Out of Water Civilizations Emerge
Focus on Pre-Islamic Persian Empires

Festival of the Passing of the Ice Dragon

8 April 2017

Pentathlon Entry - Literary Arts

Research Paper

Abstract

Water or the lack of it has the power to create or destroy empires. From prehistory to the current time period this has been shown to be true. The civilizations who have been able to harness water, transport it and conserve it are the societies that have risen to power. The Persian Empires, from the earliest to the last, were masters of water husbandry. They developed an underground transport system called qanats that enabled them to become one of the greatest empires the world has ever seen. Not only has their knowledge of water transport enabled the irrigation of fields, it provided water for domestic purposes in their homes, to air-condition their homes and allowed the use of sewage systems which helped to keep disease at bay.

Out of Water Civilizations Emerge – Focus on Pre-Islamic Persian Empires

Water has controlled the rise and fall of great empires. Rome became a great power when it was able to harvest the water from the Mediterranean Sea, China's Golden Age developed after the completion of the 1100 mile long Grand Canal for transport of goods and irrigation. Domination of the oceans by the Vikings gave rise to their success.

Civilizations are driving by the way in which they respond to the challenges of their environment. Whenever water availability has been increased and managed, that civilization has thrived and grown (TOYNBEE 1946).

Whatever the era, the most preeminent societies have found ways in which to exploit their water resources in more productive ways than their neighbors. This exploitation of the water has always been a dynamic process. As the availability of water was increased, an abundance of crops grew, populations increased, and society expanded, until the water resources were utilized to the maximum. At that point new technologies would have to be developed to increase the water available, often altering the balance of power between civilizations (Solomon 2010).

The influence of nature on civilizations

The move towards agriculture from hunter-gatherers started about 12,500 BCE in the Fertile Crescent, as the climate warmed after the ice age. See figure 1

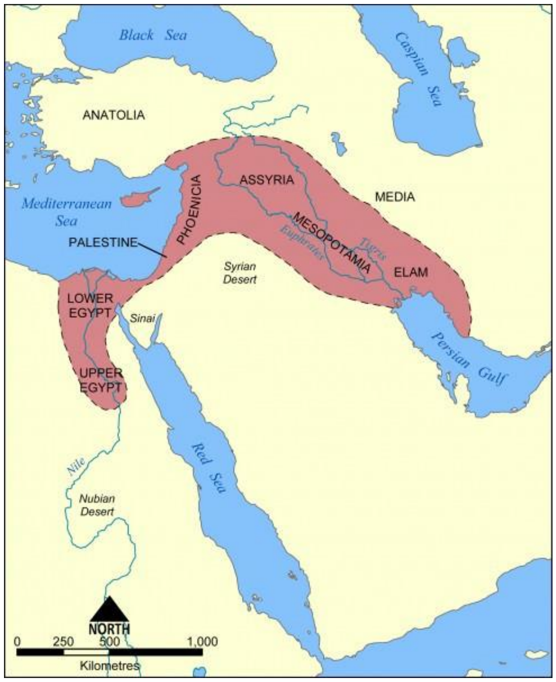

Figure 1 Fertile Crescent

Why did these early humans, the hunter-gathers, trade the relative easy life of hunting for the more labor intensive life of agriculture? This change occurred independently in separate parts of the world - the Middle East, for example, and the Americas. It is more than a coincidence. As the last ice age drew to a close it brought with it warmer climates that forced forests to move north and with them many of the animals that the hunters-gatherers depended on. Mammoths became extinct. Hunting became more difficult. At the same time in the new, warmer climate flora flourished. The more agreeable temperatures for humans to live in also provided enough plants that they did not have to travel and follow the herds. The transition from collecting the available plants, to planting and tending crops did not take long (Gascoigne 2001-current). As agriculture took over as the main source of food, human's dependence on water greatly expanded. See figure 2

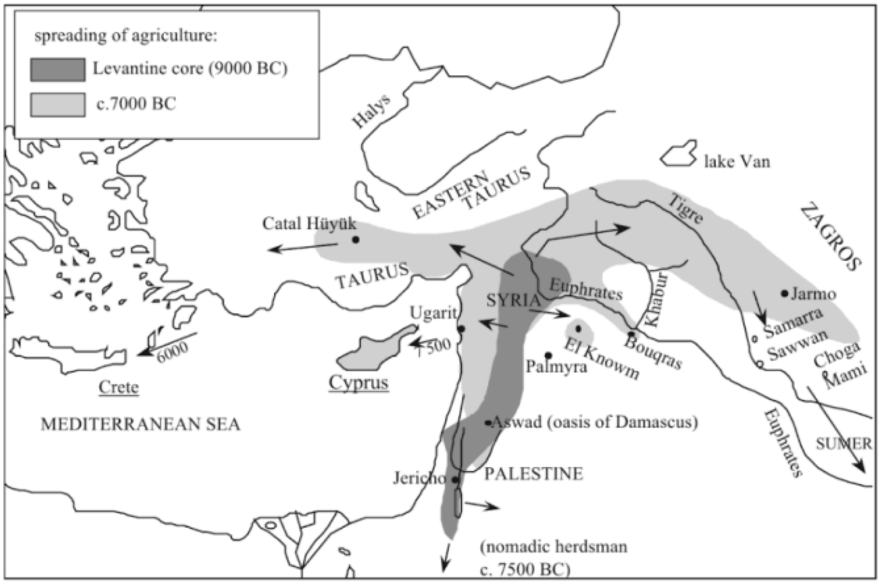

Figure 2 Spread of agriculture in the Fertile Crescent

It was not long before controlling the availability of water, and its transport, became a critical issue for cultures. As early as 1800 BCE King Hammurabi (1792-1750 BCE), sixth king of the First Dynasty of Babylon, had a system of canals made to provide water for farming. So important to their survival were these water canals, that strict laws were created. Hammurabi's famous "code" states;

> "if a man has been slacken maintaining (the bank of) his (field) and has not maintained (his) bank and when a breech has occurred in his (bank) and so he has let the waters carry away (the soil on) the water-land, the man on who's bank the breech has occurred shall replace the corn which he has (caused to be) lost." "If a man has released the waters and so has let the waters carry away the works of his neighbor's field he shall pay 10 ger of corn for every bur of land." (Ancient History Sourcebook: 1998).

