Journal of Architecture, Engineering & Fine Arts

2023 5(1): 48-69

Available online at http://dergipark.org.tr/artgrid

Research Article

WATER RESOURCES AND VILLAGE MORPHOLOGY: LESSONS FROM THREE TRADITIONAL IRANIAN VILLAGES

Hesam MOSHARRAF[1,*], Jorge CORREIA[2]

[1]School of Architecture, Art and Design, Lab2PT, University of Minho, Guimarães, Portugal.
[2]School of Architecture, Art and Design, Lab2PT, University of Minho, Guimarães, Portugal.

[*]Correspondence: hesam.mshf@gmail.com

Received: 16 May 2023; Accepted: 29 June 2023; Published: 30 June 2023

ORCID[1]: 0000-0003-3066-4783; ORCID[2]: 0000-0003-1536-2314

Citation: Mosharraf, H. & Correia, J. (2023) Water resources and village morphology: lessons from three traditional Iranian villages. ArtGRID, 5(1), 48-69

Abstract

Water plays an increasingly prominent role in the contemporary world, but its significance has been evident throughout history, particularly in arid climates like Iran. Understanding the impact of water on the built environments, such as villages, is crucial for comprehending the form and effects that have shaped these historical settlements, which are an integral part of each country's heritage. Therefore, a comprehensive review and analysis of the water's influence on the morphology of these villages becomes essential. This study explores the utilization of various water sources and management practices in different distinct types of traditional villages in the center of Iran, and their impact on the villages' morphology. The objective of this research is to demonstrate the influence of water on the different types of village forms found in this region. By examining the diversity of water sources and their management methods, this study illustrates how they have impacted the form of villages. The findings derived from this research are beneficial for the preservation of historical heritages and rural development plans, especially with the threat of climate change and water scarcity. The study begins with a literature review and then, through site surveys, focuses on analyzing the effects of water on the selected case studies in Iran. It highlights the crucial role that the availability and management of water resources play in a village's development and sustainability, as well as its form and morphology. Finally, it compares the results between each case study.

Keywords: Urban morphology, architecture, villages form, water management

Araştırma Makalesi

SU KAYNAKLARI VE KÖY MORFOLOJİSİ: ÜÇ GELENEKSEL İRAN KÖYÜNDEN DERSLER

Özet

Su, çağdaş dünyada giderek daha önemli bir rol oynamaktadır, ancak önemi tarih boyunca, özellikle İran gibi kurak iklimlerde belirgin olmuştur. Suyun köyler gibi yapılı çevreler üzerindeki etkisini anlamak, her ülkenin mirasının ayrılmaz bir parçası olan bu tarihi yerleşimleri şekillendiren biçim ve etkileri anlamak için çok önemlidir. Bu nedenle, suyun bu köylerin morfolojisi üzerindeki etkisinin kapsamlı bir şekilde gözden geçirilmesi ve analizi gerekli hale geliyor. Bu çalışma, İran'ın merkezindeki farklı geleneksel köy türlerinde çeşitli su kaynaklarının ve yönetim uygulamalarının kullanımını ve bunların köylerin morfolojisi üzerindeki etkisini araştırıyor. Bu araştırmanın amacı, bu bölgede bulunan farklı köy formları üzerinde suyun etkisini göstermektir. Bu çalışma, su kaynaklarının çeşitliliğini ve yönetim yöntemlerini inceleyerek, bunların köy biçimini nasıl etkilediğini göstermektedir. Bu araştırmadan elde edilen bulgular, özellikle iklim değişikliği ve su kıtlığı tehdidi karşısında tarihi mirasların ve kırsal kalkınma planlarının korunması için faydalıdır. Çalışma bir literatür taraması ile başlar ve ardından saha araştırmaları yoluyla İran'da seçilen vaka çalışmaları üzerinde suyun etkilerinin analizine odaklanır. Su kaynaklarının mevcudiyeti ve yönetiminin bir köyün şekil ve morfolojisinin yanı sıra kalkınması ve sürdürülebilirliğinde oynadığı kritik rolü vurgulamaktadır. Son olarak, her vaka çalışması arasındaki sonuçları karşılaştırır.

Anahtar kelimeler: Kentsel morfoloji, mimari, köy formu, su yönetimi

1. INTRODUCTION

Urban morphology encompasses the intricate interplay between the physical form, structure, and evolving components that have emerged throughout the course of history, as well as the dynamic relationships that continuously shape them (Akyıldız & Akbaş, 2020). According to Ameri and Ahmadi (2003), the villages in Iran experience two distinct trajectories of growth and progress: an inherent or spontaneous process driven by natural dynamics, and a predetermined system of planning. In the former, villages take shape and develop by interacting with natural and human-made factors, with inhabitants shaping their villages based on their experience and collective knowledge to meet their needs. In contrast, authoritarian planning toward rural development has some fundamental differences from the natural pattern. To fully comprehend the heritage of the villages, it is necessary to have a comprehensive understanding of the diverse information that defines them.

Water plays a crucial role in the central region of Iran, which is largely composed of desert terrain. Understanding the effects of water in this context is vital for appreciating the cultural heritage of the villages in the area and incorporating this understanding into future plans for development. Additionally, studying the historical utilization of water can provide valuable insights to inform effective water management policies for the region in the future. This study will analyze the impact of water on village morphology, exploring the evolution and development of the selected villages with an emphasis on how they have adapted to their environment. The findings of this study can be used to inform future planning efforts and contribute to the preservation of these historic villages.

This study aims to evaluate the effect of water on the morphology of historic villages in central Iran, specifically in desert or desert-edge regions. To select case studies for this research, a thorough analysis was conducted among the numerous villages in the targeted region. Eventually, the villages were classified into three distinct types based on their characteristics. The first two categories, which are more common, include villages situated on the flat terrain of the desert and villages located on the periphery of the desert in mountainous areas. The third type comprises villages that are relatively fewer in number, characterized by being enclosed within high walls, known as fortress villages. As a result, Qehi was chosen as a representative sample for desert villages, Abyaneh as a representative of mountainous villages, and Ghourtan as a representative of fortress villages. In mountainous villages, the flow of water is shaped by the presence of springs, while in desert villages like Qehi, the flow of water is managed and controlled through Qanats and other means. Fortified villages like Ghourtan have a more controlled water flow, managed through channels and wells by the inhabitants.

