Comparison between the impacts of the irrigation systems of Persian Safavid and Italian Renaissance gardens through a descriptive-historical approach

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This article is based on the comparison of the irrigation systems in gardens of two simultaneous periods but formed in two different lands, Italian Renaissance gardens and Persian Safavid gardens. The studies that have been done so far do not explicitly mention the relationship between these two gardens, and this research can be a starting point for referring to historical studies and discovering the possible connections and their effects on each other. The research is qualitative with an interpretive historical approach that seeks to investigate the origins of the irrigation systems of Persian and Italian Villa gardens in the Renaissance period. Methodologically, this study carries out a literature review and case studies by identifying sources in historical bibliographies and archives and by observation in Persian and Italian Renaissance gardens. The result shows some crucial changes occurred to Italian gardens which transformed the form and figure of the gardens. The first and most important one was the creation of running water. According to historical records, two important events are recognised for their impact on the irrigation system: the first was the influence between gardens within and after the Crusader period and the second was Navagaro letters and the impact of Islamic Andalusian gardens on Italian Renaissance gardens.

Keyword: Irrigation system, Italian Renaissance gardens, Persian Safavid gardens

Introduction

The irrigation systems in gardens have always been very important, in some cases to the extent that gardens were designed on the basis of the irrigation. Renaissance gardens in Italy and Persian gardens in the Safavid period (sixteenth and seventeenth centuries) had an advanced method of irrigation. During this period, great changes took place in the irrigation of Renaissance gardens in Italy and its equivalent, Safavid gardens in Iran. However, the irrigation of gardens has a rich background and has been mentioned in various historical and religious texts. One of the most important descriptions relates to the Garden of Eden. The image of the Garden of Eden gives us a few visual details by which to flesh out the image

of the first garden: there was a river flowing from Eden to water the garden, and when it left the garden it braced into four streams. The vision of heaven the Bible gives us is an even less scenic description. The idea, however, is communicated of a middle place marked by the presence of the tree of life and the tree of good and evil, with four streams flowing away from it. Irrigation runnels laid out according to a quadripartite pattern such as this must have occurred in some arid part of the ancient near east where agriculture was first practiced. Moreover, the interesting point about how to irrigate gardens is that the gardens of Iran and Italy have affected each other. Significant for the subsequent development in the field of agriculture, were the Arab conquest of Sicily in 831 and the subsequent domination which lasted until 1091. The history of the landscape differed in that period from that of the rest of Italy. The large estate Romano- byzantine was eliminated and replaced by a farm. Simultaneously numerous important plant species were introduced and cultivation and irrigation techniques were created. The new techniques introduced by Arabs were about soil arrangements, rotation and associations of crops, and irrigation systems such as wells, canals, qanats, mills and hydraulic machines. In Persian gardens instead of using statues (which was forbidden in Islam) the energy of water was used to enrich fountains. The Persian garden was irrigated in a very unique way: channels dug to artistic ends and proportion carried water in abundance. In contrast to the pre-Safavid cities based on the qanat pattern, the Safavid plan was based on three networks of water channels (madis) distributed throughout the city. These madis supplied water to the urban quarters, thus bringing life to residential neighbourhoods and public spaces, while also facilitating the construction of gardens in different areas of the city. In the Shah Abbas era, gardens and buildings had the right to receive water from a madi. Most of the madi water belonged to the king and the money earned from its sale was a source of revenue for the Safavid court. On the other hand, Renaissance villa gardens are well known for their splendid waterworks. In the Renaissance, superiority was most clearly manifested in hydraulic devices, which were a supreme example of mankind's ability to harness nature through the art of mechanics. In some of these gardens, the flowing water links areas of the garden together.

This article examines how Iranian and Italian gardens were irrigated and how they could have affected each other during and before the Renaissance. The purpose of writing this article is to examine the differences and similarities of the irrigation systems of these gardens in a particular period of history. For this purpose, first, with a historical approach, the water supply of the Persian gardens of the Safavid period is examined. Then the irrigation of Italian Renaissance gardens is investigated. Subsequently, the water supplies of these gardens will be compared. Furthermore, the possible effects of these gardens on each other are identified.

Methodology

The current research is qualitative with an interpretive historical approach that seeks to investigate the origin of the irrigation systems of Persian and Italian villa gardens in the Renaissance period. Methodologically, this study carries out a literature review and case studies by identifying sources in historical bibliographies and archives and by observation in Persian and Italian Renaissance gardens. That is, it first examines primary historical sources and then secondary sources including scholarly research, books, journals, maps, photographs and historical survey notes about the different types of irrigation system in Italian and Persian Renaissance gardens, in order to fully examine the wide range of issues related to the aims of the research.

Further, will be collected concerning case studies from Persian and Italian Renaissance gardens by carrying out studies in the field and through archival research. This requires initial bibliographical searches, archival research and documentation, and then the evaluation of findings. The aim will be to construct a holistic narrative of the subject. Through this analysis, the research will respond to the implications of commonality in attitudes in the design of water supplies and irrigation systems in Persian and Italian Renaissance gardens. The research process is shown in figure 1.