While the decline of the ice age was clearly the driving force behind the change from hunter-gather to agriculture, and the manipulation of water was the force to develop larger, thriving communities, there is another natural force that controllers communities; periods of drought. Drought, too, contributes to the rise and fall of civilizations.

The first true exploitation of water occurred prior to Alexander the Great, (400 BCE to 331CE). As the Bronze Age ended and the Iron Age immerged, large migrations occurred, (1200 BCE). With these migrations into towns, came more demands for water. The earliest water management systems included short canals, reservoirs for storing water, saving rain water, shallow wells, underground cisterns and springs (Solomon 2010).

Achaemenid Empire (550 BCE-330 CE)

The Achaemenid Empire was established during this period of migration. Both the Achaemenids and Assyrians were conquerors attempting to unify the tribes of Mesopotamia and build larger empires. The Kassites of Iran gained control of Babylonia in 1531 BCE and then started a large scale irrigation system, the qanats, which allowed a vast expansion of agriculture, and created a thriving Persian territorial state.

The qanats were a relatively new technology, underground tunnels that transported water from the alluvial plains to towns in desert areas where previously crops could not be grown. The irrigated land produced a surplus of crops that could be used to support a large military that continued the expansion of the empire by force. Under the dynasty of the Achaemenid rulers the Persian Empire comprised Iran, Mesopotamia, Syria, Egypt, Asia Minor (with its Greek towns and some islands), Central Asia, Caucasus, Thrace and parts of India. See figure 3.

Figure 3 Achaemenid Empire (550 BCE-330 CE)

By building more qanats, and parceling out the now farmable land, they empire grew until the Achaemenid Empire control 20 nations at the apex of its power, ruled by 23 local governors, or satraps (Fagon 2011). The Achaemenid rulers provided a major incentive for qanat construction by allowing qanat builders and their heirs to retain profits from newly-built qanats for five generations. As a result, thousands of new settlements were established and others expanded. Qanats defined village life on the plateau by determining settlement location; by determining the layout of the city, and by requiring social cohesion in water allocation, water distribution, water use, and system maintenance.

The qanats established the rhythm of everyday life in plateau settlements, encompassing people’s firsthand involvement with the practical world, the world of values, and the world of goods (Buttimer 1976; Seamon 1979). Qanats became an important factor in determining where people lived. The largest towns were located at low elevations on the floors of intermontane basins and in broad river valleys. Most of these early settlements were defended by a fortress (qal’eh) whose water was drawn from hand-dug wells that reached down to shallow water tables. Qanats enabled these settlements to grow by tapping water rich aquifers, located deep beneath neighboring alluvial fans. Qanats carried water from the fans, below ground, for many kilometers to such settlements, providing the water necessary to irrigate more extensive fields and sustain larger urban populations. Even more dramatically, qanats made it possible to establish permanent settlements on the alluvial fans themselves.

Exceptional climate stability characterizes the centuries from the first century BCE through the second century CE (Malmquist 2015). Archeological evidence from Britain and ice core data from Greenland shows Alpine glaciers were retreating at this time. This period of stability allowed for the expansion of farmable land, the development of cities and the expansion of the empire.

With adequate food and water, society changed from subsistence to one of surplus. It was at this time that the arts grew and flourished. An extensive road system was established. The first postal system was established along these roads (a bit like the American Pony Express). Herodotus described the postal system in this way:

"It is said that as many days as there are in the whole journey, so many are the men and horses that stand along the road, each horse and man at the interval of a day's journey; and these are stayed neither by snow nor rain nor heat nor darkness from accomplishing their appointed course with all speed" (Noury 2010).

The Persian army in the Achaemenid period was massive. It was the might of this large military that allowed the empire to rule over such a large area. It is estimated the army was 150,000 warriors strong (including the "Immortals"). There were regiments of one thousand men called hazarabam. Ten hazarabam were a haivarabam (10,000 warriors). The infamous "Immortals" were a haivarabam dedicated to the protection of the king. Persian adult men were considered available for militarily training at the age of 20. Strabo (64 BCE), however puts the figure of military training and service at the age of 24. He further mentions how groups of such 50 men were often commanded by a chosen son of a noble. Even after they had served and were released, they were probably liable to be conscripted till the age of 50 (Eduljee 2013).

The Persian army maintained a uniformed appearance with near-identical regimental dress – a system which was unique in the ancient times. For example, the infantry wore the fluted hat, short cape over a shirt, pleated skirt and strapped shoes of the Elamite court dress, or the conical felt hat, tight-fitting tunic and trousers and boots of the Median cavalry suit (Shahbazi 2017). According to Xenophon, Cyrus made a habit of giving gifts of cloaks to his Persian nobles and even lower-ranked soldiers.

Plutarch mentioned how the royal couriers of the Achaemenid Empire had to dress in specific attires befitting their high ranks. Their attire was a soft felt cap, embroidered tunic with sleeves, a coat of mail looking which looked much like the scales of a fish, and trousers. They were well armed with wicker shields and quivers of cane arrows, short spears, bows. Short swords swung from belts by their sides (Chew 2003). The consistency of their uniforms and quality of their attire would intimidate their enemies.

These warriors, equipped with the best and most current armor, were funded by taxes, a direct result of the sales of the surplus crops made possible by the water brought by the qanats.

Along with the expansion of the empire, came the construction of many palaces. Achaemenid architecture was a blend of many elements. In describing, the construction of his palace at Susa, Darius says,

> "the cedar timber—a mountain by name Lebanon—from there it was brought . . . the yak(-timber was brought from Gandara and from Carmania. The gold was brought from Sardis and from Bactria . . . the precious stone lapis-lazuli and carnelian . . . was brought from Sogdiana. The . . . turquoise from Chorasmia . . . The silver and ebony . . . from Egypt . . . the ornamentation from Ionia . . . the ivory . . . from Ethiopia and from Sind and from Arachosia . . . The stone-cutters who wrought the stone, those were Ionians and Sardians. The goldsmiths . . . were Medes and Egyptians. The men who wrought the wood, those were Sardians and Egyptians. The men who wrought the baked brick, those were Babylonians. The men who adorned the wall, those were Medes and Egyptians." (Young 2017).