1.2 Geographical Conditions of Iran

The current borders of Iran (as it's shown in Figure 1) have resulted from various historical events, including colonial divisions and the reign of different dynasties. Despite these changes, the land that we know as "Persia" has remained a constant feature of the region's geography. This area encompasses diverse locations that share similarities in their rich history, culture, and traditions.

Iran is situated between three significant cultural districts, including the Mesopotamian civilization in the West and the Chinese and Indian civilizations in the East. Its boundaries are bordered by deserted Stipa-filled fields and cold-weathered Central Asian lands in the North, tropical warm regions of Africa, and the Indian Ocean in the South. This region comprises countries such as Iran, Afghanistan, parts of Pakistan, Turkmenistan, Tajikistan, Uzbekistan, some regions of Kazakhstan, Iraq, and Southern beaches of the Persian Gulf and the Gulf of Oman (Pakzad, Ebrahimnia, Besharatizaadeh, Ayedi, & Kaveh, 2017).

It is important to note that the geographical features of a region play a significant role in shaping its culture, history, and architecture. As a result, a detailed understanding of Iran's geography is crucial to comprehending the complexities of its cultural and architectural heritage. The diverse environmental conditions of Iran, such as its desert areas, mountainous regions, and water resources, have influenced the development of various architectural styles and building techniques throughout the country's history.

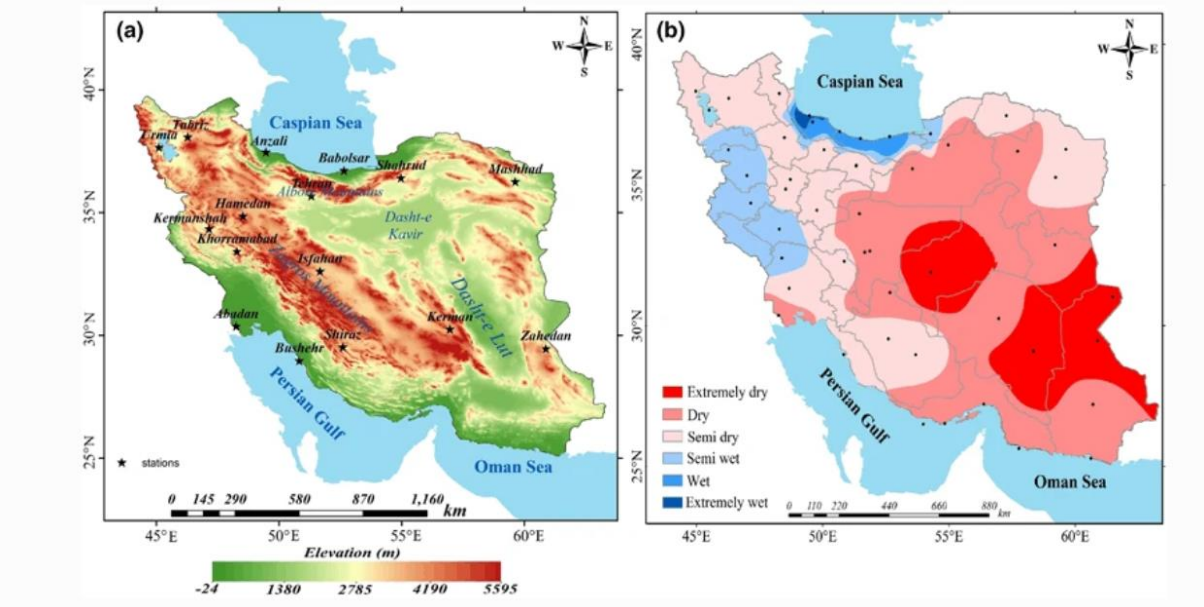

Figure 1 Climate map of Iran, by Alizadeh-Choobari, O.; Najafi, M.S. Extreme Weather Events in Iran under a Changing Climate. Clim. Dyn. 2018, 50, 249–260.

1.3 Basins and Annual Rainfall Rate in Iran

Basins are closed surfaces created by the morphology and topography of the earth. The slope inward of the basins directs the flow of surface and groundwater to the inside and center of the basin. The basins are separated by a range of mountains. Due to the diversity of natural features, basins are created on different surfaces and shapes. Dasht-e Kavir and the Dasht-e Lut create the largest basin in Iran. It is noteworthy that the altitude varies in the basins and there are different sections in terms of altitude, geographical directions, and prevailing winds. These factors have caused different climatic conditions in different regions (Ghafarisade,1995). The Precipitation distribution are shown in Figure 2.

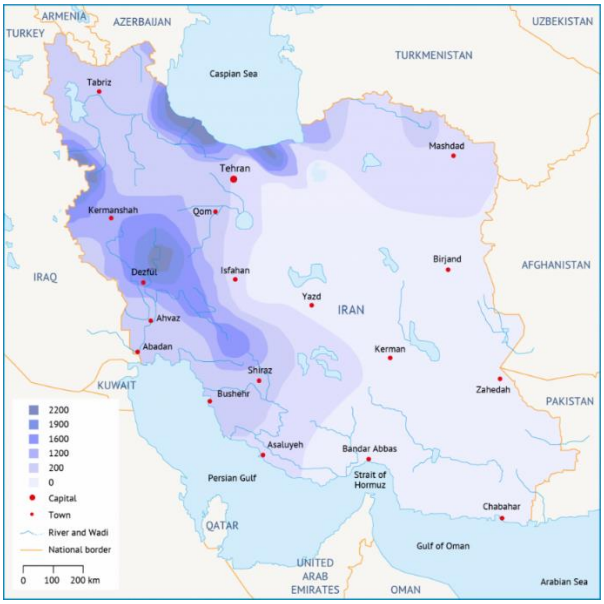

Figure 2 Map of Precipitation distribution (mm) in Iran. @Fanack water. Retrieved form: water.fanack.com. 06/2023

Initially, an extensive literature review and document analysis was conducted to develop a theoretical understanding of the subject matter and categorize the villages. Urban morphology and related information relating to water in the context of Iran were discussed, including water resources and related buildings. Furthermore, site visits were carried out to gather more specific and accurate data. These visits focused on exploring the villages, their natural environment, water resources, and the impact they had on the village structure.

