Step over the Gap, not in it: A Case Study of Iranian Sistan Archaeology

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Today more than ever, archeological research is interdisciplinary: environmental sciences, pollen analysis, botany, soil science, and hydrology. In fact, the impacts of human behaviors on environment and environment on human behaviors can be studied through use of remote sensing technology. The use of this important technique gives archaeologists the opportunity to understand these impacts, which are often invisible to the naked eye. Moreover, remote sensing an emerging field of archaeology that uses high resolution satellites with thermal and infrared capabilities to pinpoint potential sites of interest in the earth around a meter or so in depth.

During the first quarter of the second millennium BC and after collapse of Shahr-i-Sokhta, evidence of occupation in the region of Iranian Sistan disappeared until the Achaemenid period in the sixth century BC. During recent decades, archaeological field work, including surveys and excavations, have been conducted to find this gap. However, using remote sensing techniques popular in Europe and America, the present paper aims to propose a new survey method based on remote sensing and GIS techniques in the area in order to interpret the environmental characteristics of the area and to identify gap between the collapse of Shahr-i-Sokhta and emergence of Dahan-e-Ghlaman.

Keywords: *Sistan; Gap; Remote Sensing; Shahr-i-Sokhta; Dahane Gholaman*

Introduction

One of the most important problems of the archaeology of Iranian Sistan is a gap between the end of Shahr-i-Sokhta in the early second millennium BC and Dahan-e-Gholaman in the middle of the first millennium BC. While archaeologists are shedding light on the regions of Bronze Age (Shahr-i-Sokhta) and historical period (Dahan-e-Gholaman), very little work has carried on societies that existed between these periods. Moreover, modern developments in the region are destroying evidence (Mortazavi 2007: 110). Many archaeologists have tried to find this gap by using traditional methods like surveying, but they were not able to find any site between the above periods.

In my academic travels to United States of America in November of 2007, and when I was at JFK Airport in the New York train station, a warning voice said "Step over the Gap". It is warning to train passengers to remind them of the sometimes significant gap between the train door and the station platform. This phrase with a little change "Step over the Gap, Not in It" came to my mind as title of a paper to talk about gap between Shahr-i-Sokhta during the early second millennium BC and Dahan-e-Gholaman during the middle of the first millennium BC. Applying remote sensing and GIS in archaeology is a new method that could study and discover archaeological sites through aerial reconnaissance. It is notable to state this gap has also been discussed in a different paper titled "Mind the Gap: Continuity and Change in Iranian Sistan Archaeology", in this paper the author attempted to talk about the gap and believed that the civilization had continued and changed. It might be changed to a less advanced culture, but it did not stop. (Mortazavi 2007: 109-110). The phrase mind the gap also came to my mind during my studies in the UK. It was also a warning to train passengers of the sometimes significant gap between the train door and the station platform in United Kingdom.

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Importance of applying remote sensing in archaeology

One major task for the archaeologist is to locate and record the whereabouts of sites and features. However, the subsequent phases in the evolution of Remote Sensing techniques in the archaeological field are related to the diffusion of sensors capable of extending data acquisition in the electromagnetic spectrum, beyond visible bands, up to the thermal infrared area (multi-spectral and hyperspectral sen¬sors) and to the radio microwaves (radar imagery), as well as to the introduc¬tion of modern techniques for digital image processing (Parcak 2009; Lasaponara and Masini 2009; Forte, Campana and Lizza 2010).