Their metal working, glass and textiles are well known throughout the word. Not just the arts flourished, education too was considered important and nurtured. There were vast libraries, universities and teaching hospitals where surgery with anesthetics was performed and septic treatment of wounds was standard practice. It was the

Persians who established the fundamentals of anatomy, physiology and pathology, long before the Greeks (Shoja 2007).

In 331 AD the empire fell to Alexander the Great. Part of the cause of the Empire's decline has been attributed to the heavy tax burden put upon the state, which eventually led to economic decline (Olmstead 1948)., That coupled with a lack of adhesion between the spread out territories weakened the empire considerably.

Volcanic winters, however, peaked during the third, centuries CE and solar activity indicates a cooling episode about 260 CE (McCormick Autumn, 2012). These two events led to drought conditions. See figure 4.

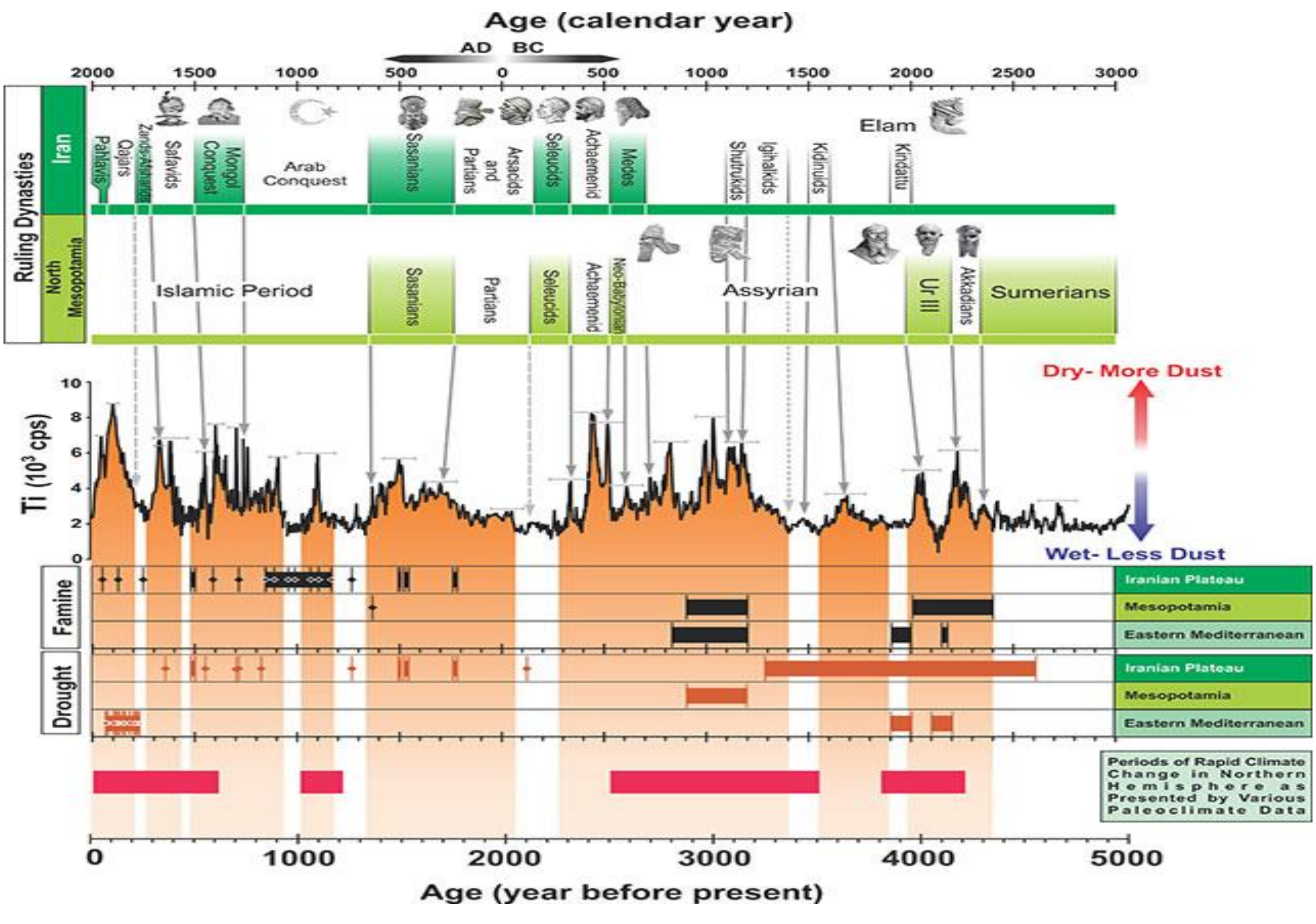

Figure 4 Drought and famine in the near East

There are “links” between drought and the fall of Fertile Crescent empires as far back as 4,200 years ago” (Malmquist 2015). It is very likely these drought conditions helped to destabilize the government (fewer crops, less taxes, less money to maintain the military) and weakened the army, contributing to the empire’s downfall.

A study published in *Quaternary Science Reviews*, used tracers from sediment cores from northwestern Iran to create a history of the precipitation in the that part of Iran back to the end of the last ice age 13,000 years ago.

> “The high-resolution nature of this record afforded us the rare opportunity to examine the influence of abrupt climate change on early human societies. We see that transitions in several major civilizations across this region, as evidenced by the available historical and archeological records, coincided with episodes of high atmospheric dust; higher fluxes of dust are attributed to drier conditions across the region over the last 5,000 years,” said Arash Sharifi, Ph.D. candidate at the department of marine geosciences and the lead author of the study (Udell 2015).