2. LITERATURE REVIEW

2.1 Urban Morphology

The term "urban morphology" refers to the examination of urban forms and the factors that contribute to their transformation and growth processes. It involves identifying the elements that shape and structure the urban fabric of a city, such as buildings, urban plots, and urban spaces like streets and squares (Oliveira, 2016; al Sudani, 2018). Urban morphology is an integral part of analyzing the overall urban form.

Urban morphology is a multidisciplinary field that intersects with various academic disciplines, including architecture, urban planning, history, and geography. Each of these disciplines is influenced by different traditions, analytical approaches, research programs, research problems, and research objectives (Gauthier and Gilliland, 2006). The term "morphology" gradually found application in geography towards the end of the 19th century (Whitehand, 2007). Otto Schlüter (1872-1959), a German geographer, is often considered the father of urban morphology due to his work on ground plans and urban landscapes. His research on tracing changes in urban form throughout history forms the foundation of long-term urban morphological studies (Ye, 2015).

In 1996, morphologists from various disciplines, such as geography, architecture, sociology, history, and planning, established the International Seminar on Urban Form (ISUF) (Cömert, 2013). This organization recognizes urban morphology as an emerging interdisciplinary field and aims to provide a platform for the exchange of ideas, theories, and information through conferences and journals, catering to a wide range of readers (ISUF, 2017). It is important to note that urban morphology is not limited to cities but can also be applied to smaller settlements such as villages.

Urban morphology is not just about cities. Small communities such as villages play an important role in urban morphology research, as well. Sometimes, villages become cities over time. In many cases, especially in Iran, villages have an essential role in the formation of cities through their expansion. They are critical human settlements, and studying historic villages is part of each country's heritage. Urban morphology encompasses not only the study of cities, but also the examination of smaller communities such as villages.According to Abaee (2022), the study of urban form in Iran has not been systematically researched. There are very few publications that rely on the classical repertoire of urban morphological knowledge. The majority of research in Iran has focused on larger cities, neglecting the exploration of village forms and morphologies, which remain understudied. However, there have been some studies and publications about villages, although they do not specifically concentrate on the theme of urban morphology.

2.2 Water and Its Importance in Iranian Villages

Water is one of the essential elements for the emergence and survival of human groups in any natural environment. It plays a critical role in the daily lives of Iranian villagers, particularly those residing in semi-arid and low-water regions, where the availability of water is scarce. The importance of water in village life in Iran is highlighted in several ways, including its biological role as a basic and necessary element, and its vital role in drinking, hygiene, and in agricultural, livestock, and other production activities (Ghobadian, 2014).

Water management and its various functions can have a significant impact on a village's form and the location of facilities for these activities. Agriculture, in particular, is highly dependent on water availability, and the production of livestock and other goods also require access to drinkable water. Water is also used for hygiene purposes, such as bathing. In addition, water is occasionally used in service and production activities, such as water mills (Zargar, 2003; Ghobadian, 2014).

Iran has various types of water resources, such as rivers, canals, springs, wells, and rainwater, each of which can be influential in shaping the physical appearance of villages. In arid and low rainfall regions on the desert margins in Iran, groundwater is a crucial factor in establishing villages. Most of the desert villages rely on groundwater, the accessibility of which is affected by natural factors such as land layers, topography, rainfall, and water reserves at heights and depths above the ground level. Qanats and wells are two common groundwater sources in central Iran that have shaped village morphology over time.

To comprehend the formation and evolution of villages in Iran, it is crucial to understand the significance of water in these communities, including different water resources and related buildings. Furthermore, an understanding of the historical use of water in the region can inform future plans that take into account the usage of water in village development. Thus, comprehending the importance of water in Iranian villages is essential for developing sustainable plans and preserving the region's cultural heritage.

2.2.1 Wells

From ancient times until recently, in most villages in different parts of Iran, it was common to use wells for drinking and sometimes for washing and sanitation, or both (Zargar,2014).

In agriculture, well water has generally been consumed since the water pumps were invented. There are two ways to utilize wells in villages:

1- Every house has its own self-sufficient well.

2- Drinking water is delivered to each house using a piping mechanism while the pumping system pushes the well water into a metal or concrete source and then into the houses.

Therefore, it can be indicated that the prevalence of piping technology gives more flexibility to the fabric of the village; since the necessity to trace a path with fixed traffic and direction in the village is obviated (Ameri & Ahmadi, 2017)**.**

2.2.2 Qanats

Qanat or Underground aqueducts, can undoubtedly be considered the economic artery of consecutive centuries of ancient Iran. It is a canal network that covered all cities and villages. in addition to supplying agricultural water, it also provided drinking water to this land (Maleki & Khorsandi-aghayi, 2015).

Figure 3 aerial photos of wells of qanats in Iran, Yazd, photo by: Gerster, Georg-1979. Retrieved from http://www.georggerster.com. 06/2023

Changing the village's water supply from the river to the aqueduct can significantly impact its physical landscape. Below is some information about Qanats.

Many believe that the qanat is an Iranian invention (Alemohammad & Gharari, 2010). A qanat is a water access technique that utilizes the gravitational force and physical properties of groundwater to bring water to the surface. Around three thousand years ago, the Iranians were able to accomplish this by identifying groundwater resources and using the force of gravity, as well as apparently simple technical knowledge such as digging wells (as shown in Figure 3) and atriums, to bring the water to the surface with a mild slope. Unlike many water transport methods, the qanat did not require the use of wind energy, fuel energy, or muscle energy from animals or humans.

As it is illustrated in Figure 4, It is only the gravity of the earth and the property of water itself that helps. Underground aquifers and alluviums are discovered in the Qanats in the foothills. There, a well is dug to get to the water. The depth of this well, called "mother well," fluctuates from 15 meters to 100 meters in Iran. The symbol of the Qanat is specified near the considered village where Qanat water can be found. The excavation of the Qanat begins from the same Qanat and proceeds directly and with a gentle and calculated slope to reach the depth of the mother well. The length of these atriums ranges from one to two kilometers and reaches up to 30 kilometers. At certain intervals, the wells are dug to reach these atriums (Zargar,2014; Ameri & Ahmadi, 2017).

