Factors Affecting the Qajar-Era Fort Settlements in Iran's Sistan Region Due to Hydrographic Changes in the Hirmand River

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Abstract

Locating fort settlements in Iran's Sistan region during different historical periods have always been associated with changes in the direction of Hirmand River which often occurred due to various natural and human factors. One of the most important determining factors in locating the aforementioned settlements is changes in hydrographic network. This study aims to identify the relation between the Iranian province of Sistan hydrographic networks and the fort settlement during the Qajar era. The research method applied, here, is descriptive-analytical, historical-comparative, documentary, library and the field study in Iran's Sistan area. The main focus of the study is on the issue of changes in the hydrographic network of the Hirmand River. The main question is to what extent have the changes in the direction of the hydrographic network of Hirmand played a role in locating fort settlements of the Qajar era in Iran's Sistan region. Records, documents, data and historical information related to the Qajar era were collected and comprehensively compared and analyzed regarding the current and the past situations in the geographic information system (GIS) using ArcGIS software. The results show that the highest number of the locating and the density of fort settlements during Qajar are related to the hydrographic basin of the Sistanriver. The main reason is branching of the Hirmand River's Hydrographic Basin through the Sistan Canal or Sistan River in the west. Also from 6 to 12 AH, in both the northern and southern delta region of Sistan, there have been settlement areas. However, in the Qajar era, 100 percent of the settlements in the northern delta area have been site selected.

Keywords: Iran’s Sistan; Hirmand River; Historical Maps; Qajar Era; Fort Settlements.

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Introduction

Life in Sistan has always been highly dependent on the Hirmand River and its branched networks. In other words, this river and its tributaries were the main source of water and hence, the human settlemnets. Changes in the location of villages and population centers and even local rulers could be made largely due to the flow of the river, its inundation cauing floods, or the lack of water leading to drought. Archaeological evidence of human settlement of previous periods implies that the redirection of the Hirmand River and its tributaries led to the destruction of the hydrographic network. Continuous deposition, the low elevation of the land and high volatility caused a more severe redirect comparing to other parts of Iran. Accordingly, the redirection of the Hirmand hydrographic network also probably played an important role in the site selection for fort settlements in the Qajar era. The current paper tries to identify the relevance and impact of changes in the hydrographic network of Hirmand for locating fort settlements in the Qajar era. By identifying Hirmand hydrographic network during the past three centuries, according to historical records, documents and evidences from ages 5 and 6 AH of Islamic era to the Qajar period, a sort of convergence with the hydrographic network and thus changes in the location of fort settlements can be studied. Based on the purpose of the research, the main research question is posed as: To what extent the track changes in the hydrographic network of Hirmand have impacted the fort settlements of Iran's Sistan region during the Qajar period? Accordingly, the hypothesis is proposed as follows: The Hirmand hydrographic network route changes (from the south delta to the north) have been the most significant factor in the fort settlements during the Qajar period in Iran’s Sistan region.

Binandeh*et al.* did a research in the North-West of the Little Zab River Basin (northwest highlands of Piranshahr) and showed the river’s basin has numerous archaeological sites. The basin due to the proximity to the river Zab, has been more conducive to the establishment of the Neolithic Age (Binandeh*et al*., 2012: 27). MousaviKuhpar*et al*., knew appropriate environmental factors effective in shaping human habitats in different historical periods of the Mazandaran province. They examined the distribution of human settlements with variables of height, waters flowing, distance and proximity to rivers (MousaviKuhpar*et al.*, 2011:1). By identifying archaeological sites belonging to the pre-historic, historic and Islamic periods, Mousavi and Makvandi showed that life and its continuity depends directly on the river of Shileh (Mousavi Haji and Makvandi, 2010:1). Bahrami*et al*., in a research on the historical district of Pasargadae, discovered an ancient lake bed at the mouth of the Bolaghi Valley and determined the course of the river bed in the desert during the Achaemenid period. (Bahrami*et al*., 2007:131). Mehrafarin and Syed Sajjadi studied the role of hydrology in the formation and destruction of various civilizations of Sistan (Mehrafarin and Sajjadi, 2005:217). Ebrahimzadeh*et al*, studied the effect of geology on the redirect of the Hirmand River and its historic role in the displacement of settlements in Sistan and showed that human factors, strong winds and the soil divergence phenomenon have been the most effective ones in the movement of Hirmand (Ebrahim-Zadeh*et al*., 2004:5).

By examining travelogues and historical accounts of Hirmand routes, Karimiyan Iqbal and AshtaryMehrjardi studied the status of water management during droughts and floods in over the past two centuries (Iqbal and Mehrjardi, 2001:422). By examining some of the historical writings and by matching the location of archaeological sites with today's identified areas, Sajjadi studied Sistan region's most important water resources (Sajjadi, 1997:8). As relevant domestic and international records show, the Hirmand River and its hydrographic network radiating from the Sistan, have always have been of the interest of researchers and academic as well as administrative centers such that the importance, special features and unique aspects of civilization have always been pointed out.

Literature Review

Numerous studies have been conducted regarding the relation between hydrographic networks and ancient settlements all around the world. Some of them are mentioned as follows: Feo*et al*, with a research in the field of water management and wastewater technologies in the ancient Greek and Roman civilizations showed that ancient technologies in the field of aqueducts, cisterns, water reservoirs, water distribution systems, and drainage and sewage were amazing in these civilizations (Feo*et. al*., 2016:3-22). Macklin and Lewin conducted a research on river civilizations, which represents the impact of climate change and waterways, canals and rivers in settlements in floodplains. They also studied changes in the hydrological systems with examples from the Nile River in Egypt, Ethiopia and Mesopotamia (Macklin and Lewin, 2015: 228-244). They suggested a new model in the dynamics of climate in the Nile River hydro systems and human solutions in ancient times. The results of field observations and numerous experiments showed that sediments and changes of the Nile River were due to hydrological regimes and geomorphologic changes during different periods (Macklin *et al.*, 2015:109-123). Wu *et al*. reviewed landscape and archeological environmental changes in China's Yangtze River valley. In this international project, they studied human interaction with the earth, ancient plants and water level changes, especially regarding the rise and fall of past civilizations according to their environmental changes (Wu *et. al*, 2012:875-892). Philip Graham studied the effect of weather, climate and environment in human life and civilization of the Jordan Valley (Philip, 2012:162-164). Najafi and Vatanfada studied the challenges to water borders and wetlands in Iran and Afghanistan Hirmand over the past decades based on the level of water used in agriculture, urban and industrial projects. Harrower, using the geographic information system, satellite imagery and analysis, tried to present a model for the flow of water in the ancient land of Yemen (Harrower, 2010: PP. 1447-1452). Delforouz examined the role of natural phenomena in the rise and fall of ancient urban areas in Iran's Sistan (South Delta), based on the characteristics of water resources, especially along the Hirmand River (Delforooz, 2010: 221-241). Whitehead *et al* used the Monte Carlo method to model hydrologic levels and potential population in the Bronze Age in the north of Jordan and simulation capabilities. (Whitehead *et. al*., 2008: 517-529). Cheng *et al.* studied the Mesolithic period in Europe, to recreate the housing situation of people around the Shotton River based on the earth seismic data (Geo-Seismic) (Ch'ng*et. al*., 2004:1-9). Laurenza and Pornet-Laurenza, examined the fluctuations in the value curves (contour) of theHirmand River of the Hamon Lake over the past one hundred years, using the geographic information system capabilities for archeological data recovery of Iran's Sistan (Laurenza and Pornet-Laurenza, 2001:85-91). Maghsoudi*et al*, investigating the impact of natural factors (geomorphology, topography and water resources) in the formation of archaeological sites of Silakhor plain in Lorestan province, in three historical periods showed that archaeological sites were formed due to the flat topography and adequate water resources (Maghsoudi*et al*., 2014: 171). Bahramnia*et al*., with a review of environmental factors and their role in the formation of human settlements in the Neolithic and Chalcolithic periods in the city of Ardal in ChaharMahalBakhtiari, Iran, evaluated the impact of environmental factors on these settlements due to the altitude above sea level, percentage and slope, and the distance from the river using statistical methods (Bahrami Nia *et al*., 2013:21). Maghsoudi and colleagues attempted to determine the role of the Shadchaay River in locating the prehistoric hill of Meymoun-Abad and benefiting from archeological analysis and sampling, showed that in the past a branch of the river had another path (Maghsoudi*et al*., 2013: 145). Heydariyan examined environmental factors and their role in spatial shaping of the pre-historic settlements in the Neolithic, Chalcolithic, Bronze and Iron prairie periods in Songhor plain (Heydariyan, 2013:139).