This research shows the fall of the Akkadian Empire (4,200 years ago) coincided with an episode of exceptionally high windblown dust in the Arabian Sea that would occur from a drought. Dust layers also coincided with the collapse of the Ur III empire (3,955 years ago), the Elam empire (2,800 years ago), and the Medes empire (2,500 years ago), as well as the demise of the Achaemenids (2,280 years ago), the Parthians (1,730 years ago), the Sasanians (1,300 years ago) and the Safavids (950 years ago) (Malmquist 2015) .

After the fall, Persia was under Greek rule for about 80 years. Following Alexander the Great's death, three main dynasties merged: the Antigonids (Asia Minor and Greece); the Ptolemies (Egypt); and the Selecuids, (present-day Lebanon towards Persia). The eastern part of the Seleucuid Empire broke off to become the Parthian Empire. The Selecuids Empire was completely absorbed by the Parthian Empire in the 2nd century B.C. (Hayes 2013) .

The Parthians controlled the peasants by use of military force. Their success in this allowed the nobles to resist and then then defy the king, refusing to pay levies and failing to answer the call to arms. This undermined their power causing disorganization and fragmentation of the empire.

The Sassanian Empire 224 CE to 651 CE

In A.D. 224, Ardashir, a Parthian governor in a province of Persis (Fars), overthrew the Parthian government and established the Sasanid Empire which would rule Iran until the Islamic conquest in A.D. 641. The Sasanid Empire focused its efforts on irrigation projects, particularly in Mesopotamia. More efficient irrigation meant an increase in agriculture production. An increase in agriculture production meant an increase in tax collection. This increase in taxes paid for increasing the military and the expansion of the Persian Empire. The Sasanians focused much on centralizing control of irrigation, not for the sake of water itself, but for the political and economic power afforded by water control (Montakab 2-13).

Xyzestan and Iraq were two provinces that were extremely fertile and many crops were grown and exported making them the areas with the highest tax income for the government, which allowed for more qanats to be build. There was an immense expansion in the construction and distribution of qanats. The building of the qanats also brought about more urbanization. These urban areas attracted immigrants and the towns grew. Textiles, glass and metalwork increased in these towns again providing taxes to the government. Roads were added for trade, as were shipping ports (Daryaee 2010). Sasanian competition for trade with the Byzantines created constant conflict with them over access and control of the “silk road”. The Sassanid Empire rapidly grew. The military was also expanded and new territory added; new towns and beautiful palaces were built. Afghanistan was conquered, and access to the “Silk Road was assured resulting in expanded trade with China. See figure 5.

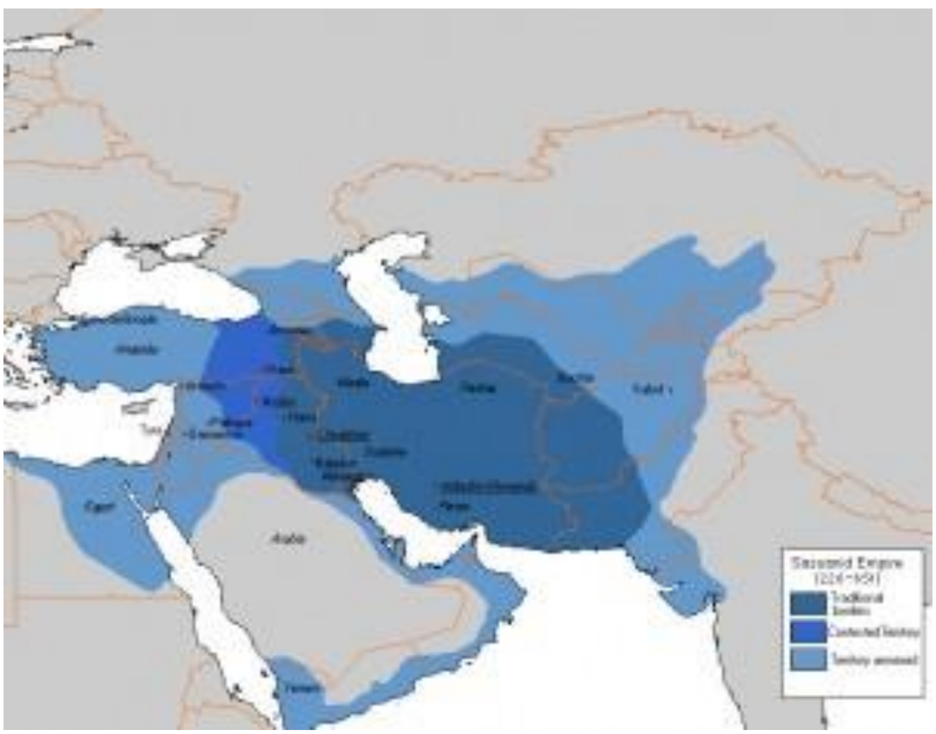

Figure 5 Sasanid Empire at its peak

The ownership of the qanats was more important than the ownership of land. During the Sasanian era, canal building was a profitable business, towards the end of the dynasty, Sasanian kings encouraged wealthy families to invest in irrigation technology. Nowhere is this more evident than in the Book of a Thousand Judgements. It is one of the most important surviving legal sources from the Sasanian period. The Law Book is a compilation of legal cases, composed during the reign of Xusro I. These Sasanian laws derived their legitimacy from the Zoroastrian Avesta. The Law Book shows the high level of centralization that existed at the time of Xusro I. There are laws that directly affect Sasanian irrigation management. Chapter Thirty-Four particularly concerns a legal case regarding water; this case occurs in Mesopotamia and concerns partners sharing irrigation sources (Anahit 1980).

The expansion of the empire worried Rome, and there was much conflict between them. Over time the Sassanians lost lands, but then during the reign of Shapur II (r 310-379) the empire flourished again and regained its lost lands. With this expansion came attacks from Roma, and once again the empire shrank. King Khusrau I (r 351-379) was able to reestablish the vast empire, regain lost lands and added new ones. Following his death though, there were internal revolts and with generals and relatives of the king vying for power. The last 72 years of the Empire saw the Sassians go through 17 kings. That is an average of 4 years on the throne.

Most of these kings died of assassinations. This left a very unstable government. Constant wars with the Byzantines over trade further weakened the Sassanid Empire leaving it open to attack by Arab forces united under Islam. The last Sassanian king, Yazdgard III died in 651.