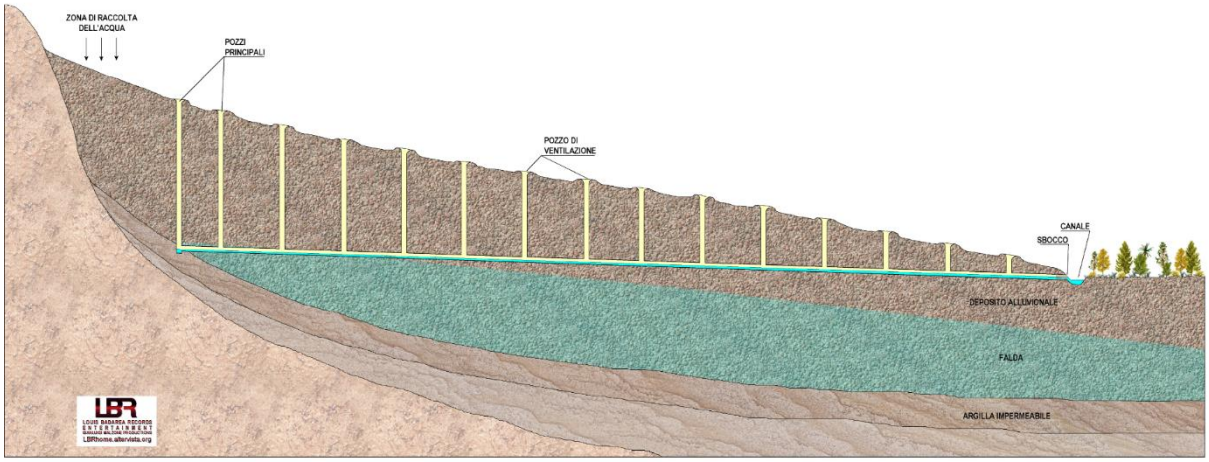

Figure 4 Section of Qanat, http://lbrhome.altervista.org/antichi-acquedotti-qanat-e-foggara accessed on 5/12/2022,

One major factor influencing the urban morphology of villages is the impact of qanats and springs. First, villages located near these water sources tend to have a compact and clustered form. Secondly, an important issue is the potential limitation of water supply from these sources. As water resources are restricted, the amount of water available for the village may decrease. Therefore, when the population of such villages reaches a saturation point in terms of water usage, the number of houses will also reach its limit and further development will be restricted.

Another point is that concerning the topography of the area and other factors, the Qanat is often either in the upper part of the village and very likely in the middle of a square of the village, or outside the village and completely out of public access. The fabric of these villages is mainly dotted. The movement of water from the Qanat point to the inside of the village and within its fabric network is dependent on the shape and slope of the land. Therefore, access to streams that direct the water from the Qanat, or fountain is considered a kind of value. Irregular and non-geometric passages in many villages can be due to following the water flow. On the other hand, given the cleanliness of the water in Qanat and its gradual contamination, proximity to the Qanat will be considered a kind of value. Thus, the village form can have a hierarchy depending on the manifestation of the Qanat and its creeks.

The custom of the villages was to bring drinking water from a spring or Qanat. Families washed their clothes in the water flow, and then the remaining water was used for agriculture. Whether the village water source is the river or the Qanat, in the villages, the particular areas where water is determinant are devoted to activities that the work is in their responsibility from gender division; The place where women gather to wash clothes, and sometimes the dishes usually establish privacy.

It is important to note that springs are often abundant in the foothills of the fountain, but people use more spring water for drinking and cooking, and many times, villages use river water for irrigation (Zargar,2014; Ghobadian, 2014).

The refreshing and moist breeze from qanats, or underground aqueducts, was utilized to regulate the basement air temperature and provide relief on hot days in arid regions. The influence of qanats on village formation is evident in the following ways:

-The rural landscape with a single-point water source, such as springs or qanats, is densely populated in limited areas.

-The physical development of these areas is severely restricted by the limited water supply from qanats and springs.

-The structure of the villages is hierarchical, depending on the origin of the qanat and its distribution.

2.2.3 Ab anbar and Yakhchāl

Apart from the sources of water, there are structures in Iran that are closely related to water and have influenced the form of villages. The ancient Iranians developed two types of structures for water storage and ice preservation: "ab Anbar" and "Yakhchals". "Ab Anbar" refers to cisterns, which are underground reservoirs used to store water for families or villages(figures 5 and 6). These structures played a crucial role in regions with limited or unreliable water sources, as they enabled communities to store and preserve water during the wet seasons for later use during drier periods. "Yakhchals" were a type of evaporative cooler used to store ice.

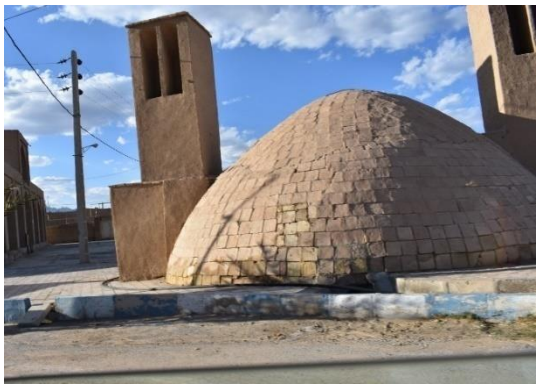

Figure 5 Ab anbar roofs with windcatcher, photo by author

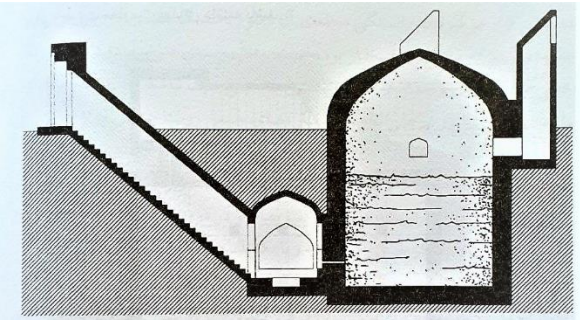

Figure 6 Section of an Ab anbar source (Pirnia ,2009)

These structures have been in use for thousands of years, with the oldest remnants of cisterns dating back to the early days of Iran's first civilization (Ghobadian, 2014). Both "Ab Anbar"

and “Yakhchāl” played a crucial role in the survival of ancient communities, providing them with access water (Pirnia ,2009; Zargar, 2014). This structures with their unique architecture had affected the morphology of villages and cities.