Research Theory Bases

There are several theories about the cause or locating residential centers which in general, are the result of conditions and characteristics of the geographical environment (natural and human) areas.

In the past, natural factors and mainly water played a decisive role in settlements. So the existence of the world's great civilizations (such as Egypt and Sumer) in the vicinity of the giant waterways and Nile, Euphrates and Tigris can be considered a key factor in the development of ancient cities. VujicanYevjevich believes that the status of any civilization can be measured by its water-related infrastructure in proportion to its whole infrastructure. Each civilization can be a collection of different infrastructure (political, cultural, economic, communication, management, etc.). Water makes up a large portion of the infrastructure and has had a great influence on its growth and development. The water resources technology has had an effective phenomenon in the ancient civilizations of Babylon, Egypt, Hittites, Greece and Rome, China, Mesopotamia and Iran. As a result of this development, flood plains and irrigation settlements along the great rivers were formed. Harold Carter believes that water is the primary source of formation of settlements and then the rapid population growth, centralization; creating monuments and social stratification have provided subsequent developments. Michael Bonine knows water channels and topography as the determining factors in the context of cities of Iran (Yazdi and Sanajerdy, 2003: 68-69).

Based on the hydraulic theory in the development of settlements and irrigated arable land, increasing population density in the favorable natural areas have been major factors in forming the first settlements in Iran with relatively good water and soil. This is to the extent that we can say that the natural environment, even in the form of physical settlements are affected by these factors and have led to the formation of integrated settlements in most regions of the country. According to Toulon, natural factors affecting the population density and settlements are: climate, vegetation, water resources, rugged topography (height and tilt) and the much more (Mousavi et al., 2011:3). Archaeologists have long been using the position of archaeological sites in the surrounding natural landscape to study economic systems. Ancient people paid attention to important factors such as access to land, water, marine resources and minerals in choosing their homes (Dark Ken, 2000:164).

Today, this theory has been accepted that "water" is the main cause of the rise of civilization on Earth and it is also quite clear that due to the human need to fresh water he has had to live near rivers and springs. As a result, the population density along streams and rivers and the need for inclusive social life and other considerations that human has laid civilizations in different societies (Mostafavi, 1982: 53-54).

Various geographical factors were involved in the locating and distribution of human settlements. For centuries, decision on the choice of settlements has been due to a variety of reasons. In other words, the formation of settlements has been in relation to various factors such as geomorphology, landform and access to water resources. The primitive humans chose the best place to live with an overview of the area and by identifying environmental features (Maghsoudi*et al*., 2014: 172). In Sistan, the life is dependent on the "Hirmand River Flow". Residents of the area due to a loss of precipitation and groundwater have no dependence to these phenomena. On the other hand, due to dense sedimentary particles, no groundwater trip in the area is formed. So the people of Sistan are dependent on the Hirmand River (Mehrafarin and Sajjadi, 2005: 223). Based on what is mentioned above and scholars (Hydraulic theory, history, archeology, geography, etc.) various geographical factors have impacted creating and distribution of human settlements of which the most notable confirms the relationship between population-centers and settlements with water resources, rivers and waterway networks (Hydrography).

Research Methodology

The research method is descriptive - analytical, historical – comparative, documentary, library and field study in Iran's Sistan area. Information relevant to the subject (Islamic period, the Qajar period and the current situation) exhaustively matching together and with historical maps were analyzed using ArcGIS software. The location of Qajar castles were recorded with GPS. Maps derived from ancient sources and simple sketches were drawn on Calc paper and were fitted together with aerial photographs of 1965. Then they were digitalized using ArcGIS 10 software. During the last three years 2014, 2015 and 2016 evidence and findings related to hydrographic networks of Hirmand and castle settlements related to the Qajar period were identified. Of which, 9 fort settlements were selected and studied: Sekouheh, Loutak, Varmal, Khan Malek, Khajeh Ahmad, Mohammad Hassan khan Naroui of Ghal'e Now, Alam Khan Tower or Ghal'eKohne, NosratAbaad Castle (current Zabol). Also the GIS database covering 565 archeological sites from 5 and 6 AH to the Qajar period (Mousavi Haji and Mehrafarin, 2006 to 2009) was provided. Different maps (hydrography, land, history, etc.) were provided and analysis of statistical and policy analysis detection (Buffering) was done.

The Study Area

Sistan is a vast land coveriung 8117 square kilometers of area. To the north and east, it is limited to Afghanistan, from the south to Zahedan, and from the west and north-west, it is limited to Lut Desert and the city of Birjand. It is located between 500 and 600 meters above sea level. (Khosravi and Ghayour, 1989:163). Its highest point is "Khajeh Mountain" at an altitude of 595m above sea level (Ranjbar*et al*., 2005:74). Based on the main division of geomorphology, the type of ground in this area is alluvial and there is a gentle slope in the southeast to the northwest (Badi'iAzandahi*et al*., 2011:209). The lowest point of it is the Goudazreh pond at 470 meters above sea level (Karim Koshteh*et al*., 2001:200). So, the Sistan plain is one of the flattest lands of the Iranian plateau; in terms of topography of the area it is flat to the height difference of some several tens of meters. This has led to a situation in which cities, towns and villages in the Sistan region are severely threatened by flooding, because with the flow in the region, there is almost no natural barrier that would prevent the flow of large volumes of flood water to residential areas (Mousavi Haji *et al*., 2010:87). Soil studies in the region indicate a uniform soil profile to a depth of 5.1 meters (DaneshKararasteh, 2006:96). Its alluvial deposits are too fine and are the size of clay and silt particles which has prevented from the formation of underground aquifers. On the other hand, due to the fact that under the surface layer of sand and rock of the plain, there is a clay layer with a thickness of 850 to 1000m, underground aquifers have not formed and hence; the so-called underground water level is too high (Zomorodian and Pourkermani, 1988: 114). Only West Hamon, according to coarse-grained sediment transport has had the chance to penetrate nearby mountains and form little underground water (Khosravi and Ghayour, 1989:175). To consensus, it can be stated that the underground water, in addition to low capacity due to its high salinity and hardness, is unusable in terms of irrigation and drinking (Zomorodian and Pourkermani, 1988:115), Given that the average annual precipitation of Sistan is also very low (61mm) (Zia Tavana*et al*., 2010:51); it is among the arid and deserts of Iran (Sharifikia, 2010: 159). Water evaporation is also very high: the evaporation in Sistan reaches more than 5,000mm per year (Bazi, 2013:148). Water supply needs in this area is all provided by the Hirmand River (Hafeznia*et al.*, 2006:31). Notwithstanding the above, this area used to be one of the most prosperous regions of Iran and one of the country's centers of civilization (Re'issTusi, 1997:47). Archaeological and historical evidence clearly suggests that Iran's Sistan was regarded as one of the most fertile regions of the country (Mousavi Haji and Makvandi, 2010:2). The area was called "Iran's Egypt" and Arab geographers in the Middle Ages called all the eastern part of Iran as *Khorasan* which means the country of the Sun (Malekzadeh, 1969:23-22). So it has been because of the Hirmand River and its productive soils that rural and urban settlements in the history have been kept alive (Ebrahimzadeh, 2005:19). The Hirmand river basin with an area of 350,000 square kilometers and with a length of 1,100 km comes from the 3,800-meter high mountains of Yaghman, 60km west of Kabul (Shamohammadi and Maleki, 2011:32). The river water comes from melting snow in the Hindukush Mountains (Eta'at and Varzesh, 2012:199). It flows from the vicissitudinous areas of Hazarajat to the south-west direction. The river flows northward with a steep slope near the Iranian border. (BadiiAzandahy*et al*., 2011:207). Figure 1 displays a three-dimensional (DEM) of the Hirmand River Basin and the proposed study area.