During the period of the Sassanid Empires, the climate was good with adequate rainfall. However, a drought was occurring during its last years. If this had an impact on the fall of the empire, it is not known, but it is an interesting co-incidence.

Qanats and water management of the Persians

The Iranian Empires of history covered vast areas, a large part of it dry and windblown deserts. For much of prehistory and into the recorded past, the weather dominated society. Empires fell as a result of droughts in these desert regions.

The Persians, however, were able to conquer the problem of water better than their neighbors, which led to their relative success in the deserts over other cultures. The pre-Achaemenid Persians are credited with developing tunnel wells, called *Kariz* in Persian, and *qanat* in Arabic, that then spread to Egypt, the Levant, and Arabia. The Arabians in turn, carried these to North Africa, Spain and Cyprus. They are also found in Central Asia, western and China (Ward 1968). Their elopement and use of the qanats is well established. See figure 5.

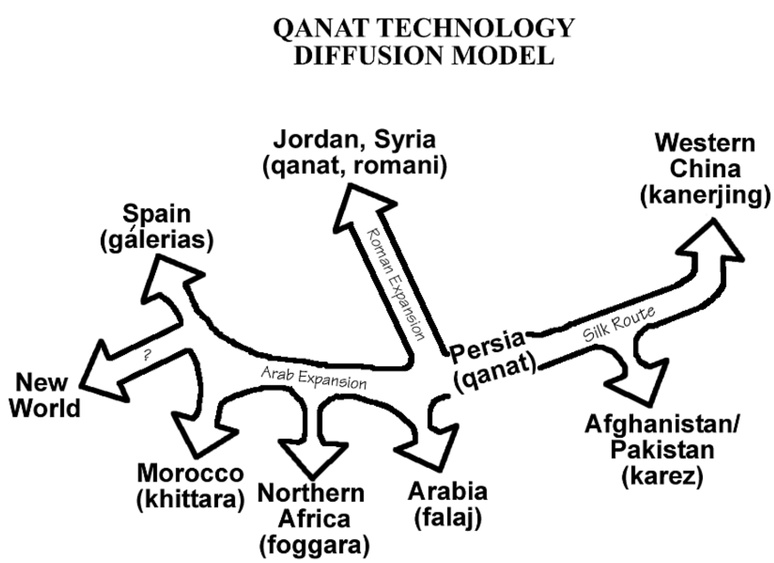

Figure 5 Distribution of early qanats

As early as the 7th century BCE, the Assyrian king Sargon II reported that during a campaign in Persia he had found an underground system for tapping water. His son, King Sennacherib, applied the "secret" of using underground conduits in building an irrigation system around Nineveh (K. T. Bowser 2004)

Vitruvius, the first systematic historian of technology, gave an account of the Qanat system in technical detail in his historic work *De Architectura* (about 80 BCE). Another source of this information comes from the ninth century CE Persian provincial governor, Abdullah ibn-Tahir, who ordered a group of writers to compiled a treatise on qanats, the subject titled *Kitab-e Quniy*. Furthermore, about 1000 CE Hasan al-Hasib, an Arabian authority on engineering, wrote a technical work that is still available and gives surprisingly good details of the construction and maintenance of the ancient qanats (Wulff 1968).

Qanats are dug nearly horizontally into an alluvial fan until the water table is reached. The ground water slowly flows into the underground channel, then runs down its slope, and eventually emerges at the surface as a stream. To create this horizontal tunnel, vertical shafts are dug down every 50 to 150 meters leaving a chain of wells across the landscape (Ward 1968). At the base of these verticle shafts tunnes are dug in either direction, to reach the next shaft, thus the long underground tunnerl is developed. See figure 6.

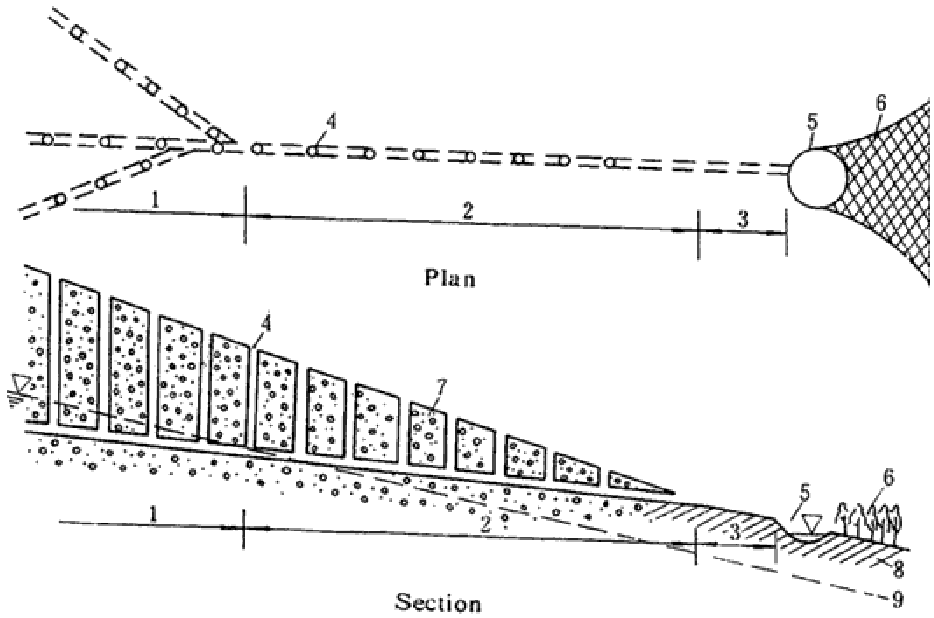

Figure 6 General Schematic for a Qanat.

(1) Infiltration part of the tunnel

(2) Water conveyance part of the tunnel

(3) Open channel

(4) Vertical shafts

(5) Small storage pond

(6) Irrigation area

(7) Sand and gravel

(8) Layers of soil

(9) Groundwater surface

Qanat's use no energy to move the water, relying on only gravity, the also have a minimum of evaporation since the water is underground, and they water source is not exhausted, if the aquifer is well maintained, lasting for centuries. The canals can be hundreds of kilometers long, and the wells up to 300 meters deep.