3. METHODOLOGY

This study employed a qualitative research methodology, which involved the combination of various data collection methods. To ensure a comprehensive research approach, a thorough review of existing literature was undertaken, aiming to gain a deeper insight into the formation and evolution of the villages while considering the role of water. However, due to the rural nature of the case studies, there were limited sources of visual imagery and information, such as old aerial photographs. To address this constraint, researchers utilized a combination of library resources, including books, articles, dissertations, previous research, and government reports, along with physical surveys of the villages. During the site visits, the influence of water resources and streams on each village type was assessed, and ultimately, the results were compared.

The collected data were then analyzed using qualitative research methods with maps and photos to show the effect of water on each type of village in the center of Iran. In conclusion, this study employed a mixed-methods approach to comprehensively gather and analyze data, with the aim of providing an in-depth understanding of the impact of water on the morphology of historic villages in central Iran.

4. DISCUSSION

4.1 Water in Abyaneh Village

This section discusses the presence and influence of water in the village of Abyaneh. The village is located in a valley (figure 7), and the presence of water and surrounding mountains has created a milder microclimate compared to the mountains and deserts surrounding the village.

Figure 7 Abyaneh from distance, source: author

Abyaneh has two major springs, with the Do Abi Spring being the main source of water supply throughout the year. The presence of water canals inside the village adds to its visual beauty and contributes to the quality of urban spaces. The traditional canal in Abyaneh runs in a west-east direction and is supplied by the two springs (Saqafi, 2007). As it's shown in Figure 8, the movement of water in this village creates high-quality urban spaces with eye-catching scenes and contributes to the improvement of urban space quality.

Figure 8 water streams in the main route of Abyaneh

The water stream in Abyaneh enters the village fromthe side of the mill in the west and leaves in the eastern part of the Herdeh neighborhood. Thus, this axis passes from the west to

the east through the village. Next to the water route, the main passage of the village has been formed. In the north of this passage, due to the difference in level, there is no direct access to water (Ahmadi-Lari, 2013). However, in the southern part, water channels have been separated from this passage in several places, forming water streams to the south of the village.

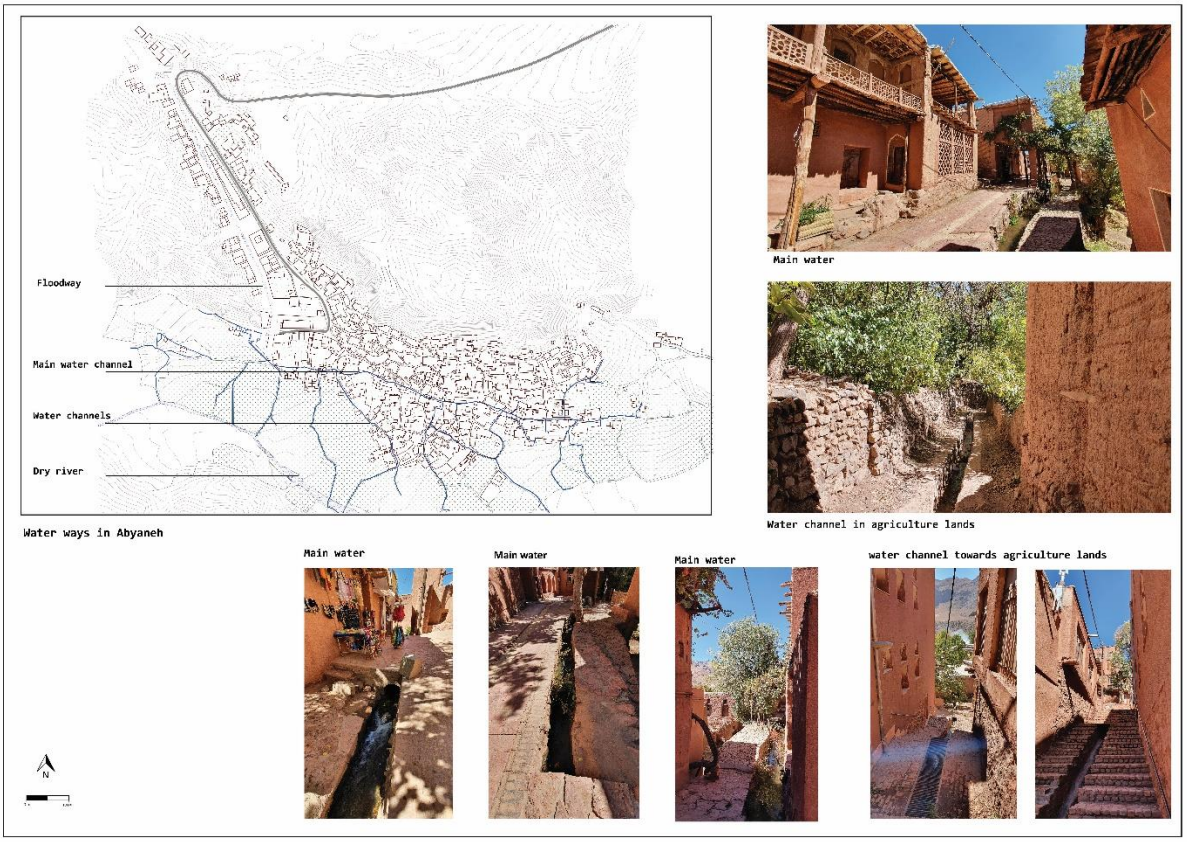

Figure 9 Water in Abyaneh, by author, base map from Heritage organization.

The map in figure 9, illustrates the various water flows in Abyaneh. The slope of the surface water demonstrates that the flood trap parallel to the village's entrance street directs the majority of the surface water towards the south gardens and the river. The main streams of water that flow in the direction of the village's main route enter from the west and exit from the east. The water from inside the canals that is divided in various locations flows to garden and agricultural lands via a land slope and finally arrives in the dry river. The dry river has no water most of the year, and when it floods due to heavy rainfall, it becomes a torrent and flows there. In addition, when the water from Do Abi spring is not used by the fields during the winter, it is directed to the dry river.

Overall, the water resources in Abyaneh, particularly the two major springs, have played a significant role in shaping the village's physical appearance and social dynamics. The water canals and streams in the village have contributed to the quality of urban spaces while also providing water for various purposes such as drinking, hygiene, and agriculture.

In this village there are some water reservoirs (Ab anbars) buildings, none of which are currently operational. They are located in the center of the village and provide easy access to all villagers; the main water reservoir is shown in figure 10.