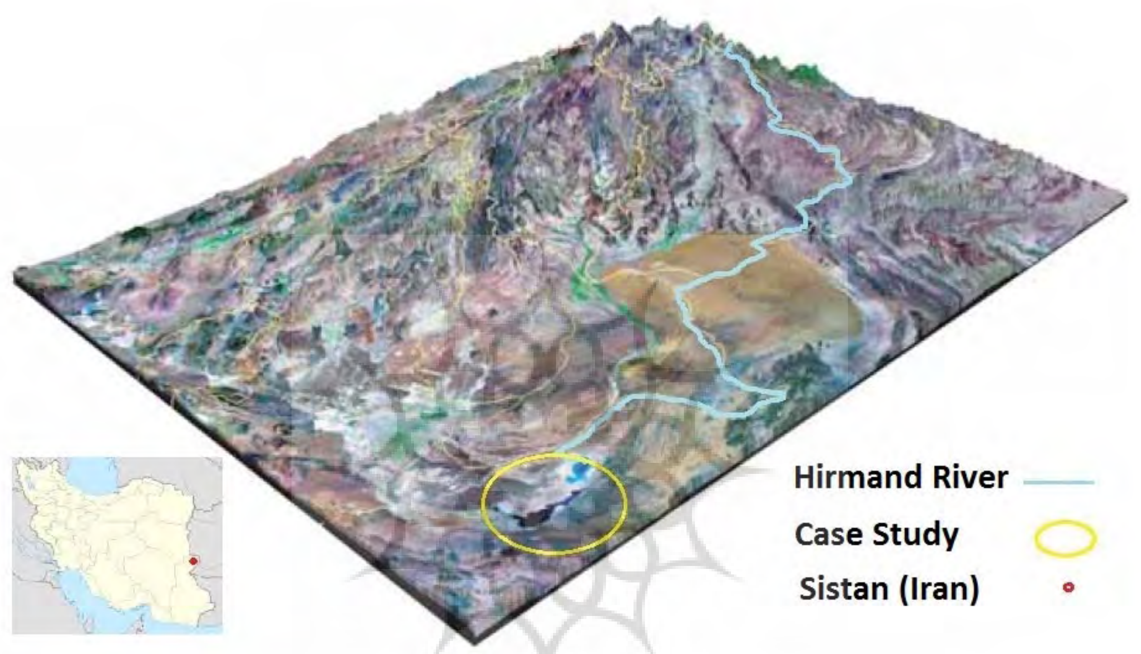

Figure 1 Displays a Three-dimensional (DEM) of the Hirmand River (UNEP & ITC, 2006 and Authors Changes, 2016)

Research Results

Considering redirecting of the Hirmand River and the hydrographic network of Iranian Sistan during historical periods and consequently locating of human settlements and considering the environmental conditions, first the distribution of ancient areas of the Islamic period (in northern and southern deltas) in relation to the hydrographic network of irrigation in Iranian Sistan is presented (Figure 2).

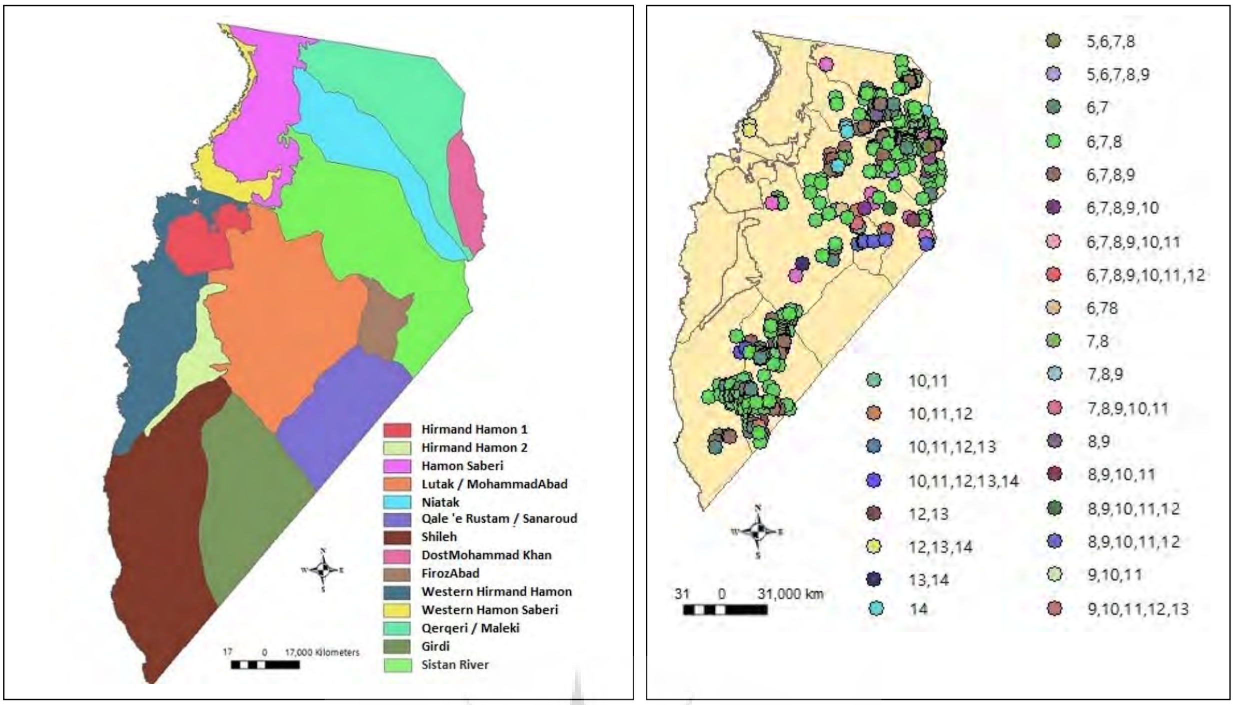

Figure 2: (Right) Sample showing Distribution of 565 Sites of the Islamic Period (5th to 6th Centuries AD until the End of Qajar), Iranian Sistan Plain Archeology Survey (2006-2009). (Left) Irrigation Areas of Iranian Sistan Plain in Northern and Southern Deltas of Iranian Sistan (Authors, 2016)

Constant sedimentation of Hirmand and its main branches has caused the river to permanently change the hydrographic network and create several deltas in the Iranian Sistan area. Sir Henry McMahone (1905) believed that there were at least 3 historical delta of Hirmand, each with its own plain. Based on this theory, Colonel Yate wrote: the first Delta in Sarotar and its plain is called LalehNavar, which is a huge hole, east of the Hirmand channel, entirely located in Afghanistan. The second delta (the southern one) isRamrood-Targhoon whose flood water is drained to Godzereh. Nowadays, half of this delta is located in Afghanistan and the other half in Iran. And the third one, (the northern delta) is the current system of dams and the hydrographic network of the river which is located entirely in Iran and its flooding flow is drained into the northern Hamon (Ahmadi 1999:410). Therefore, this study based on the research hypothesis has tried to study the characteristics and factors of locating the fort settlements of the Qajar era due to changes in the hydrographic networks of Hirmand.

Extracting Hydrographic Network of Qajar-era Fort Settlements from Maps and Historical Records

Due to the importance and special attention of researchers, historians, geographers and travelers to the importance and issues of the Hirmand watershed and hydrographic network, a wide variety of resources (domestic and foreign) including written records, maps, simple sketches and figures have been created though the historical eras. A brief outline of these resources is presented in Table 1 and Figures 3, 4 and 5.

Table 1 The Characteristics of Fort Settlements of Qajar Era in Relation to Hydrographic Network in Historical Records (Authors, 2016)