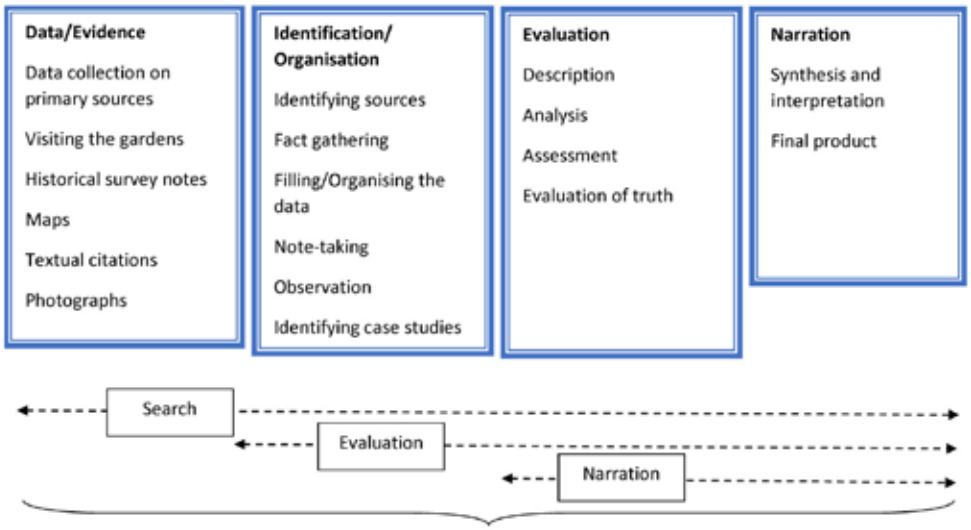


Fig 1: Chart of research process. Source: Author[1]

Examining the various systems of irrigation in Persian gardens

Water was highly valued in Persia and regarded as the source of life, symbolising the life force in Persian art. Irrigation canals and underground canals (qanat) made cultivation possible in desert regions. Surface channels were used for irrigation. The Chaharbagh pattern was an enclosed space divided into four parts by water channels.[2] The origin of the classic four-square (Chaharbagh) may never be determined. It could be up to 5000 years old. Ceramic representations of the world divided into four quarters date from 4000 BC and are thought to relate to the Buddhist mandala. The book of Genesis recounts that a river went out of Eden to water the garden and became four heads. The Quran describes the four rivers which flow through paradise as being of water, of milk, of wine and of honey. Wilber believes that the four-square plan was crystallised at least as early as the Sassanian period (224–642 AD). The oldest plan of a four-square religious space with crossing paths was drawn by a monk who had visited Constantinople in 820. However, the oldest surviving four-square gardens date from 1200 AD.[3] So, it can be concluded that the origin of the Chaharbagh pattern in Persia

[1] GROAT, Linda, WANG, David. *Architectural research methods*. Second edition. John Wiley & Sons, Inc., Hoboken, New Jersey, 2020, p. 137

[2] TURNER, Tom. *Garden history: Philosophy and design 2000 BC–2000 AD*. Taylor and Francis, 2005, p. 125

[3] Ibid., p. 130

is uncertain. The paradise garden outlined in the Quran. It is the final resting place of the righteous and devout. Paradise consists of four gardens with four rivers of milk, wine, honey and water. There are also four fountains in the garden of paradise, two of which are flavoured with musk. The beauty of the garden and the specific references to fountains became the design inspiration for royal gardens throughout the Islamic world.[4]

The Safavid government in Persia owned public channels which were called *madi* and carried water diverted from the river, which flowed in manmade madis and channels. Where it flowed onto private property, owners were taxed, making monthly and annual payments for water based on the size of their lands. According to the travelogue of Chardin entitled "Travels in Persia", the owners had to pay twenty deniers for each Jerib[5] each year in order to buy the river or spring water.[6] Jean-Baptiste Tavernier also complained about the high cost of water, finding this unfair to farmers. The amount of water that entered each garden and the length of time that it was used there were measured. [7] This was achieved by placing stones called lats (dividers) in the course of madis or streams in order to specify the amount of water used. The period of water consumption was measured by a pangan (cup) that worked as a water watch.[8] Not only did madis provide water for public use in mosques and madrasas (religious schools), but the madi network was physically incorporated into their design. For instance, in the Chaharbagh madrasa, the madi that passed through the building was designed as an axial water channel. By passing through these buildings, water changed their nature from static to active and made them interact with their natural context, a rare phenomenon in Iranian architecture. A more developed variation on this approach is manifest in Fin Garden in Kashan near Isfahan, in which two water channels run through a building located at the centre of the garden (Figs 2–3).

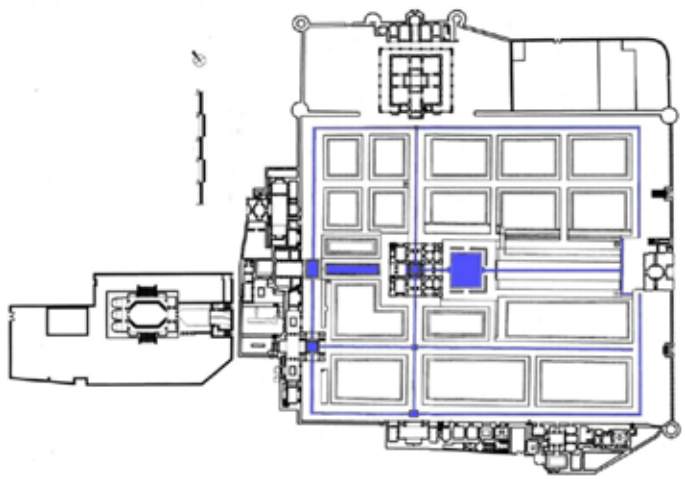


Fig. 2: *The plan of Fin Garden in Kashan*, Iran – the circulation of water and the geometric design of Chaharbagh[9]

[4] CAMPBELL, James W. P.; BOYINGTON, Amy; PAN, Yiting. Studies in the history of services and construction. In: *The proceedings of the fifth conference of the construction history society*, Queen's College Cambridge, 6–8 April 2018. The Construction History Society, 2018, p. 248.

[5] The Jerib is a traditional unit of land measurement in the Middle East and southwestern Asia; each Jerib is equal to 10,000 m².

[6] Chardin, Sir John, *Travels in Persia, 1673-1677*, Dover Publications, 1988.