Figure 10 Ab anbar (water reservoir) in Abyaneh, by author

4.2 Water in Qehi Village

Qehi, like many desert and semi-desert areas, is characterized by hot and dry weather (figure 11). Although the summer days are extremely hot, the nights are cool and pleasant. The majority of rainfall occurs during autumn and winter when the weather is very cold. Due to this arid environment, underground water is the main source of water, which is transported to the surface by numerous aqueducts. The village benefits from the presence of nearby mountains, located 16 kilometers north of the village, the Zayandehrood river, 30 kilometers to the south, and the Gavkhouni swamp, 55 kilometers southeast, which bring in slightly more humid winds and a milder climate than the rest of the desert. However, the drying up of the wetland and the river has led to the area becoming a complete desert.

Figure 11 Qehi village, by author

In the village of Qehi, underground aqueducts play a crucial role in providing water for both the village and its agricultural fields. The villagers report that some of these aqueducts predate the arrival of Islam, as evident from their ancient Persian names such as "Kohani" and "Klopeh". Although the village once had approximately 21 aqueducts, a lack of maintenance has caused only a few to remain in operation (Mohammadnejad, 2007). Two of these aqueducts, Kohni and Esfidab, pass through the village buildings. The maintenance and preservation of these traditional water systems is essential to ensure the sustainability of the village and the surrounding agricultural land. However, currently, these water systems are mostly ruined and not maintained. Figure 12 shows the poor condition of one of the streams of a qanat in Qehi, which has been closed off.

Figure 12 one of the Qanat's stream in Qehi, by author

The main source of water for the old aqueduct system is a mother well located approximately 8 km north of the village, with an additional 54 wells dug along the way to the village. This aqueduct runs through the upper neighborhood and has seven water distribution points within

the village. It ultimately reaches the southwestern part of the village, next to Imamzadeh Abdul Wahed, where it supplies water to the older farms. Another aqueduct, Esfidab, begins 8 km away from the village and reaches it by digging 55 wells (Mohammadnejad, 2007). As it is shown in figure 13 , this aqueduct runs through the lower neighborhood and has four water distribution points, while also providing water directly to ten houses. The aqueduct ends in the southwestern part of the village, where it enters the Esfidab farm. Unfortunately, many of the water canals and distribution points have been destroyed. Additionally, there are two Ab anbars, or water storages, that were crucial for the water system of this village.

Figure 13 Water in Qehi village,source map from Hadiplan, modified by author, photos by author

As mentioned, there are two Water reservoirs (figure 14) , one located in the western part of the village known as Kadkhoda reservoir or Paein neighborhood reservoir, which was built during the reign of Nasreddin Shah Qajar. The other reservoir, known as Haj Mokhtar reservoir, is older and dates back to the time of Fath Ali Shah Qajar. It is referred to as the reservoir in the upper neighborhood. This reservoir is built in a circular shape with a diameter of 14 meters and features four windbreaks on both sides of the dome, with a height of 7 meters (Mohammad-Nejad, 2005 ; Hadi's revised plan, 2012).

Figure 14 (right) Paieen(lower) neighborhood's water reservoir, and (left) Bala(upper) neighborhood's water reservoir, by author

4.3 Water in Ghourtan Village

Ghourtan is a village located in the desert but, on the banks of the Zayandehrood River (figure 15). The village is unique in that it includes a large, historical, abandoned fort within its boundaries. It appears that the original village of Ghourtan was situated within the fort, and was fortified, but is now almost abandoned. People now live primarily outside of the fort. This village is rarely mentioned in historical sources (Ganji, 2014). In 941 CE, Ibn Huql al-Baghdadi, an Arab geographer and tourist, mentions Ghourtan briefly in the Isfahan section of his book. Therefore, the village is much older and dates to 1067 years ago (Heydarian, 2011; Hajrasouliha, 2018). From the time the fort was built until recently, there was residence there (Kiani-Abari, 2015).

Figure 15 Satellite view of Ghourtan, Source: Google earth

The focus of this research is on the old village that was inside the fort, which is now abandoned, as shown in figure 16. The historical section of the village was built inside the enclosed walls of the fort, giving it a different architectural style than other villages in the region. This type of fortified village can be found throughout the central desert of Iran, likely due to the lack of natural topography for defense. The research aims to investigate the morphology of the village inside the fort, known as Ghourtan Fort, and to generalize the findings for other fortified villages in the area.

Figure 16 Inside Qehi fortress, by author

Regarding the water, the old village was relied on a combination of surface and underground water sources to meet its water needs. One of the primary sources was a stream that flowed into the city near the main gate and then ran through the main passages before ultimately flowing into the Zayandehrood river from under the southern wall. This stream was one of the sub-branches of Ghourtan's main water canal, Madi. In addition to this, many houses in Ghourtan had wells, which were relatively shallow due to the high water table in the area. These wells were typically no more than three to eight meters deep, and their water was primarily used for livestock, poultry, and other purposes (Mohebi, 2004).

However, over time, the water sources in this region weakened, making it increasingly difficult to maintain a steady supply of water for both drinking and other purposes. This highlights the importance of proper management and maintenance of water resources to ensure their sustainability .

Figure 17 shows the flow of water in Ghourtan. The stream that served as a primary water source flowed into the city near the main gate, ran through the main passages, and then flowed out under the southern wall into the Zayandehrood river(Mohebi, 2004). Additionally, there is an Ab anbar (water storage) located outside the fort(figure 18). The water storage was

a crucial component of the water management system in Ghourtan, allowing for the collection and storage of water during times of surplus to be used during times of scarcity. Proper management and maintenance of water resources are essential for the sustainability of the water supply system in Ghourtan. As water sources in this region weaken over time, it is imperative that measures are taken to ensure that the water supply is sufficient to meet the town's needs. This can be achieved through the implementation of water conservation measures, such as reducing water waste, as well as proper management of the Ab anbar and other water storage systems to ensure that they remain in good condition .