Characteristics	Resource	Page No	Explanation
Sekooheh Fort	Zolfaghar&Kermani, 1872	57	After Zereh Lake is made and water surrounds Sekooheh, the village of Sekooheh is destroyed.
	Frier, 1846	102	The water of this fort comes from wells that have been dug around the fort.
	Smith 1870	138	The lands around Sekooheh are very unsuitable (for camping) and almost everywhere there are rivers and streams. We could hardly find a dry piece of land and camp there.
	Smith, 1870	139	In Sekooheh, you can reach water by digging a well at any place within the sturdy 25-foot wall of the city and reach water. The depth of the well doesn't have to exceed a few feet.
	Smith, 1870	143	The way from sekooheh to Nosrat Abad, where we went through, was crossed by many canals and irrigation streams.
	Sir Henry Rawlinson, 1875	330, 332	The old canal called Garshasb stream runs by Sam fort (about one kilometer from Sekooheh fort). General Pollock has seen this stream on his way too. Dr. Bellew writes that the mentioned canal used to water the southern half of Iranian Sistan plain. Apparently it was built by Garshasp, Jamshid's grandson and Rostam's great grandfather.
	Siex, 1897	457	When Timor or Shahrokh destroyed Rostam dam, the agriculture in the Howzdaar region south of Iranian Sistan was destroyed and Hirmand river made a new waterway. This waterway separated from the main stream of Hirmand around where today's Iranian Sistan dam is and

			moved westbound around Sekooheh hill. Sekooeh was not a residential area at the time.
Kohak Fort	Smith, 1870	166	This fort is located about 1.5 miles south of Band-e-Kohak, to the left of the main stream of Hirmand. It's a small delta surrounded by Hirmand on one side and a big canal on the other side.
	Zolfaghar&Kermani 1872	110	This fort which is located on a hill was built by Heshmat-al-molk to protect band-e-Kohak.
	Goldsmid, 1870	309	At Band-e-Kohak, the main stream of Hirmand in on the right and a human-made canal is on the left.
Ghal'eh-Kohneh (Old Fort) or Alam-Khan Tower	Zolfaghar&Kermani, 1872	129	When passing through Ghal'eh-Kohneh (The Old Fort) I had to ride a Totan because there was a lot of water.
	Frier, 1846	96	After this fort, Hirmand is divided into a few branches. 3 of the most important ones are streams that have big flows at the time of flooding.
	Smith, 1870	158	The main stream of Hirmand canal here is attached to the dam on the eastern coast. The water's pace is so high here that it took us 3 hours to cross it. This fort was on the west of the big canal next to Sabzekam. Sabzekam is the dried plain that used to form here because Hirmand over flooded.
	George Peter, 1903	179	In 1839 when Conelly visited Sistan, Alam tower was beside Hamon
	MirzaMousa Khan Kargozar, 1872	60	Alam-Khan tower is located next to the river and over flooding of the water does not allow horses to cross it.
	McMahone, 1905	389	On the north of Ghal'eh-Kohneh in 1904 there was a big lake.
Khajeh-Ahmad Fort	Conelly, 1893	40	9 years ago there was a big flood, the main stream of Hirmand moved from its old channel and made a new stream along a small stream near Khajeh Ahmad village.
Varmal Fort	Landor, 1901	682	Varmal had good and abundant water.
Ghal'eh-No (New Fort)	Sir. Charles Edward Yate	101	We exited Ghal'eh no and after 7 miles on flat land we got to the west coast of the main river.

Nosrat-Abad Fort	Landor, 1901	658	Hasanaki dam is one of the most important canals of Sistan dam (Sistan dam was built in 1821) that provides water to the towns of Naseri (Nosrat-Abad) and Hosein-Abad. This canal is along the northwest.
	Anandal, 1919	884	Near Nosrat Abad we saw another waterway that was narrower but more active.

Source: Frier, Rawlinson, Siex, Goldsmid, McMahone, Conelly, Landore and Anandal (Ahmadi, 1999).

Tate reports that in the late 11th and early 12th centuries A.D, Hirmand shifted from the dessert river to its old canal that runs through the Northern Delta and it is still running through the same channel (EbrahimZadeh*et al*., 2004:15). Therefore, when Hirmand returned to the Northern Delta, it made Shileh rout or the Nasro River (Figure 3, dark green, 1692) after Hirmand was stabilized as Nasro River in the Northern Delta, the first and then the second branches were formed around 1760 (Figure 3, purple, 1760). By 1800, the first and second branches of Nasr had turned into a single branch and rerouted to the south of the plain. This canal ran from the east of Ghal'eh-No to the west and drained to Hirmand's plain, south of Khajeh Mountain (Figure 3, blue, 1800). Like this branch (the third branch of Nasro) other branches were gradually formed, one of which ran southwest-bound near an ancient fort calledGhal'eh-Sam (around 1 kilometer from Sekooheh) and drained to the plain near Varmal village. (Ahmadi Karvigh 2015,:400, 404,406). Conelly (1839) believed that 9 years before his visit, the main stream of Hirmand had changed its rout due to a big flood and it had made a new wide canal (Jaroki River) along the Khajeh-Ahmad stream toward Daktir (KarimianEghbal and AshtariMahjerdi, 2001:425). Khajeh-Ahmad village is precisely 3 kilometers north of Ghal'eh-Kohak. At that time, there were other irrigation streams, like the Alamdar River that ran 1.5 kilometers east of Jahan-Abad at the time and drained to Poozak Plain. When Frier visited Sistan in 1845, the Alamdar River was well stabilized. He writes: The water of Hirmand turns into branches after the Alamdartower. Frier also mentions another branch "the western branch", around 2.5 kilometers from Ali-Abad village. (Figure 3, light green, 1840) (Ahmadi Karvigh, 2015:410, 4015). After a few years, the western branch (a branch of the Alamdar River) dried and farms of western Sistan were left water-less. In order to provide water, Taj Mohammad Khan built a huge canal in 1855, which was named after him and its water came from the Alamdar River and later came to be known as the Sistan River (Shamohammadi and Maleki, 2011:205) (Figure 3, orange, 1855). The increase in the flow of water in the Alamdar River caused more sedimentation in its estuary and the circumstances changed in favor of another rerouting. Around 1860, Hiramand started a new canal near Alamdar Canal east-bound that was called the Nadeali River (Ahmadi Karvigh, 2015:415).

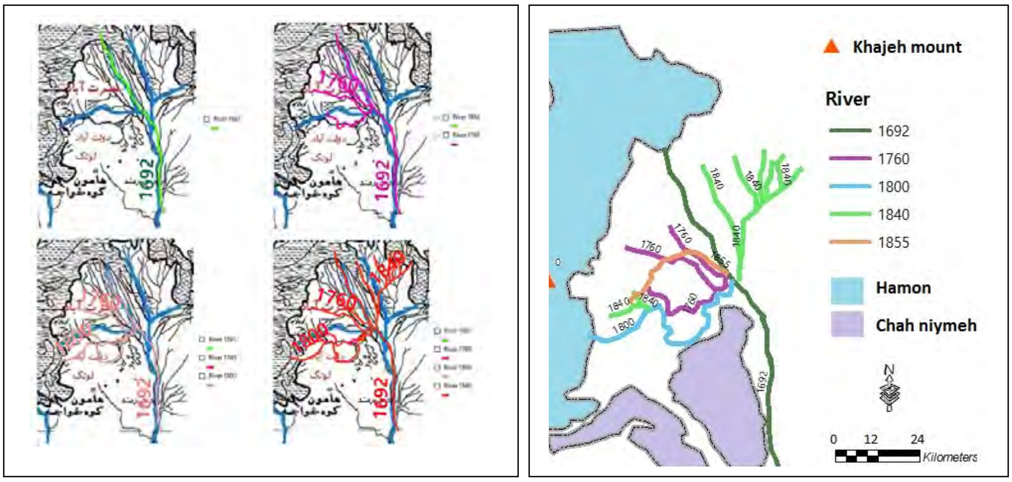

Figure 3 (Right) Changes in the Course and Direction of Hirmand River and the Network of Streams (hydrography), during 1692, 1760, 1800, 1840 and 1855 (Through Ahmadi Karaviq's Maps, 1394: 402, 403, 405, 414 and 416), in Northern Delta of Iran's Sistan. (Left) Changes in the Course and Direction of Hirmand River and the Network of Streams in Iran's Sistan, during 1692, 1760, 1800 and 1840. Based on Anandal's Map (1919), using ArcGIS 10 Software (Drawn by Authors, 2016).

At the time of Frederick Goldsmith, years between 1870 and 1872, the main channel of the Hirmand River in Iran's Sistan was Nad Ali, whose direction was toward north. (BadieeAzandahy*et al*., 2011:215). Goldsmith cites: by means of this passage, the river's course was directed toward west, and the water would enter the big main channel of Sistan, this channel was so important that the majority of visitors thought of it as the river itself. In fact we should consider it as the "artificial Hirmand."

Sistan's main channel, which some reporters used to mistake for the main river, carries some of Hirmand's waters toward west, and to the heart of Sistan. Some cities including Dashtak, Chalang,BorjAlam Khan, etc. are located by the side of the "main channel of Sistan". It is from this channel that all the minor channels are diverged, and carry the water to the region's north and south (Ahmad, 1999: 247 and 286). From Goldsmith's map, it is evident that during the last 30 years, southern Hirmand has been drawn more toward the West. Hirmand's water in the Sistan passage divides into a number of branches, and one of these goes to the northwest (Hedin, 2002: 680). Also, close to the minor channels that diverge from Sistan's main channel, towards north and the northwest of Sekouhe, Qale'e No and Nasir Abad are located (Figure 4).