[7] GHARIPOUR, Gardens of…, p. 117

[8] GHARIPOUR, Gardens of…, p. 117

[9] KHANSARI, M, MOGHTADER, M. R., YAVARI, M. *The Persian garden: Echoes of paradise*. Washington DC: Mage publishers, 1998.

(a) **(b)**

Fig. 3: a) *The main pool in the courtyard of Chaharbagh Madrasa, Isfahan, Iran*; **b)** *Pool with floated water in Fin Garden in Kashan, Iran*. Source: Author, 2019

Dominated by water, the whole pavilion thus becomes transformed into a transparent and light structure. In summary, the new Safavid irrigation network, facilitating the use of water in public buildings and spaces, was an important innovation and revolution in Iranian urbanism, which seems to parallel the public distribution of water featured in the Renaissance cities of Italy. Irrigation in the gardens was so important that the structure of the gardens was based on the irrigation system.

Another feature of water in Iranian gardens is the reflection in it. Apart from water canals, the front of the pavilion was usually dedicated to a large pool or pond to reflect the image of the building and the sky. The large pool in front of the mansion usually reflects the pavilion and the greenery of the gardens, which adds another feature to the complexity of the water in Persian gardens.[10]

Achievements in the irrigation systems of Persian gardens

The first and most important achievement was the innovation of qanats, which became one of the most important methods of irrigating arid areas, its history dating back to the pre-Islamic and Achaemenid periods. The systems aqueducts are slow-sloping tunnels that are drilled horizontally into an alluvial fan until the water surface is perforated. After construction, groundwater is filtered into the canals, descend their gentle slope and appears as a stream on the surface. These tunnel wells, which are connected from a series of wells and are connected at a considerable distance, had many advantages in supplying hot and dry areas and were used extensively. First, qanats need only gravity to maintain water flow. Second, water can be transported in these underground channels with the least risk of pollution and loss. Third, the water flow is balanced with the amount in the aquifer, so these canals have remained a reliable source of water for years. In many cases, these underground networks were built before the actual physical structure of gardens and even cities, and were even widely used in the

[10] MAHMOUDI, Leila, MOTAMED, Bahareh, JAMEI, Elmira. Persian gardens: Meanings, symbolism and design. In: *Official journal of the International Association for Landscape Ecology*. Landscape online, 2016, p. 13.

modern horticultural style.[11] In the Safavid era, the use of qanats for irrigating gardens became widespread, the slope in these gardens enabling the flow of water within their canals and pools (Fig 4). Their geometric and rectangular forms structure the primary and secondary axes. In Fin Garden, the movement of water is directed from aquifers in the Karkas Mountains through underground aqueducts to a reservoir.[12] It is then directed throughout the garden through qanats. It is directed from its canals into fountains that maintain a continuous flow implying specific symbolic references.[13], [14] At the completion of this sequence, the water flows into the garden surrounding the *Howz Jushan* pavilion. Its reliance on the square geometry and axes, and thereby the garden's regular form, defines a simple landscaping strategy.

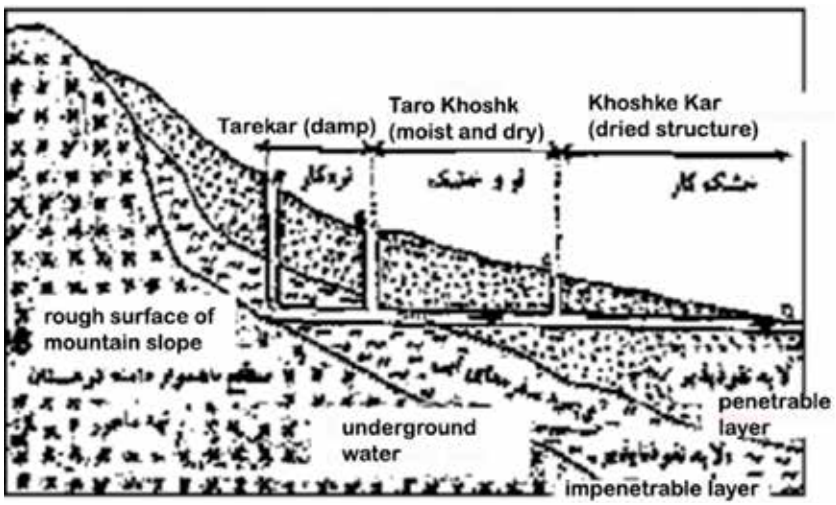


Fig. 4: *qanat section*[15]

During the Sassanid era, gardening and garden-making grew and developed widely. Sasanian kings preferred to build their own palaces in a region that was dominated by large pools that were filled with natural springs. These natural ponds and pools probably inspired the pools in the post-Islamic Persian gardens. The most distinctive characteristic of the gardens of this age was that the geometrical variety and the quadripartite order and axial organisation were improved during this period. Later, the invasion of large regions of the Sassanid and Byzantine empires by recently converted Muslim Arabs after the seventh century AD resulted in the diffusion of the concept of the Persian garden in the Middle East. While the tradition of hunting parks declined after Islam, the design of delight gardens, which represented the

[11] LATIFFI, Abdul, MAHERAN, Zainab,YAMAN, Mohd. Revisiting Andalusian garden: Visions for contemporary Islamic garden design. In: *Planning Malaysia: Journal of the Malaysian Institute of Planners,* volume 15 issue 1, 2017, p. 128.

[12] Monshizadeh Arezou. "Sound-perception system of water in the Persian garden case studies: Fin and Shazdeh gardens. In: *Journal of architecture and urban planning*, Spring-Summer 2017, Volume 9, Number 18, p. 81–98, p. 89.