A winch is set up at the surface and a vertical shaft about meter in diameter is dug, just wide enough for a man to enter. The excavated soil is hauled up in buckets. This soil is mounded around the entrance to the shaft so that it will prevent rain water and runoff from letting pollutants into the water below. About 30-150 meters away (depending on the geology of the area) a similar shaft is built. Then the two are connected by tunneling towards each other. In this way long distances are covered (Kowsar 2012).

A gently sloping tunnel is thus constructed which transports water from groundwater wells to the surface some distance away. In firm soil there is nothing lining to the tunnels, but in loose soil the tunnel is reinforced with clay rings. These tunnels must be cleaned periodically to remove dirt and minerals. The rate of flow of water in a qanat is controlled by the level of the underground water table. The slope if the tunnel varies from .1% to 0 .3%. If it is too steep, turbulence can erode the tunnel and require constant repairs, if it is not steep enough the water can get backed up by sentiment that settles in the tunnel (Khaneiki 2017).

Water flows continuously in a qanat, but during the spring and summer there is a need for more water than at other times of the year. The continuous flow of the water is controlled to maximize the water needed during the growing seasons. During fall and winter, gates can seal off the qanat opening, damming up and conserving groundwater. In spring and summer, night flow may be stored in small reservoirs at the mouth of the qanat and held there for daytime use (K. T. Bowser 2004).

Qanats have been so success that even today there are about 32,000 Qanats in Iran which provide about 10 Billion MCM water per year (Gharari 2010).

In the Persepolis (Achaemenid Empire) water was transported to the area via the qanats, as it reached the city, the clean water was made available to the entire city by wells leading down to the water level. From there it flowed downstream, southeast where it was eventually used for irrigation. At the point where the water enters the city there are large public cisterns, these cisterns are often encased in tile. In the more modest parts of town there are smaller cisterns and channels that run along the streets or under houses. See figure 7.

Figure 7 Entrance canal on the north side of the city

There was a 60 meter deep reservoir on the south side of town to capture the water as it reached that area. There was also a built-in contingency in case of flooding. Channels would drain any overflow away from buildings to the western plains. See figure 8.

Figure 8 Persepolis with the reservoir

Within the palace were five zones –corresponding to buildings. Water from roofs would flow through small holes in columns to channels underground where it would join other draining water and be directed away from the city (al 2009).

Where tunnels run beneath houses, water is accessible inside on the lowest level of the home for various uses. These were usually the homes of the more prosperous members of the city. The wealthier families lived on higher ground, where the qanat would first enter the city so their water was the freshest; from there it would run to the less prosperous areas, then it would travel to the poor areas, where it would only be available in channels on the streets. Lastly the water would enter the reservoir on the lowest level of the town where it would be used for the irrigation of crops. In the wealthiest homes were pools to bath in and clean clothing, as well as providing water for drinking and cooking.

While the poor did not get the freshest water, it was still relatively clean. Unlike the European medieval period, early civilizations took great pains to have drainage systems for sewage. The earliest system was found in 6500 BCE in Habuba Kebira, plaster lined gutters that ran under doorways and holes in the wall to exit away from towns. Similar systems are found in El-Kowm (current Syria), Mari (Pakistan) and Crete (Greece) (Viollet 2007). See figure 9