In 1896, there was a massive flood in Sistan, which caused the Hirmand River (Nad Ali) change its course towards the west, and flow in a completely new channel (Pariyan). Considering the fact that this river was chosen as the borderline between Iran and Afghanistan, caused a number of problems. In order to prevent heated disputes, during the years 1903 to 1905, Henry McMahon was appointed by the British government to cater a new map. McMahon believed that during centuries, the Hirmand River has regularly fluctuated between the east and west and has left a lot of mud in its course (MehrAfarin and Sayed Sajadi, 2005:228). In McMahon's map, it can be seen that from Kohak passage, a small channel is drawn toward the west, and the end of which is located Qale'e No and Sekouhe.

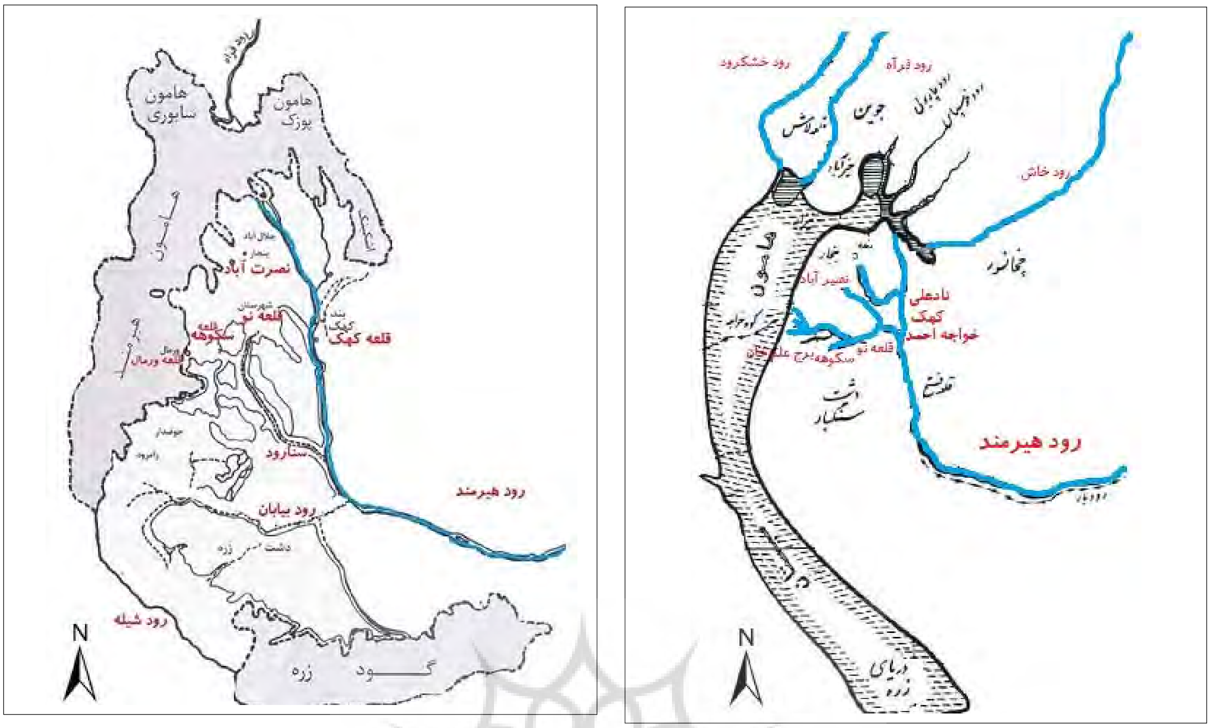

Figure4. (Right) Goldsmith's Map, 1872 (Ahmad, 1999:282). (Left) McMahon's Map, 1905, (Ahmadi Karaviq, 2015: 50).Changes in Hirmand River's Course and Hydrographic Network during 1872 and 1905 (Modified by Authors, 2016).

Tate's map, drawn in 1905, is very similar to McMahon's (Figure 5). Tate writes: next to the Kohak castle, there was Sistan Passage; and from this passage, the water was diverted to the Sistan Channel (Ahmadi, 1999:734). In Tate's map, it can be seen that, close to the Puzak plain, the Hirmand River divides into two main branches. The branch on the right is the Sikh Sar channel, and the branch in left is the Pariyan River. Also, Sanaroud is specified with dotted lines, which shows the old trajectory of Hirmand.

As about Sanaroud, some researchers believe that towards the end of the second millennium BC, the trajectory of the Hirmand River relocated to the channel of Sanaroud (northern part of the present-day Sistan), but this current did not remain persistent, and the river flowed towards northwest which is its current trajectory (EbrahimZadeh*et al*., 2004:14). After 13th century, the Hirmand River once again flowed in its ancient channel (Sanaroud-Tarqoun), but at that time, the amount of its water was very low, while the current was mostly flowing northward, which is its current path (Jozie and MehrAfarin, 2013:69).

On the maps and historical records from the Qajar dynasty, changes in the trajectory of the hydrographic network (old) are displayed by dotted lines. Anandal, in 1919, while describing the course of Hirmand river in a report from the highlands of Afghanistan, in a map specifies the main channel of this river in Iran's Sistan region as the PariyanRoud, and holds that most of the water of the river goes to this channel, and the Kamal Khan passage takes the rest towards the west, and to the Hirmand Plain (Ahmadi, 1999:879). As it can be seen in Anandal's map, the Girdi irrigation basin is located at the end of Sistan River (Figure 5).

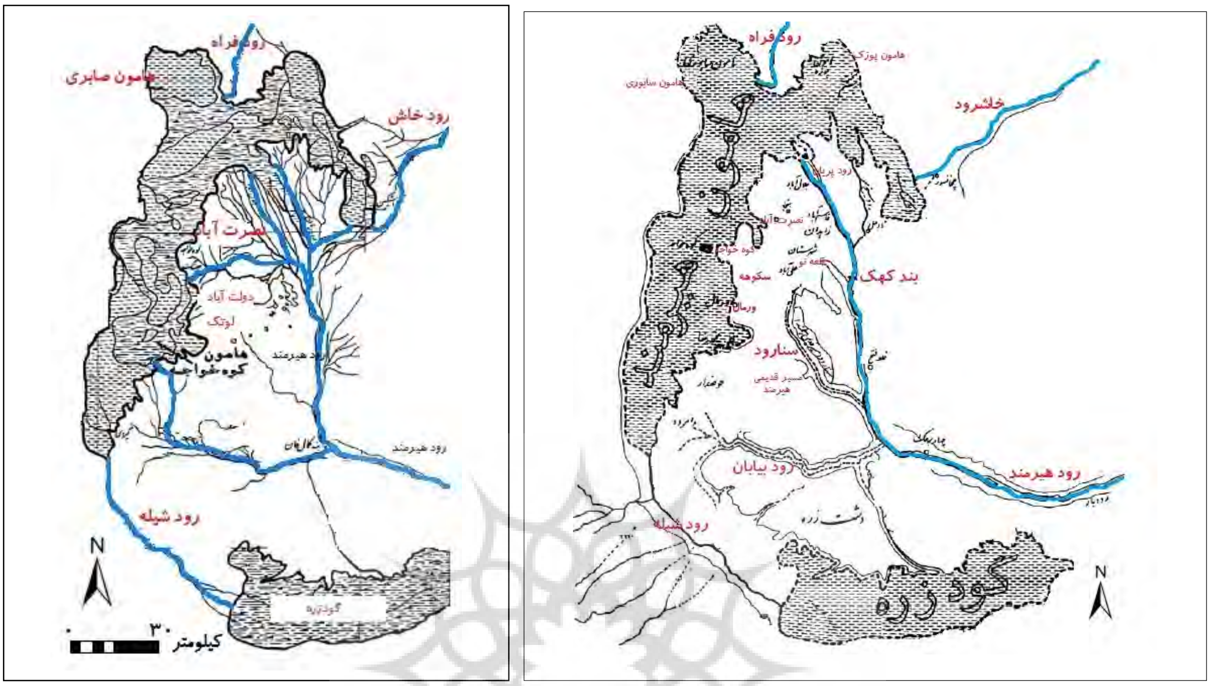

Figure 5 (Right) Tate's Map1905 (Ahmadi, 1999: 735), (Left) Anandal's Map 1919 (Ahmadi, 1999: 881), Hirmand River's Change of Trajectory and Hydrographic Network from 1905 to 1919 (Modified by Authors: 2016)

Adjustment of the Qajar-era Fort Settlements with Hydrographic Network in Iran's Sistan Plain

During 2014-2016, some field visits were carried out concerning the status of the natural environment and fort settlements of the Qajar era in Iran's Sistan region, which include the analysis of factors related to the subject in further matching the documented data and historical information with objective and ancient evidences. Figure 6 shows the connection between fort settlement centers and hydrographic network of Hirmand River from the Safavid (for comparison) to the Qajar period in Iran's Sistan plain. As it can be seen in this figure, the most amount of residence, related to the network of streams of the Hirmand River is noticeable in the west of Sistan.