[13] SEIEDALMASI, M. Water flow in the Persian garden. [Online] Available: http://www.persiangarden.ir /Indexb.as ?ID=608&IDD=651&IDDD=610&Langu=FA, Accessed March 12, 2020.

[14] OKHOVAT, Hanieh. Conceptual, functional and esthetic analysis of natural principles of water and plant with an emphasis on spatial aspects of Persian gardens. In: *Journal of environmental science and technology*, Volume 16, Number SPECIAL ISSUE; 2015, p. 487–500.

[15] JAVAN, M; JAVAHERI, M. Technical and engineering specialties of aquatic structure which are used in Ghanats of Shiraz plain. In: Collection of Ghanat essays. Regional water limited company of Yazd, 2000.

Quranic paradise, was pursued by both the political authorities and the wealthy. In Persian gardens, straight lines and four axes were used to design the garden to reduce water wastage. Also, the garden was divided into four parts, which were mostly square or rectangular, and then into four squares, in symmetrical and geometric shapes. Depending on the irrigation process, which depends on the type of land, gardens are usually built on a natural slope, so natural flux can create natural waterfalls. The Chaharbagh irrigation system allowed water to flow from the top to the bottom again, and the gardener irrigated each of the four plots by constructing temporary dams, respectively.[16]

The best-known example of irrigation mechanisms is the book of ingenious devices (Kitab al-Hiyal) published in 850 AD by the Iranian Banu Musa brothers. It describes the working of 100 mechanisms, of which 75 were their own invention. The treatise presents six models or designs for the construction of fountains, including the mechanisms for creating different shapes, jets and sprays. The treatise is particularly important in providing the first descriptions of fountains' buds or nozzles that determined the shape of the water emitted. The three basic shapes of water proposed by the brothers were the lily, shield and spear. These basic shapes were then extended and combined to create even more elaborate water displays. Islamic research in hydraulics extended beyond fountains. Ibn Khalaf al Muradi of Andalusia, Spain, was an eleventh-century mechanical engineer and scientist who wrote a book of secrets about the result of thoughts (Kitab al Asrar Fi Nataij al Afkar). A 1260 copy is preserved in the Laurentian Library in Florence and is the earliest surviving Arabic work relating to automata. Although Al-Muradi did not develop the Banu brothers work on hydraulic engineering in relation to fountains, he did develop 31 devices powered by water wheels, 19 of which were water clocks.[17] These key works were later developed in the Middle Ages by Ibn-Rezzaz al Jazari (1136–1206) who published a book of knowledge of ingenious mechanical devices in 1206. His work included developments upon the mechanisms behind fountains and an entire section devoted to the engineering and hydraulics of various fountain designs entitled "On the construction in pools of fountains which change their form and shape, and of machines for the perpetual flute", as well as a further section dedicated to water-raising devices entitled "On the construction of machines and systems for raising water from standing water which is not deep, and from a river". Al- Jazari's work was extremely popular throughout the Islamic civilisation, aided by the 173 detailed illustrations that accompanied his descriptions.

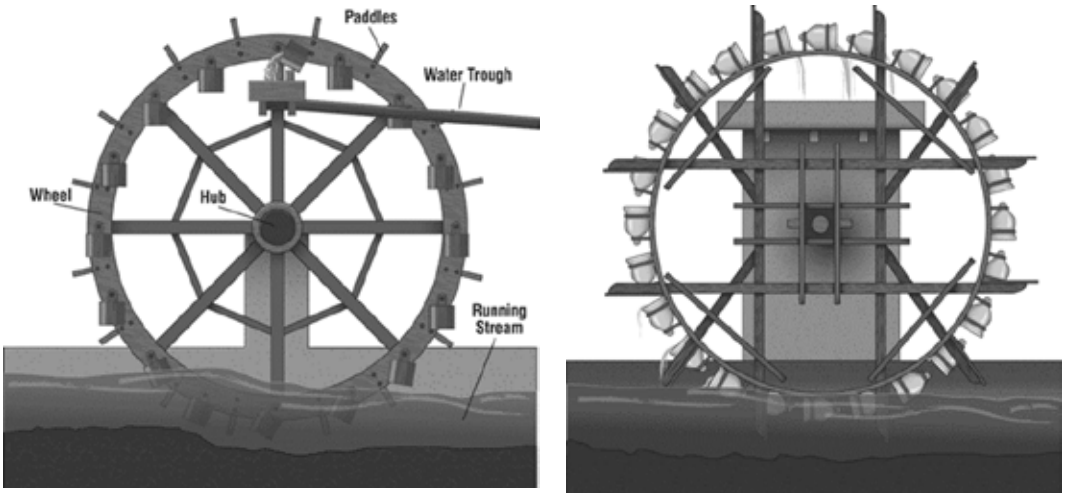
Another achievement was the use of pipes in the gardens. Many of the main plumbing systems in the gardens have now been destroyed, but excavations have shown that Persian gardens used lead or ceramic pipes. Moreover, Al-Jazari regularly mentions copper and brass pipes in his treatise. Excavations show that they use lead and brass materials to make nozzles and finer elements, but they are very expensive to use for underground pipes and are prone to corrosion. Meanwhile in Western Europe, wooden pipes were used throughout the Middle Ages, made of hardwoods such as almond or elm. But the use of wood materials for pipes was not accepted in Iran because wood was scarce in this land. So lead was used in Isfahan and Sir Tomas Herbert (1606–1682) pointed it out in his travelogue in the seventeenth century.

The third achievement was water lifting, the main devices for raising water were the shaduf, noria and saqyia. The shaduf was the simplest tool for this task, and a bucket was mounted on

[16] LATIFFI, Abdul, MAHERAN, Zainab, YAMAN, Mohd. Revisiting Andalusian garden: Visions for contemporary Islamic garden design. In: *Planning Malaysia: Journal of the Malaysian Institute of Planners*, volume 15 issue 1, 2017, p. 191–200.