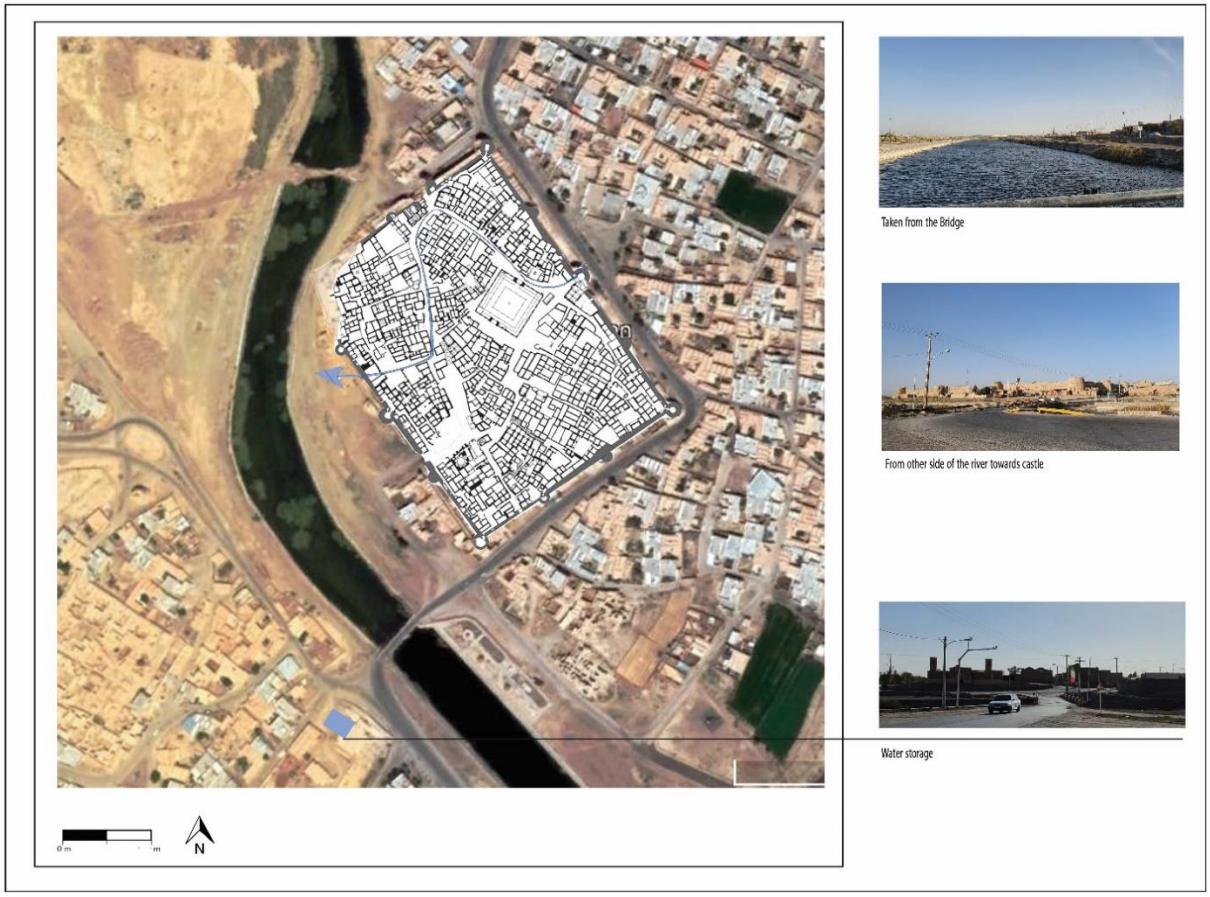

Figure 17 Water in Ghourtan, by author, base map is from Miras organization and Google earth.

Figure 18 water reservoir, outside the fort, by author

In conclusion, the case study of Ghourtan highlights the importance of proper management and maintenance of water resources to ensure the sustainability of the water supply system. Because this village was inside a fort, water was managed carefully and the proximity to the river provided easy access to water from wells. This ensured that in case of danger, there would not be a significant problem. Perhaps this is why the water reservoir is located outside the fort, to be used mostly in years when irrigation is lower and causes water shortages in wells. The combination of surface and underground water sources, as well as the use of Ab anbar, played a significant role in meeting the water needs of the village. Therefore, the streams of water and water sources did not have much effect on the village's layout, unlike in previous cases, because it was all designed and controlled within the village fabric.

5. CONCLUSION

Water is a crucial resource for the development and sustainability of any village. The case of Qehi and Abyaneh demonstrates that groundwater sources, such as springs and qanats, have been the primary sources of water for the villagers. In contrast, the river has been the main source of water for Ghourtan, which was built along the Zayandehrood river. Mountainous villages like Abyaneh have springs as their primary source of water, while desert villages like Qehi rely on qanats designed by humans. Floods caused by seasonal rivers in the low-lying areas of mountainous villages must be managed and controlled. In fortress villages like Ghourtan, the water is controlled by the inhabitants, who direct the river water into the fort and use wells within the fort (as summarized in table 1).

The flow of water in a village has a significant impact on its development and expansion, particularly in mountainous and desert villages. In such villages, the flow of water is the primary factor that shapes the form of the village. In contrast, in fortified villages, the water flow is more controlled by the people, and the form of the village is limited to the design of the fort. The villagers in mountainous villages adapt to the natural flow of water and develop the village accordingly, whereas the villagers in desert villages have to manage and control the water resources actively. The width of passages in the water path broadens significantly, creating a beautiful view of the trees. In villages where the primary source of water is the aqueduct, crossing nodes and social hangouts are formed at the place of water division and diversion.

Table 1 different water sources and the type of village and their management

Village	**Main Water Source**	**Type of Village**	**Management**
Qehi	Qanats	Desert	Moderately Controlled
Abyaneh	Springs	Mountainous	fairly controlled, village form is adopted
Ghourtan	River	Fortified	Completely Controlled

The existence of irregular and non-geometric passages in many villages may be related to following the movement of water streams. Moreover, due to the purity of water in the aqueduct's appearance and its gradual pollution, being close to the aqueduct or "springhead" is considered a value, and houses that are farther away from this point will be deprived of this privilege. Therefore, the village's fabric can have a physical-social hierarchy in proportion to the appearance of the aqueduct and its streams (Abaszadegan, 2017).

In summary, the availability and management of water resources are critical for the development and sustainability of villages. The flow of water in a village has a significant impact on its form and development. Mountainous villages adapt to the natural flow of water, whereas desert villages have to actively manage and control their water resources. In fortified villages, water flow is more controlled by the inhabitants, while in villages where the primary source of water is an aqueduct, nodes and social hangouts are formed at the place of water division and diversion. In all cases, the main stream of water or sources are located on the main roads and close to public buildings.

AUTHOR CONTRIBUTIONS

Hesam Mosharraf: Designing the research, writing and reviewing the manuscript. **Jorge Correia**: Reviewing the manuscript.