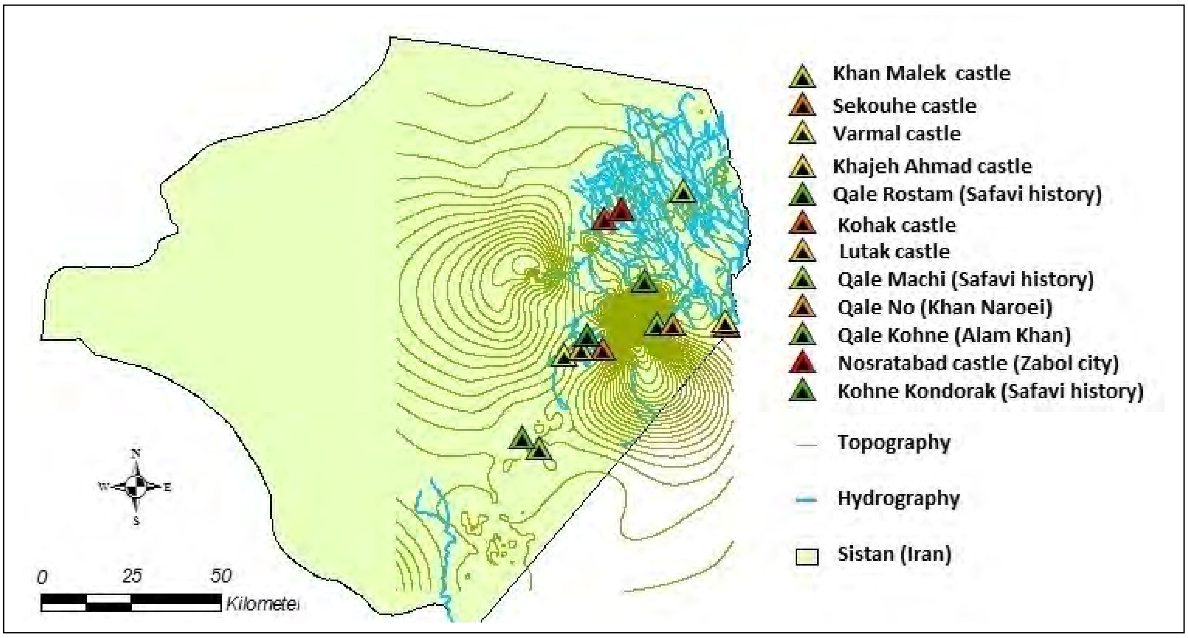

Figure 6 Connection between Fort Settlement Centers and Hydrographic Network of Hirmand River (Hydrography) from Safavid (for comparison) to Qajar Period (Authors, 2016) in Iran's Sistan Plain.

Figure 7 Kohak Fort Settlements, Qajar Era. (Right): Artificial Channel in the Vicinity of Kohak Castle, (Right): The Sistan River (Hirmand) (Authors: 2015)

Figure 8 Example of Old Channels around Sekouhe Fort Settlements (Authors: 2015)

Table 2 shows the approximate distance between the most important fort settlements belonging to the Safavid and Qajar periods (gray columns) in Iran's Sistan region, as related to the network of channels and rivers (hydrography). Machi Castle, which belongs to the late Safavid era, is registered in Table 2, to compare the ratio of the change in the choice of location for fort settlements in the southern to northern delta, which results from the change in the trajectory of the hydrographic network.

Table 2 The Approximate Distance between most Important Fort Settlements belonging to Safavid and Qajar Periods in Iran's Sistan, as related to the Network of Channels and Rivers (Hydrography), diverged from Hirmand River (Authors: 2016)

Name and features	Kohak Castle	Khan Naroei (Qale'e No)	Machi Castle (Late Safavid Era)	Varmal Castle	Lutak Castle	Sekouhe Castle	Khan Malek Castle	Qale'eKohne (Alam Khan Tower)	Nosratabad Castle (Zabol city)	Khajeh Ahmad Castle
The nearest network	Azar creek	Taheri creek	Biyaban River	Taheri creek	Taheri creek	Taheri creek	Shirdel creek	Taheri creek	Sistan River	Sistan River
Distance (m)	118	2065	180202	7462	4273	963	2500	998	5483	1100
The nearest network	Pariyan shared and Sistan River	Sistan River	-	Range to the surface of the lake	To third branch	To third branch	Niatak	Sistan River	-	Pariyan Shared
Distance (m)	911 and 606	3897	-	638	-	-	4380	4226	-	4600

More than half (56/55 percent) of the fort settlements from the Qajar period (Sekouhe, Loutak, Varmal, Qale'e Khan Narouiee, and Qale'eKohne) are located in the water basin of Taheri Creek. From among the fort settlements that were analyzed, Kohak is the closest castle to the Sistan River (606 m), and it has been built with the purpose of controlling the water and protecting the Kohak Passage. It is noteworthy that the Taheri creek or channel has been created in 1323 (1944). It begins from the upstream of the Zahak Passage, and divides to a number of sub-channels. Based on the proximity of fort settlements to the river, it can be concluded that the above-mentioned creek has been constructed in the original route of Sistan or old Sistan river (Nasro River, Figure 3, colors mauve and blue, years 1760 and 1800.) and (the western branch river, diverged from Alamdar River, Figure 3, light green, 1840).

The reason for Khan Malek castle's locating away from the Sistan River has been related to politics. During Naser-e-Din Shah's reign, Khan Malek was trying to revive the powerful government of Kayani clan, and for that purpose, he chose Jalal Abad as his command headquarters.

Today, this castle is located next to Shirdel new creek (built 1970 AD.), which is one of the splits of the internal Pariyan River, and supplies two other rivers: Niatak and Melki. It seems that, in Qajar era, sub-channels diverging from Alamdar River (Figure 3, light green) supplied the farms as well as the castle with their needed water.

During the year 1800, one of the sub-branches of the Nasro River was flowing westward, from the vicinity of the Sekouhe fort settlement. After flowing westward, this sub-branch would change its direction towards Varmal, and after that, it would finally discharge to Hirmand plain (Figure 3, blue, 1800). Landor (1901) believed that Varmal has been abundant with water; therefore, it seems that due to the nearness of Varmal to the plain as well as the existence of a pit on the south, this place has been an appropriate place for sub-channels of Hirmand to discharge their water in the plain (Ahmadi Karaviq, 2015:406).

Nosratabad Castle (current Zabol), as shown by Table (2), is 5483 meters away from the Sistan River. Historical evidence shows that after the death of Nader Shah, for more than 100 years, Sistan was paying taxes to Afghanistan's government, and during the reign of Ahmad Shah Abdali, MalekSoleimanKayani, Sistan's ruler, accepted the Afghan government's allegiance. Accordingly, Naser-e-din Shah Qajar, in order to confirm Iran's dominance over Sistan, took a number of actions, the most important of which was the construction of the Nosratabad castle. Therefore, this castle has been built for some political reasons. Ahmadi believes that a creek flowing in the vicinity of Nasro has been responsible for watering this castle. Today, this creek is called Shahr creek (Ahmadi Karaviq, 2015: 404). Fort settlement of a village called Khajeh Ahmad is located about 3 KM north of Kohak castle, and it is about 1100 meters away from Sistan River. Conellybelieves that as a result of Sistan's massive flood (1830), Hirmand River's main current left its original path and alongside Khajeh Ahmad branch, it has provided itself with a wide and new channel called the Jarouki River.