[17] Campbell and Boyington, Studies in the history of…, p. 249.

a long axle and was suitable for lifting water from a pool or river for agricultural and domestic use, but it usually had little power and could not provide the water needed for garden fountains. The noria and saqyia are older, as Vitruvius points to a device similar to the noria from the first century BC, but its roots probably date back to Hellenism. The noria is mostly used in Iran and is also known as the Iranian waterwheel, while the saqiya was adapted throughout the Arab world. The noria is a water wheel that consists of hinged chambers that sink into a river or stream and fill with water. An important feature of the noria compared to more conventional water wheels is that it is the flow of the river that is used to carry buckets to the top of the wheel and then drain (Fig 5).[18]



(a) **(b)**

Fig. 5: a) *Parts of the noria*, **b)** *Persian noria Using a wheel of pots for raising water*[19]

The history of the saqyia dates back to Egypt and the third century BC. This device is developed in hot and dry areas. The saqyia consists of two interconnected wheels, one horizontal and the other vertical. The horizontal wheels are driven by animals, and the vertical wheels have a bucket or glass that sinks into the water.

The fourth achievement was the use of pools and fountains. The pool in front of the pavilion was the simplest form of water display in Persian gardens. The pools were irrigated from an area above or below ground level, so that they were level with the surrounding paths and the water flowed through them. Fountains are made up of many elements, including hidden plumbing that feeds the fountain and the structure of the fountain, the head of the spring or nozzle from which the water flows, and the pool or pond into which the water flows. The design of fountains in the Persian garden is in the form of a row of fountains, which often consist of a marble or carved stone column and are fed by a central pool beside the pavilion (Fig 6).

[18] CAMPBELL and BOYINGTON, Studies in the history of…, p. 250

[19] https://www.machinerylubrication.com/Read/1294/noria-history, accessed 16/06/2021.

(a) **(b)**

Fig. 6: a) *Water axes characterising the Chaharbagh pattern in Kashan Fin Garden*
b) *The design of fountains in the Persian garden is in the form of a row of fountains.*
Source: Author, 2019

Examining the various systems of irrigation in Italian gardens

One of the main features that distinguished renaissance gardens from their medieval predecessors concerned their advanced and elaborate waterworks. There are various kinds of irrigation system in Italian Renaissance gardens, one of the most common ones being fishponds. Fishponds were common in medieval gardens, but the architectural character of these introduces us in a preliminary way to what would become one of the chief means of Italian Renaissance gardens, the use of water as an important design element.[20] Water was employed with great imagination in subsequent sixteenth-century Italian gardens, appearing in fountains, pools, water staircases, water parterres and droll water games (gloccihid' acqua) that involved the spectator physically by offering a surprise drenching from concealed jets suddenly activated (Fig 7). Water in these gardens was a means of providing a memorable movement and excitement through reflections and the play of light.

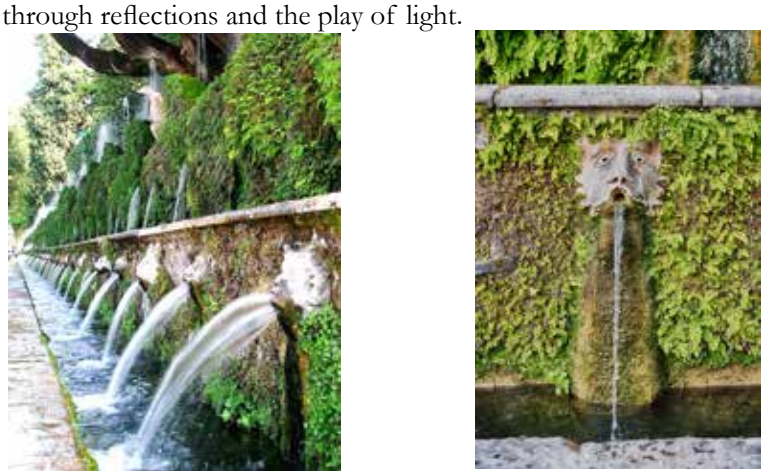


Fig. 7: *The hundred fountains of Villa d'Este at Tivoli*[21]

[20] BARLOW ROGERS, Landscape design…, p. 135
[21] BARISI, I.; FAGIOLO, M.; MADONNA, M. L. Villa d'Este. Roma. De Luca Editori d'Arte, 2003, (Italian) s

In the Renaissance period, superiority was most clearly manifested in hydraulic devices and irrigation systems in gardens, which were a supreme example of mankind's ability to harness nature through the art of mechanics. Giovanni Battista Aleotti (1589) provided the design, construction and maintenance instructions for a four-cylinder force-pump, which would supply the water for his automat. "Necessary to the irrigation of the garden and documented from the time of Boccaccio's Decameron in the fourteenth century, water channels later evolved into the water chains and water stairs of the grand in sixteenth-century gardens in central Italy."[22] So, water was employed with great imagination in subsequent sixteenth-century Italian gardens appearing in fountains and grottoes that could be powered by refillable cisterns, pools, water staircases, Nymphaea ponds, fishponds, small cascades, water parterres and droll water games. The flowing water linked areas of the garden together. Although this is still conjectural, several garden historians have pointed to Navagero's letters as a possible source for the dynamic use of water in sixteenth-century Italian gardens. His descriptions of Granada offer a tantalising model for the proliferating fountains and burbling water chain in the gardens.[23] "In most gardens, the apparent source of water was often a grotto, which imitated naturally dripping caverns and intimated the presence of a real mountain spring."[24]