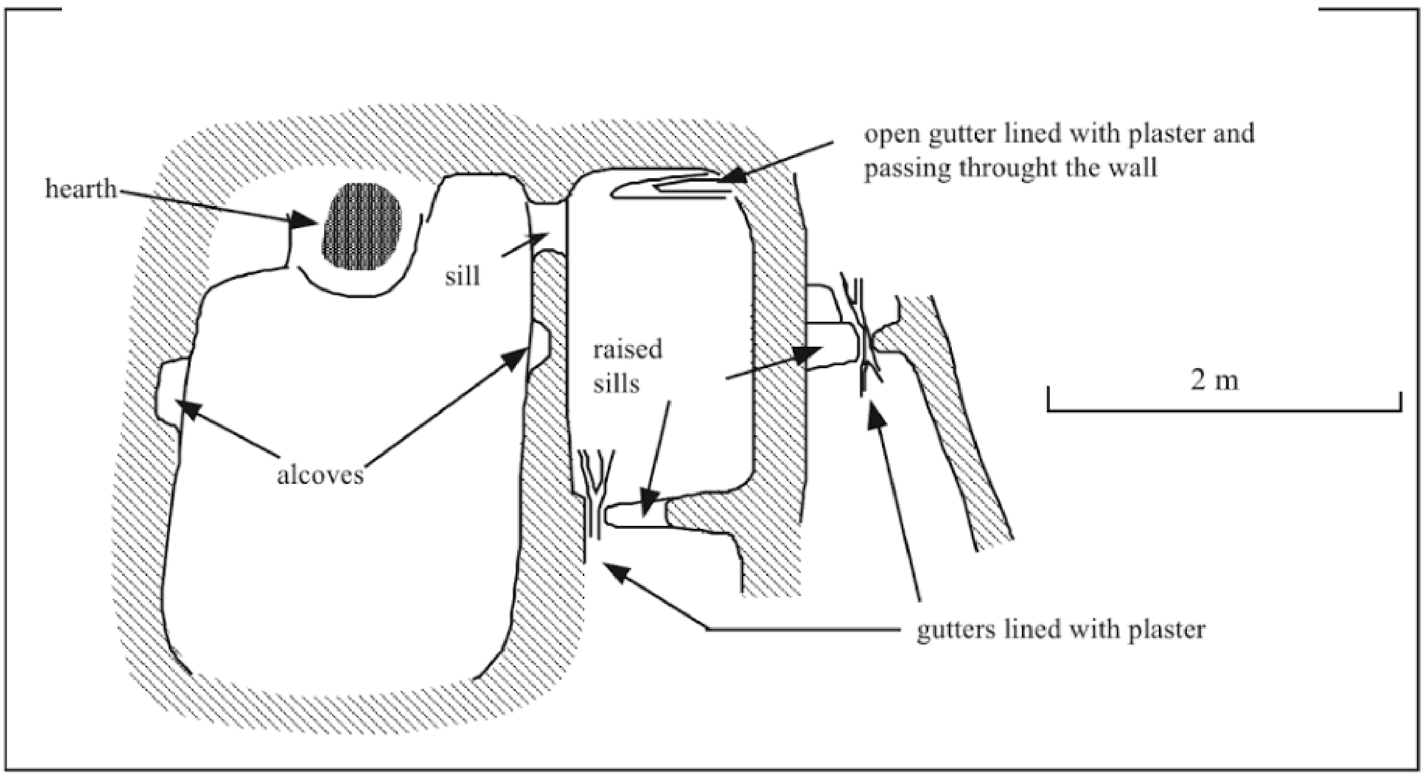

Figure 9 El-Kowm, oldest know sewage system, 6,500 BCE

A few well known quants today include the Vazvan Qanat (Central Plateau of Iran, in Isfahan province), the Kish Qanat (Kish Island, south of Iran), Mun Qanat, Ardestan (Mun in city of Ardestan). Fin Garden Qanat (central desert of Iran). See figure 10.

Figure 10 The Vazvan Qanat dams that control the flow of water during agricultural season

Kish Qanat has been rebuilt as a museum to show the incredible fresh water the city enjoyed for over 2000 years at this location. See figure 11.

Figure 11 the Kish Qanat tunnels, rebuilt

Fin Garden Qanat City of Kashan, in the desert. This city has one of the most famous gardens in Iran, named Fin Garden. This garden is irrigated by the use of water from a Qanat. See figure 12.

Figure 12 Fin Garden as it could have looked 2000 years ago

In wealthy homes, special rooms are constructed beside the underground stream with tall shafts reaching upward to wind towers above roof level. Air caught by the wind towers, is forced down the shaft, circulates over the water (K. T. Bowser 2004). See figure 13.

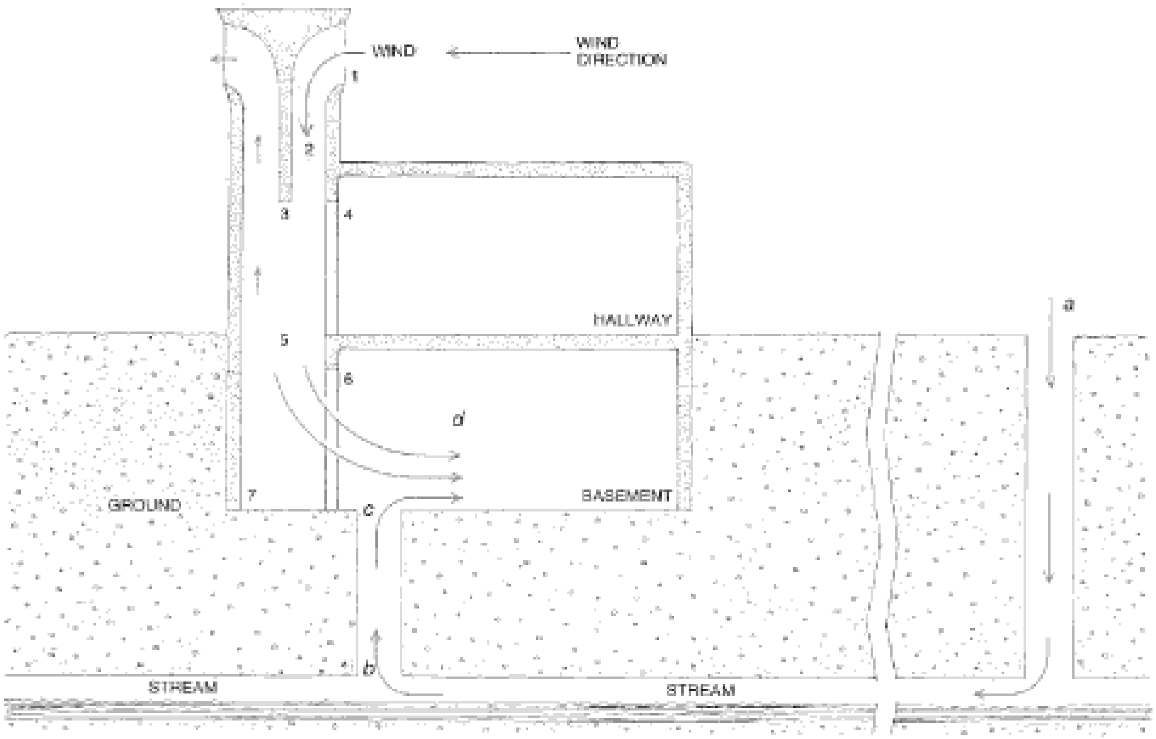

Figure 13 The air flow in a combination wind tower/qanat cooling system (from Scientific American).

"Hot dry air enters the qanat through one of its vertical shafts (a) and is cooled as it flows along the water, the rate of cooling is quite high since the water is usually quite cool. The wind tower is placed so that wind flowing through the basement door of the tower passes over the top of the qanat tunnel. As the air flows from the large passage (the tunnel) through the smaller one (the door), its pressure decreases. The pressure of the air from the tower is still diminished when it passes over the top of the tunnel, so that cold moist air from the shaft is drawn along by the flow of cooled air from the tower (c). The mixture of air from the qanat and air from the tower (d) circulates through the basement" (Wulff 1968).

Even today, as much as one third to one half of the irrigated fields and orchards on the plateau–an estimated 15 million acres–are still watered by qanats. Cities like Tehran, Qum, Qazvin, Hamadan, Nishapur, Yazd, and Kirman received virtually all of their water from tunnel-wells until deep wells were introduced after World War II. In the 1960s, an estimated 21,000 qanats were still functioning in plateau settlements with an additional 17,500 used but in need of repair (Ghahraman l958). Their aggregate length has been placed at more than 160,000 kilometers, and their total discharge at 20,000 cubic meters per second (Goblot l962).

