybani	1960
Gol Afroz Dehghan	1941	Hamidreza Heydari	1964
Mahmoud Saeidian	1947	-	-

Author Contributions

The first author was responsible for conceptualization, methodology, validation, writing, and supervision. The second author was responsible for the preparation of architectural and visual documentation as well as textual and visual editing.

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Data Availability

The raw data are held by the authors and can be accessed upon reasonable request.

Conflict of Interest

The authors declare no conflict of interest in relation to the authorship or publication of this article.

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