From the end of fifteenth century, water channels in gardens functioned in the design and were not simply a practical necessity. Also, in the Renaissance period, the fountains and sculpture first centralised a regular space, later served as a focal point at the end of the axes, and finally linked parts thematically and reinforced a visual axis. This general schema occurred in the cases of such gardens as the Boboli Garden and it seems to be a development of the sixteenth century. A book of the machines of Agostino Ramelli (an Italian engineer, 1531–1610), first published in 1588, illustrates devices for raising water. These same machines were used to lift water and bring it into gardens, especially those on the hills around Rome's centre, high above the water level. "Ramelli's inventions addressed other practical problems of creating the great terraced gardens of the later 16th century. Ramelli's published inventions included designs for water organs and for fountains with singing birds and moving parts. The illustration in plan and cross-section reveals a complex inner structure of compartments and networks of pipes." These hydraulic devices were inspired by the *Pneumatics of the Hero of Alexandria* (10–70 AD, an ancient Greek mathematician and engineer), which became well known in the fifteenth and sixteenth centuries through translations from the original Greek into Latin.[25]

The sixteenth-century devices for irrigation systems were very complex, employing gears and pulleys. They were more efficient machines activated by water power rather than manually, by pumping air or playing a water organ. These achievements in the area of hydraulics also revolutionised design, making water a dynamic force that helped unify multi-terraced layouts in both narrative and aesthetic terms. In most gardens, the source of water was often a cave (grotto), built like a naturally dripping cave, intimating a real mountain spring (Fig 8).

[22] LAZZARO, The Italian Renaissance garden, p. 86–87
[23] GHARIPOUR, Gardens of…, p. 17
[24] LAZZARO, The Italian Renaissance garden, p. 86–87
[25] LAZZARO, The Italian Renaissance garden, p. 16

Fig. 8: *The cave (grotto) as the source of water in Villa Lante, Italian Renaissance garden*. Source: Author, 2018

The impacts of irrigation systems between gardens

The provision of new freshwater sources to the populace was a common trope in Renaissance descriptions of the ideal prince. In a 1566 description lauding the merits of Naples (city in Italy), and particularly the urban improvement projects executed during the viceregency of Pedro de Toledo, Giovanni commented that above all, that which a city most requires is fountains of fresh, flowing water because beyond the practical benefits that these offer (which is huge and incomparable), they render beautiful, pleasant and lively that city in which they are found. As Conforti has observed, well into the sixteenth century, even in the most populous cities, the principal water supply was provided by wells. Thus, the continuous flow of springwater, transported by aqueducts and dramatically displayed in fountains, would have been especially remarkable and appreciated in the urban setting.[26] What appears for the first time at Poggioreale (town in Sicily, Italy), however, is the decision to collect and employ water for spectacular effects and entertainments in a ruler's garden prior to its passage to the city. In the case of the Florentine translations of Poggioreale, the villa's own Florentine quattrocento architectural language may well have facilitated adaptation to a hydraulic model, even though Poggioreal's hydraulic system itself owes a greater debt to Persian garden traditions.[27]

[26] EDELSTEIN, Bruce L. Acqua viva e correlate: Private Display and Public Distribution of Fresh Water at the Neapolitan Villa of Poggioreale as a Hydraulic Model for Sixteenth-Century Medici Gardens In: Artistic exchange and cultural translation in the Italian renaissance city, 2004, p. 191.
[27] Ibid., p. 192.

Cardinal Gambara hired a specialist in hydraulics, Tommaso Chiruchi, from Siena to design the fountains and the water chain (Catena Dacqua) in Villa Lante. Water is the dominant element in the design of the Villa Lante. Its seven fountains not only help unite the layout but through their decorative programmes, also convey the meaning of the garden as a whole. The same approach is evident in the Villa Caprarola. Here, water is also an essential element in the upper garden's layout, with a fountain at the base of the water chain greeting visitors as they arrive at the entrance to the casino (summer house). Above is placed another fountain, flanked by dual staircases that echo the entrance way to the villa, with statues similar to those in the lower gardens lining the perimeter of the stairs and parterres. The Safavid master plan was proposed more than forty years after the creation of these Italian villas (Lante and Caprarola). In terms of design, their fountains and pools were never intended to be as delicate as those of Italy, nor did they include statues or decorative programmes. Nevertheless, it is known that they were considered integral elements of the site plan, and, even more importantly they extended into the public space of the city.[28] The irrigation of these plants has indeed posed new challenges, bringing about a fundamental rethinking of the role of water in Italian Renaissance garden design. Ancient and early modern agricultural theorists traditionally recommended manual watering techniques, which involved various methods of soaking and dripping; running water was generally to be avoided due to the soil erosion that it was likely to cause. What a typical fifteenth-century garden needed was a well with an adjacent trough, which allowed the warming up of water in the sun and its mixing with the essential fertiliser, manure. Because of their relatively shallow root systems, citrus trees required regular irrigation, usually twice daily, early in the morning and after sunset, making, by the middle of the sixteenth century, the introduction of fresh aqueduct water in Italian gardens a pressing necessity. The harnessing of running water in the garden context opened up further possibilities for its artistic manipulation. Mid–sixteenth-century waterworks included not only fountains and grottoes that could be powered by refillable cisterns, but also nymphaea, fishponds and cascades – in short, the whole range of elaborate Giochi Dacqua that became synonymous with the Italian renaissance garden experience. These achievements in the field of hydraulics also revolutionised design, and water in the gardens became a dynamic force that helped to integrate multi-storey designs in terms of validity and beauty.

Discussion

The Crusader period

The Crusader period (1095–1492) offered the most favourable conditions for artistic exchange between east and west. Crusaders may have seen paradise gardens in the east which were designed in this way, or traders may have seen examples in Islamic Spain.[29, 30] The aspects that made significant progress during the crusader period were agriculture and water irrigation in gardens, where most of the relevant information was not only transmitted to Europe via Spain but also completed and developed during the Crusades. The use of water wheels, which was an important tool for irrigating gardens and lands in the city of Hama in Levant, was adopted by the Europeans, and complete examples can be found in Italy and Germany.