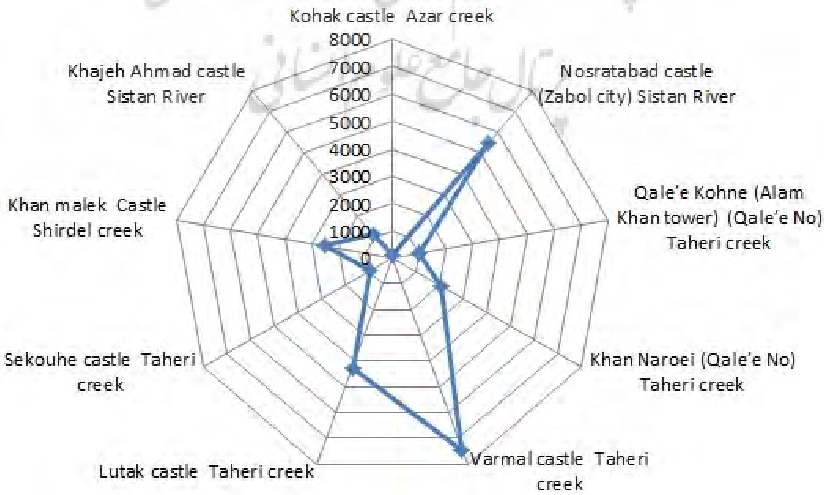

Chart1 The Distance between Fort Settlements (belonging to Qajar) and the Nearest Network of Rivers or Streams Diverging from Hirmand in Iran's Sistan Region (Authors, 2016).

Chart (1) represents the distance between fort settlements (belonging to the Qajar era) and the nearest network of rivers or streams diverging from Hirmand in Iran's Sistan region. As the dots and lines get closer to the center of the chart, they are closer to the hydrographic network of fort settlements. Figure 9 shows the status of establishment of fort settlements in accordance with sub-basins of Hirmand in Iran's Sistan region during the Qajar era.

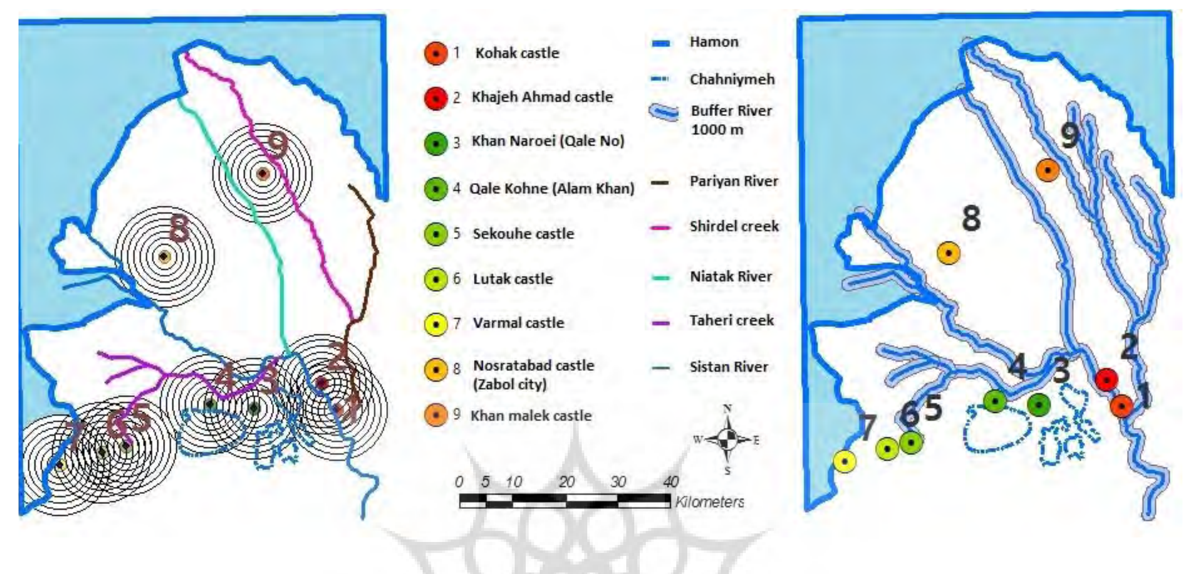

Figure 9 The Classification of the Range of fort Settlements during Qajar, considering 1000 m on 8 classes, in accordance with the Hydrographic Network of Hirmand River in the Northern delta of Iran's Sistan Region. Output Analysis Privacy Buffering Navigation in ArcGIS 10 (Authors: 2016)

Table 3 Classification of the Status of Sites in Islamic Period, the Positionof Sites with Hydrographic Network of Irrigation Basins and Changes in Locating in Northern and Southern Deltas of Iran's Sistan (Authors: 2016).

Hydrographic Basin of Irrigation Based on Figure 2 ArcGIS Maps	6th – 10th Centuries A.D	10th – 12th Centuries A.D	12th – 14th Centuries A.D	Total number of ancient sites	Total Percentage of Ancient Sites	Number of Sites in Northern Delta	Percentage of Sites in Northern Delta	Number of Sites in Southern Delta	Percentage of Sites in Southern Delta
HirmandHamon 1	0	0	0	0	0	0	0	0	0
HirmandHamon 2	0	0	0	0	0	0	0	0	0
HamonSaberi	0	0	0	0	0	0	0	0	0
Lutak /MohammadAbad	37	3	3	43	610/7	43	169/11	0	0
Niatak	88	0	4	92	283/16	92	896/23	0	0
Qale'eRustam / Sanaroud	0	0	0	0	0	0	0	0	0
Shileh	30	0	0	30	310/5	0	0	30	667/16

DostMohammad Khan	63	0	1	64	327/11	64	623/16	0	0
FirozAbad	0	1	6	7	239/1	7	818/1	0	0
Western HirmandHamon	0	0	0	0	0	0	0	0	0
Western HamonSaberi	0	0	0	0	0	0	0	0	0
Qerqeri / Maleki	109	0	0	109	292/19	109	312/28	0	0
Girdi	139	11	0	150	549/26	0	0	150	333/83
Sistan River	60	3	7	70	389/12	70	182/18	0	0
Results	526	18	21	565	100	385	100	180	100

Based on the classification of the status of sites during the Islamic period, the positionof sites with hydrographic network of irrigation basins and changes in locating in northern and southern deltas of Iran's Sistan region in Table (3) can be described by this way: the total number of identified sites in the early Islamic period is 1662, of which 565 sites belong to Islamic period in Sistan (Mousavi Haji and Mehrafarin, 2008). We have demonstrated these 565 sites because they very well explain and confirm the changes that have occurred in the hydrographic network during the Islamic period, especially in the Qajar era (Figure 2).

These 565 sites belonging to the Islamic period altogether form 34 percent of identified sites in the region. Since Sistan region has some Hamon (Saberi, Puzak, and Hirmand), and the surfaces of these Hamon have fluctuated during different historical periods, as far as investigations show, no ancient sites have been identified within the range of Hamon. Therefore, in Table (3), the first 3 rows, and the lines related to the west parts of both Hirmand and SaberiHamon are null (zero).

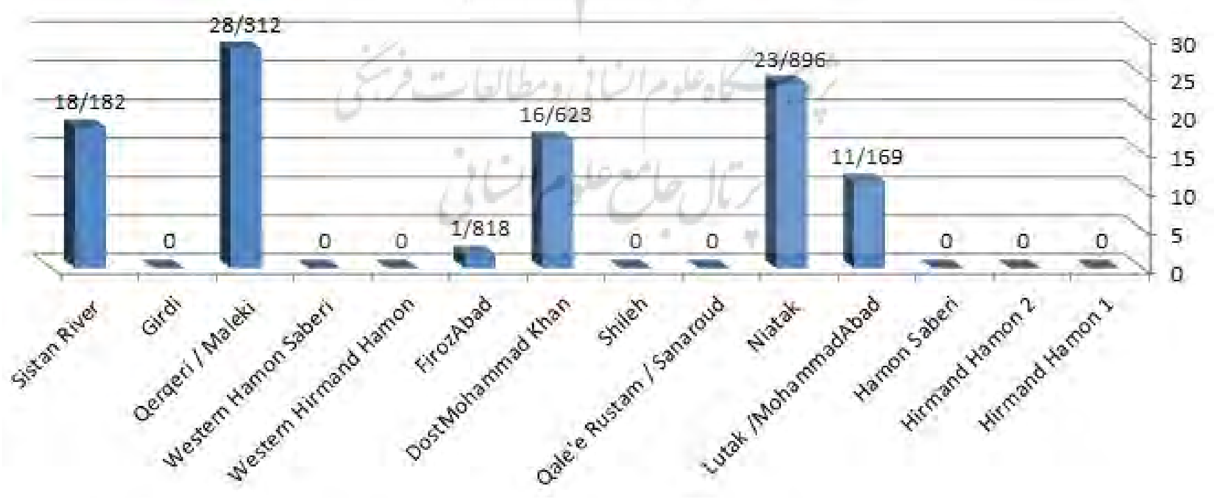

Chart 2 The Positionof Sites with Hydrographic Network in Northern Delta of Iran's Sistan Region (Authors: 2016)

Also, the line related to Qale'eRustam (Sanaroud) is void of any noteworthy works or sites belonging to Islamic period. Based on the findings of the study, the data from Table 3, and historical documentations from Table 1, as well as field studies represented in Table 1, the majority of sites belonging to the Islamic period (68.142%) are located in the northern delta of Sistan.