FUNDING STATEMENT

This research received no external funding.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest

ETHICS COMMITTEE APPROVAL

This study does not require any ethics committee approval.

REFERENCES

Abaszadegan, M. (2017). Manzar Roostahaye Iran (View of Iranian villages). Tehran: Markaz Tahghighat Rah, Maskan va Shahrsazi (Road, Housing and Urban Development Research Center of Ministry of Roads & Urban Development).

Abaee, M. (2022). The study of urban form in Iran. Urban Form, *ORCID: https://orcid.org/0000-0003-3069-3920*

AL-Sudani, A. H. (2018). Analyzing the Influence of Urban Morphology on Thermal Microclimate in a Temperate Maritime Climate . *University of Liverpool.*

Ahmadi-Lari, O. (2013). Imen Sazi Baft Tarikhi Roostaye Abyaneh ba Mehvariat Shivehaye Tarahi Va Sakht o saz boomi (Securing the historical context of Abyaneh village with the focus on local design and construction methods). Tehran: Thesis, Shahid Beheshti University, faculty of Architecture and Urbanism.

Akyıldız, N. A., & Akbaş, E. (2020). Yaş Dostu Kent Kriterlerinin Kentsel Morfolojiyi Biçimlendirmesi. Sosyal Çalışma Dergisi, 4(2), 84-90.

Alemohammad, H., & Gharari, S. (2010). Qanat: An Ancient Invention for Water Management in Iran. Water Resources Management, 24(14), 3967-3976. doi: 10.1007/s11269-010-9658-6

Ameri, H., & Ahmadi, M. (2003). *Roosta 2 (Village 2). Tehran: Payam Noor University.*

Ameri, H., & Ahmadi, M. (2017). Roosta 1 (Village 1). Tehran: Payam Noor University.

Cowan, R. (2005). The Dictionary of Urbanism,. *Tisbury: Streetwise Press.*

Ganji, M. H. (2014). Brresi va arzyabi Vijegihaye Kalbody va Fazayi ghale ghourtan bar asas andishehaye … (Investigating and evaluating the physical and spatial features of Of Ghourtan Fort based on christopher alexander theories). Isfahan, Art University of Isfahan.

Cömert, N. Z. (2013). Testing an Integrated Methodology for Urban Typo-morphological Analysis on Famagusta and Ludlow . Eastern Mediterranean University.

Gauthier, P., & Gilliland, J. (2006). Mapping urban morphology: A Classification Scheme For Interpreting Contributions To the Study of Urban Form. *International Seminar on Urban Form, 10, 41-50. Retrieved from http://www.urbanform.org/online_unlimited/pdf2006/200d6101_41-50.pdf*

Ghafarisade, A. (1995). Boom Shenas iDar Shahrhaye Kohan Iran Markazi(Ecology in the ancient cities of Central Iran). *Sofe., 5(4-3), 1-17.*

Ghobadian, V. (2014). Baresi eghlimi abnie sonati Iran(Climatic study of traditional Iranian buildings). Tehran: University of Tehran.

Hadi Plan, (2012). Hadi's revised plan of the village of Qehi,Office of Technical Affairs and Plans Preparation,. *Esfahan: Bonyad Maskan Enghelab Eslami.*

Hajrasouliha, A. (2018). Tarh Hadi va Gardeshgari roostahaye ghoortan va balan(Hadi and Tourism plan for ghoortan and Belan Villages). *Tehran: Bonyad maskan enghelab eslami.*

Heydarian, M. (2006). The registration report of Ghortan Fort in. *Isfahan: Heritage Organization.*

Kiani-Abari, S. (2015). baresi parametr ha va Rahbordhaye toseye gardeshgari roostayi dar roostaye Ghourtan(Investigation of parameters and strategies for Rural Tourism Development in Ghourtan village). *Isfahan: Master thesis, Art university of Isfahan.*

Maleki, Ahmad Khorsandi-aghayi,. (2015). Qanat Dar Iran ,Motale Moredi Qanavat dar Tehran(Qanat in Iran, case study research in Iran). *Tehran: Sherkat Pardazesh Va Barnamerizi Shahri (Urban processing and planning company).*

Mohammad-Nejad Kobaria, H. (2005). Shenakht,tarh va maremat va ehyaye baft tarikhi roostaye ghehi va (Recognizing, planning and restoring and revitalizing the historical fabric of qehi village and revitalizing Imamzadeh Abdulvahid and its surrounding area). Tehran: University of Tehran.

Mohebi, F. (2004). Ecomooze Ghourtan Ba Mehvariat Ghale Tarikhi Roosta(Ghourtan Ecomuseum with the focus on the historical castle of the village). *Tehran: Shahid Beheshti University.*

Oliveira, V. (2019). J.W.R. Whitehand and the Historico-geographical Approach to Urban Morphology. *Springer International Publishing.*

Hadi Plan, (2012). Hadi's revised plan of the village of Qehi,Office of Technical Affairs and Plans Preparation,. *Esfahan: Bonyad Maskan Enghelab Eslami.*

Pakzad, J., Ebrahimnia, V., Besharatizaadeh, A., Ayedi, m., & Kaveh, e. (2017). Tarkh shahr va shahrneshini dar Iran az Aghazta Selseleye Qajar(History of the city and urbanization in Iran from the beginning to the Qajar dynasty). *Tehran: ArmanShahr.*

Pirnia, M. k. (2009). Sabkshenasi Memari Iran(Styles of Iranian architecture). *Tehran: Sourosh Danesh.*

Saqafi, A. (2007). Tarh behsazi Roostaye Tarikhi Abyaneh (Abyaneh Historical Village Improvement plan). *Abadi(24), 86-93.*

Whitehand, J. W. (2007). Conezenian Urban Morphology and Urban Landscapes. *Istanbul: Proceedings, 6th Internathional Space Syntax Symposium.*

Ye, Y. (2015). Urban Form Index For Quantitative Urban Morphology And Urban Design Analyses. *University of Hong Kong.*

Zargar. (2003). Daramadi bar Shenakht Memari Roostayi Iran(An Introduction to the Knowledge of Rural Architecture in Iran). *Tehran: Shahid Beheshti University* .

Zargar, A. (2014). Vijegi am Roostayi Iran(General features of rural architecture in Iran). *Sofeh(25), 14-19.*