[28] GHARIPOUR, Gardens of…, p. 114

[29] HOWARD, Deborah. V*enice and east: The impact of the Islamic world on Venetian architecture, 1100–1500*. New Haven CT: Yale University Press, 2000.

[30] CHRISTIE, Niall. *Muslims and Crusaders: Christianity's Wars in the Middle East, 1095–1382, from the Islamic Sources*. 2nd edition. Routledge, 2020.

According to Mu ʾjam ul-Buldān, an encyclopaedia that was written by Yaqut ibn `Abd Allah *al*-Hamawi (1179–1229), there were various water wheels in Hama in 884 AD.[31] However, the current surviving water wheels in Hama cannot be dated earlier than the Ayyubid dynasty (1170–1260/1341),[32] for which Hama was the capital from 1260 until 1341 (Figs 9–10).

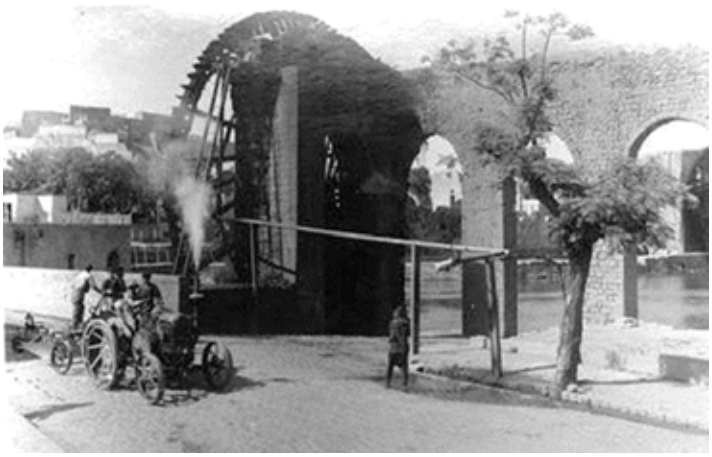


Fig. 9: *The ancient water wheel al-Jisriya, Hama, Levant*[33]

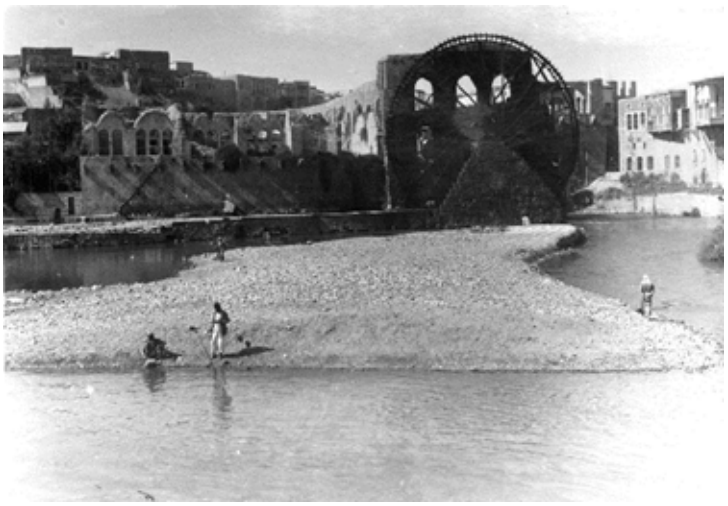


Fig. 10: *The ancient water wheel al-Mamuriya, Hama, Levant*[34]

In 1086 AD there were 5000 water mills or wells whose slow motion was doubled by a gear and pulleys and was used as an important tool in industry. The windmill that existed in Western Europe in 1105 AD was previously adopted by the Crusaders from the Muslims and became

[31] Yaqut ibn ʻAbd Allah al-Hamawi, Mu'jam al-buldan, Tihran: Maktabat al-Asadi, 1998, 308-3012

[32] GATIER, Pierre-Louis, GATIER, Robert-Louis, GUBEL, Eric, MARQUIS, Philippe. *The Levant: History and Archaeology in the Eastern Mediterranean*. Konemann, 2000, p. 298–300.

[33] Ibid., p. 298–302.

[34] Ibid., 2000, p. 298–302.

popular in Europe.[35]

Andrea Navagero description

One of the influences of Persian gardens in Italian Renaissance gardens was the use of water stairs. It has long been assumed that Persian influences led the way to this solution for the practical problem of conducting water along a slope. An important element was emphasised by Andrea Navagero (1483–1529), a researcher, poet and amateur horticulturalist who analysed the Alhambra in an informed and perceptive way with the use of classical literature. In 1526, Navagero visited the early fourteenth-century Generalife gardens at the Alhambra of Granada and described the staircase. He had an effective role in introducing the water chains in Italian Renaissance gardens by his descriptions from Alhambra. Navagero's description of the Alhambra's water chains and water stairs reminds of the form of the water stairs in Villa d'Este in Tivoli which appeared as an innovative element in the Villa d'Este, and other Italian Renaissance gardens were inspired by it.[36]

> At the highest part of the site in a garden, there is a lovely wide staircase… the stair is made of masonry and every few steps have a loading with a hollow to hold water. The parapets on each side of the stair have hollowed stones on the top, like channels. The valves at the top of the stairs are arranged so that water can run either in the channels or in the landing hollows or both. The volume can be increased so that the water overflows and inundates the steps and drenches anyone there.[37]

Fig. 11: *The use of water stairs or water cascades in Villa d'Este, Tivoli.* Source: Author, 2018

The water organ at Tivoli is known to have been based on the hydraulics treatise of the Hero of Alexandria called *The Pneumatics*, but the consideration for the water chains is most likely to have come from Navagero's description of the Alhambra. He was also friends with

[35] DURANT, Will. The age of Faith. In: The story of civilization, Volume 4. New York: Simon & Schuster, 1980, p. 833.