In the first 3 columns of Table (3), identified sites belonging to the Islamic period are presented (in accordance with the classification based on the hydrographic network of irrigation). The majority of place positionbetween sites and hydrographic network belong to 12th to 16th centuries A. D, and the highest amount of density in this period belongs to Girdi (139), Qerqeri or Melki (109) and Niatak (88). From 16th to 18th century also, the largest amount of ancient sites belongs to Girdi basin. However, it is worth mentioning that during 18th to 20th century (Qajar era) the number of ancient sites in Girdi basin has drastically decreased, in a way that no site has been identified from this period, while the Islamic period (12th to 16th centuries), has had the largest number and the greatest amount of density. From this status and historical maps and documentations, it can be inferred that the real reason has been the changes that have occurred in the trajectory of hydrographic network (rivers and streams).

The largest number and the highest amount of density of locating or formation of ancient sites during the Qajar era (third column in Table 3) are related to Sistan River's hydrographic basin (7 cases). This is mainly due to the divergence of the trajectory of Hirmand River's hydrographic basins through Sistan or Sistan River toward the west it has been so that over the ages 10 to 12 AH in the Sistan River area it has reached a total of more than 2 times the number of sites. What is important is the fact that from 12th to 16th centuries A. D. both deltas (northern and southern) in the Sistan region have had settlement sites, however as it can be seen, during the Qajar era, 100% of settlement sites are located in the northern delta, therefore the hypothesis holding that the changes in the trajectory of the hydrographic network of the Hirmand River (from the southern delta toward the northern delta) has played a major role in the choice of location for the fort settlements in the Qajar era of Iran's Sistan region, is confirmed.

Conclusion

Experience, world records and theoretical foundations indicate a relationship in many parts of the world between rivers, waterway networks and ancient settlements. Because of the importance and specific characteristics of the Hirmand River and streams radiating from it during the past three centuries, maps and hydrographic documents related to the subject by researchers, travelers, historians, geographers were produced and written. Their results were used in this study. This study shows that more than half (56/55 percent) fort settlements (Skvhh, Lvtk, Varmal, Khan Naroui castle and the old castle) are in the Taheri Creek water basin area. Documentation shows that the Sistan River Situation in the Qajar period (the Nasrou) and (the western branch) Taheri Creek is consistent with the current situation. Research findings show, castle settlements were site selected close to the bypass channel branched from the Alamdar Khan property. The Nosratabad fort settlement (today's city of Zabol) had

had its stream from a river close to the Nasrou River (now called Nahr-town). Because of the proximity Hamoun, Varmal fort castle had been a good place to dump sub-channels driven from Hirmand. Kohak castle settlements have been constructed largely to control and protect its waterways and networks in specific. The Hirmand River has had a direct relation with locating human settlements in different periods. Based on this understanding of the status of locating settlements in the northern delta and the southern castle, Hirmand's temporal trends in the hydrographic networks, all sites of different periods of the sixth century AH to the Qajar period, which have been identified in archaeological studies are analyzed due to Sistan irrigation areas. In this study, 565 area of the Islamic period (6th century AD to the Qajar period), a total of 34 percent, were examined at regional level (Table 3). According to the findings of the study, the largest number (385) areas in the Islamic period, a total of 142/68% are located in the North Delta. The highest ratio of areas with the hydrographic networks is related to the Ages 6 to 10. AH. And the highest density in this period is related to the Girdi (139), Qorqori or Maleki (109) and Niatak (88). In the centuries 10 to 12 AH the largest number of archaeological sites has also been in the Girdi area. The important thing is that at ages 12 to 14 AH (during Qajar period) no area in the Girdi basin has been identified. This is while during the Islamic period (Ages 6 to 10 AD) it has had the highest number and density. This shows that the real cause is the redirect of the hydrographic network (rivers and streams) in the Qajar period that has been inactive in the hydrographic basin of the Girdi. Most of the location and density of archaeological sites in the Qajar period is related to the hydrographic basin of the Sistan River (7) whose main reason is branching of the Hirmand River Hydrographic Basin through the Sistan Canal or Sistan River trough the west. The important thing is at ages 6 to 12 AH both Deltas of (northern and southern) Sistan area, Iran has had settlement areas while in the Qajar period 100% of settlement areas were located in the North Delta. Thus the research hypothesis is confirmed.

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بررسی تأثیر تغییرات مسیر شبکهٔ هیدروگرافی هیرمند در مکان‌گزینی سکونتگاه‌های قلعه‌ای دورهٔ قاجار منطقه سیستان ایران*

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چکیده

مکان‌گزینی سکونتگاه‌های قلعه‌ای منطقه سیستان ایران در طول ادوار مختلف تاریخی همواره با تغییرات مسیر رودخانه هیرمند به‌دلیل عوامل متعدد طبیعی و انسانی ارتباط داشته است. یکی از مهم‌ترین عوامل تعیین‌کننده در مکان‌گزینی سکونتگاه‌های مذکور، تغییرات شبکه هیدروگرافی بوده است. بنابراین، هدف مقاله حاضر شناسایی ارتباط تغییرات شبکه هیدروگرافی منطقه سیستان ایران با سکونتگاه‌های قلعه‌ای دوره قاجار است. روش تحقیق پژوهش، توصیفی -تحلیلی، تاریخی -تطبیقی و مبتنی بر مطالعات اسنادی، کتابخانه‌ای و بررسی‌های میدانی در سطح منطقه سیستان ایران است. تأکید و تمرکز بیشتر بر مسئلهٔ تغییرات شبکه هیدروگرافی هیرمند است. سؤال اصلی بدین‌صورت مطرح می‌شود که تا چه حد تغییرات مسیر شبکهٔ هیدروگرافی هیرمند در مکان‌گزینی سکونتگاه‌های قلعه‌ای دورهٔ قاجار منطقه سیستان ایران نقش داشته‌اند؟ مدارک، اسناد، داده‌ها و اطلاعات تاریخی دورهٔ قاجار مرتبط با موضوع گردآوری و با وضعیت کنونی و گذشته (۵۶۵ محوطه دوران اسلامی از قرن‌های ۵ و ۶ هجری قمری تا دورهٔ قاجار) به‌طور جامع در تطبیق باهم و نقشه‌های تاریخی و کنونی در سیستم اطلاعات جغرافیایی (GIS) با استفاده از نرم‌افزار ArcGIS بررسی و تحلیل شدند، ضمن آن بررسی‌های میدانی نیز انجام شد. نتایج نشان می‌دهد؛ بیشترین تعداد و تراکم مکان‌گزینی سکونتگاه‌های قلعه‌ای در دورهٔ قاجار، مربوط به حوضه هیدروگرافی سیستان رود است که علت اصلی آن انشعاب مسیر حوضه‌های هیدروگرافی رود هیرمند از طریق کانال سیستان یا رود سیستان در جهت غربی است .همچنین در قرنهای ۶ تا ۱۲ هجری قمری هر دو دلتای شمالی و جنوبی منطقه سیستان ایران محوطه‌های سکونتگاهی داشته است، اما ملاحظه می‌شود که در دورهٔ قاجار ۱۰۰ درصد محوطه‌های سکونتگاهی در دلتای شمالی مکان‌گزینی شده‌اند.

واژه‌های کلیدی: سیستان ایران، رودخانه هیرمند، نقشه تاریخی، سکونتگاه‌های قلعه‌ای دوره قاجار .

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