Agriculture was the economic foundation of Persian society. Barley and wheat were cultivated, along with various vegetables and fruits such as peas, lentils, onions, dates, apples, pears, and apricots. Beer and wine were common beverages. Agricultural surpluses were needed to support the army (Hanson 2017),

More recently in Iran, a hereditary class of professional qanat diggers called muqannis build and repair these systems. These specialists travel from place to place on the Iranian plateau, for example, working at one settlement where a flash flood has damaged a qanat, and then moving on to another where a lowered water table requires that a qanat tunnel be extended deeper into the alluvium. The most famous muqannis come from the desert city of Yazd. They are paid high wages, and command respect. Unfortunately few young people want to learn this trade and the Persian qanats are in danger of falling into ruins.

Works Cited

Anahit, Perikhanian. *The Book of A Thousand Judgements.* Translated by Nina Garsoian. New York: Mazda Publishers, 1980.

King, L. W., ed. *Ancient History Sourcebook:.* Fordham University. 3 1998. http://sourcebooks.fordham.edu/halsall/ancient/hamcode.asp (accessed 3 9, 2017).

Bowser, Edward et al. *Qanats.* 10 12, 2004. http://www.waterhistory.org/histories/qanats/ (accessed 5 1, 2016).

Bowser, Karaji, Thompson, Wittfogel. *Qanats.* 10 12, 2004. http://www.waterhistory.org/histories/qanats/ (accessed 1 17, 3).

Chew, Sekunda and. *The Persian Army 560–330 BC (Elite.* Oxford: Osprey Publishing, 2003.

Daryaee. *Sasanian Persia: The Rise and Fall of an Empire.* New York: Macmillan, 2010.

de Suza, Philip. *The Greek and Persian Wars 499-386 BC (Essential Histories) .* New York: Osprey Publishing, 2012.

Eduljee, Author: K. E. *Zoroastrian Heritage.* 2013. http://www.heritageinstitute.com/zoroastrianism/reference/strabo.htm (accessed 2 22, 2017).

English, Paul. *Qanats and Lifeworlds in Iranian Plateau Villages.* Hartford: □□□□, n.d.

Fagon, Brian. *Elixir: A History of Water and Humankind.* Bloomsbury Publishing, 2011.

Gascoigne, Bamber. *HUNTER-GATHERERS TO FARMERS.* 2001-current. http://www.historyworld.net/wrldhis/PlainTextHistories.asp?ParagraphID=ayh (accessed 3 4, 2017).

Gharari, Alemohammad and. *Qanat: An Ancient Invention for Water Management in Iran.* 2010. http://hamed.mit.edu/sites/default/files/Qanat_WHC_2010.pdf (accessed 1 39, 2017).

Hanson, David. *Persian Empire.* Virginia Western college. 3 1, 2017. https://sites.google.com/a/email.vccs.edu/hanson-history/history-111/lectures/04-persian-empire (accessed 3 9, 2017).

Hayes, Jeffery. *PERSIA, ALEXANDER THE GREAT AND AFTER ALEXANDER.* 2013. http://factsanddetails.com/world/cat56/sub371/item1978.html (accessed 12 1, 1-16).

Khaneiki, Yazdi and. *Qanat Knowledge: Construction and Maintenance.* Springer, 2017.

Kowsar, Kowsarand. "Karaji: Mathematician and Qanat Master." *Ground Water*, 2012: 812-817.

Malmquist, David. *Study of past Mideast climate links drought and empire.* William and Mary. 9 23, 2015. http://www.wm.edu/news/stories/2015/study-of-past-mideast-climate-links-drought-and-empire221.php (accessed 8 12, 2016).

McCormick, Michael et al. "Climate Change during and after the Roman." *Journal of Interdisciplinary History*, Autumn, 2012: 169–220.

Montakab, Sophia. *Irrigation Management in Ancient.* Graduate paper, Irvine: Department of History, University of California, 2-13.

Moradi-Jalal et al. *Ancient Water Technologies.* Edited by L. Mays. Tempe: Arizona State University, 2009.

Noury, M. Saadat. *First Iranians who founded the First System of Postal Services.* 4 15, 2010. https://iranian.com/main/blog/m-saadat-noury/first-iranians-who-founded-first-system-postal-services.html (accessed 3 9, 2017).

Olmstead, A. T. *History of the Persian Empire.* Chicago: University of Chicago Press, 1948.

Persian Warriors. 3 1, 2017. http://www.legendsandchronicles.com/ancient-warriors/persian-warriors/ (accessed 3 2, 3017).

Shahbazi, A. Sh. *History of Iran.* 2017. http://www.iranchamber.com/history/achaemenids/achaemenid_army.php (accessed 3 8, 2017).

Shoja, Mohammadali M and R Tubbs, Shane. "The history of anatomy in Persia." *Journal of Anatomy*, 2007: 359–378.

Solomon, Steve. *Wate: The Epic Struggle for Wealth, Power, and Civilization.* New York: Harper, 2010.

TOYNBEE, ARNOLD J. *A Study of History.* London: Oxford University Press, 1946.

Udell, Diana. *Study Finds Abrupt Climate Change May Have Rocked the Cradle of Civilization.* 7 23, 2015. http://www.rsmas.miami.edu/news-events/press-releases/2015/study-finds-abrupt-climate-change-may-have-rocked-the-cradle-of-civilizatio (accessed 1 30, 2017).

Viollet, Pierre-Louis. *Water Engineering in Ancient Civilizations: 5,000 Years of History.* Boca aton: Tayler and Francis Group, 2007.

Ward, Paul. "The Origin and Spread of Qanats in the Old World." *Proceedings of the American Philosophical Society*, 1968: 170-181.

Wulff. "The Qanats of Iran, H. E." *Scientific American*, 1968: 94 - 105.

Wulff, H.E. "The Qanats of Iran." *Scientific American*, 1968: 94-105.

Young, Jr., T. Cuyler. *Achaemenid Society and Culture.* 2 4, 2017. http://www.iranchamber.com/history/articles/achaemenid_society_culture.php (accessed 3 11, 2017).