[36] FERRERO, Giuseppe Guido, ed. Lettere del Cinquecento. 2nd ed. Turin: U. T. E. T., 1967, p. 141–156.

[37] MACDOUGALL, Elisabeth. Introduction, in Fons Sapientiae: Renaissance Garden Fountains. Washington: Dumbarton Oaks, 1978, p. 10.

Fra Giocondo, the Venetian author of the first illustrated edition of Vitruvius, and while in Spain requested that Ramusio send him the book. He was also friends with Raphael, Baldassare Castiglione and Pietro Bembo. In a letter of April 3, 1516, Bembo writes of their plan to visit Hadrian's villa at Tivoli together. So, he was an informed scholar who associated with many scholars during the Renaissance and his descriptive letters from the Alhambra had a great influence in the design of Renaissance gardens and afterward. The other influence of Spanish Islamic gardens upon the Renaissance landscape can be found in the dynamic connection of water-courses reinforcing the transition between the built environment and the agricultural landscape at Fumane (the Province of Verona in the Italian region Veneto). Renaissance Italy had to have looked to contemporary gardens believed to be the descendants of this ancient tradition, whether in Spain or Iran. Although Islamic gardens in Spain may have provided the immediate model for the water chains of Renaissance gardens, we should not forget that the Islamic garden originated in pre-Islamic Persia and spread throughout the Islamic world, and water falling down a slope belonging to a greater network of channels flowing throughout the garden, whether on a slope or over flat terrain, was a common design in Persian Gardens. Also, Persian gardens were built around the intersection of two major water channels' axes, which arrangement is called *Chaharbagh*. The practice of Chaharbagh and water chains shows a clear impact in the Islamic gardens of Alhambra and, as stated above, in Renaissance gardens and can be considered an indirect diffusion which passed from Persian gardens to Andalusia and then to Italian Renaissance gardens.

Conclusion

During the sixteenth century, some crucial changes occurred to Italian gardens which transformed the form and figure of those gardens. The first and most important one was the creation of running water. This article showed that identifying Renaissance garden elements that did not come from the indigenous traditions of Italy can lead us to the garden elements that have been adopted from other cultures. In this article, the reason why they were adopted and how they arrived was recognised and two important events were mentioned according to historical records: the first was the influence between gardens within and after the Crusader period and the second was Navagaro's letters and the impact of Islamic Andalusian gardens in Italian Renaissance gardens. Characteristic of Renaissance gardens with no links to Persian gardens are sculpture, topiary and grottoes. The relevant features are running water, particularly as it flows down the stone channels carved in banisters and steps descending on a slope. These impacts in the irrigation systems between gardens can be known as collisions between cultures. The collision between cultures may have occurred in different situations and periods. The initial collision started before the Renaissance, and from the eleventh century, after more than four centuries of hostility and total incomprehension, the Christian West had come into direct contact with the Islamic religion and Persian culture. The five most important moments of this rapprochement were:

1. The consequence of the conquests of Cotania in 1061 and Palermo in 1072 by the Normans, who started the birth of Sicily's Norman kingdom, which allowed the creation of a flourishing Islamic culture Normanna.[38]

[38] THEOTOKIS, G. (2010). The Norman Invasion of Sicily, 1061–1072: Numbers and Military Tactics. In: War in History, 17(4), p. 381–402. Retrieved April 24, 2021, p. 390, from http://www.jstor.org/stable/26070819.

2. The conquest, in 1085, by the Spaniards (of the Kingdom of Castile and Leon) of the city of Toledo, where the most famous centre of interpretation and translation was born, into Latin or Castilian, of classical, scientific, philosophical and theological texts, which had been preserved and transcribed in Arabic or Hebrew, then to be spread throughout Europe.[39]
3. The capture of Jerusalem by the Crusaders in 1099, who began the formation of the Latin states of the east, which despite the harshness of the military clashes, allowed the development of important centres of trade between east and west.[40]
4. The diffusion in southern France of the Arabic poetry of Spain.
5. The first translation of the Quran into Latin by Robert of Ketton, which took place between 1142 and 1143, which was commissioned by Peter the Venerable (1029–1156).

Therefore, cultural contact occurs when two or more cultures interact with one another through the creation of a form of exchange promulgated by the media, trade, travel, migration or conquest. This process, labelled as cultural diffusion, describes the spreading of the cultural and artistic attributes from one culture to another. Cultural diffusion normally exists in one of three forms: direct diffusion, forced diffusion and indirect diffusion. Direct diffusion occurs when two cultures are very close to each other (through trade, intermarriage etc.). Forced diffusion happens when one culture conquers or enslaves another and imposes its own customs. And finally, indirect diffusion occurs when traits are passed from one culture to another through intermediates, without the cultures involved in this mediated exchange ever being in direct contact. In exchanges between west and east, we can recognise this third kind of diffusion and "a new Renaissance period could be defined, that is the relation of Europe with the Islamic world, the Muslim Mediterranean and Persia",[41] which don't have clear chronological boundaries. There might be other impacts between these gardens other than irrigation systems, such as on planting techniques. Therefore, we cannot consider the Renaissance period as an isolated period. Since the construction of gardens has always been a sign of the power of governments throughout history, they were very quickly influenced by cultural developments, which, as it turned out, can be seen in the garden irrigation system. However, what is clear is that there may have been effects on irrigation systems other than those discussed in the article and because this is a piece of descriptive historical research, it needs to be completed over time. Future research could address other effects between Persian Safavid and Italian Renaissance gardens.

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