Archaeologists should not forget that many monuments have never been lost to posterity: the massive pyramids of Egypt, or of Teotihuacan near modern Mexico City, have always been known to succeeding generations, as has the Great Wall of China or many of the buildings in the Forum in Rome. Their exact function or purpose may indeed have aroused controversy through the centuries, but their presence, the fact of their existence, was never in doubt. Nor can one credit archaeologists with the discovery of all those sites that were once lost. No one had ever made a precise count, but a significant number of sites known today were found by accident, from the decorated caves in France of lascaux, and more recently Cosquer, the underwater entrance to which was discovered by a deep-sea driver in 1985, to the amazing terracotta army of China's first emperor, unearthed in 1974 by farmers digging for a well, as well as the countless underwater wrecks first spotted by fishermen, sponge-gatherers, and spot divers. Construction workers building new roads, subways, dams, and office blocks have made their fair share of discoveries too-for example, the *Templo Mayor* or Great Temple of the Aztecs in Mexican City. Nevertheless it is archaeologists who have systematically attempted to record these sites, and it is archaeologists who seek out the full range of sites and features, large or small, that make up the great diversity of past landscapes. A practical distinction can be drawn between site discovery conducted at ground level (ground reconnaissance) and discover from the air or from space (aerial reconnaissance), although any one field project will usually employ both types of reconnaissance (Renfrew 2001: 72).

The ancient Maya of Mexico and Central America, long known for their grand achievements in art and architecture, remain shrouded in a veil of mystery surrounding exactly how they were able to sustain such large populations. While there has been localized evidence of intensive agricultural techniques (such as terracing and canalized fields) in some areas of the Maya lowlands, such practiced do not appear to have been widespread. Researchers investigating this topic have turned to remote sensing techniques in order to address such issues on a regional scale. The majority of large Classical period sites, however, lie deep within jungles of Mexico and Central America, buried beneath a canopy of dense vegetation. Efforts to pierce this canopy with remote sensing techniques have yielded mixed, through occasionally positive, results (Hixson 2005: 3). The sudden termination of Mayan culture has been a mystery for some time, in part, because archaeologists had not been able to figure out how Mayan Civilization had been possible in the first place. It had been presumed that the Maya grew their food using a swidden system of agriculture like the one that contemporary Mayans use. The problem was that no one could understand how Sweden could support the population densities (200 person per sq km) the Maya achieved. The enigma was solved when new methods such as remote sensing discovered canals and ridged fields. The traditional model of Maya life assumed that the cities were not cities at all but mere ceremonial centers inhabited by priests. The peasants could not live in urban concentration because slash-burn techniques required they be dispersed over a large area (Sabloff 1990: 24).

Therefore, it must be stressed that aerial reconnaissance, particularly aerial photography, is not merely or even predominantly used for the discovery of sites, being more crucial to their recording and interpretation, and to monitoring changes in them through time (Renfrew 2001: 79).

Environment of Sistan

Sistan and Baluchestan Province has a lengthy boundary with Pakistan and Afghanistan and consists of two parts, the Sistan Plain which is located in the north of the province; and the Baluchestan region, which is situated in the south ('see figure 1'). The Sistan plain has been divided between two countries of Iran and Afghanistan (Seyed Sajjadi 1995: 62-85). The Iranian part of Sistan ('see figure 2'), the main location of third millennium BC settlements such as Shahr-i-Sokhta and Rud-i-Biyaban, occupies the central and southern parts of the terminal lake Plain, at the southwest end of the Plio-Pleistocene sediments (Costantini & Tosi 1978: 167). The climate of the Sistan Plain is characterized by extreme aridity and strong, continual wind. The two seasons are a hot summer between May and October, and a cold, damp winter between November and April. Precipitation is very low and varies from year to year, the annual average being 50-100 mm. Because of the great distance, 600 km, from the sea, and the barrier formed by the coastal ridges of the Makran, the climate is extremely continental with hot dry summers and cold damp winters (Anderson 1968: 167, 171). The study area, which is located in an unstable environment, has long story of flooding and drought ('see figure 3') (Piperno and Tosi 1975: 186). Wind, soil and flooding are three main factors that constantly effect settlements in this vast area (Piperno and Tosi 1975: 186). Traces of flooding and drought are evidenced in different layers of Shahr-i-Sokhta, however these traces have not yet been studied. These traces, which are seen in different layers of the cemetery of Shahr-i-Sokhta are testifying that the weather of this area was un-

Fig. 1: Map showing the study area in southeast of Iran (After: Sharifikia 2013).

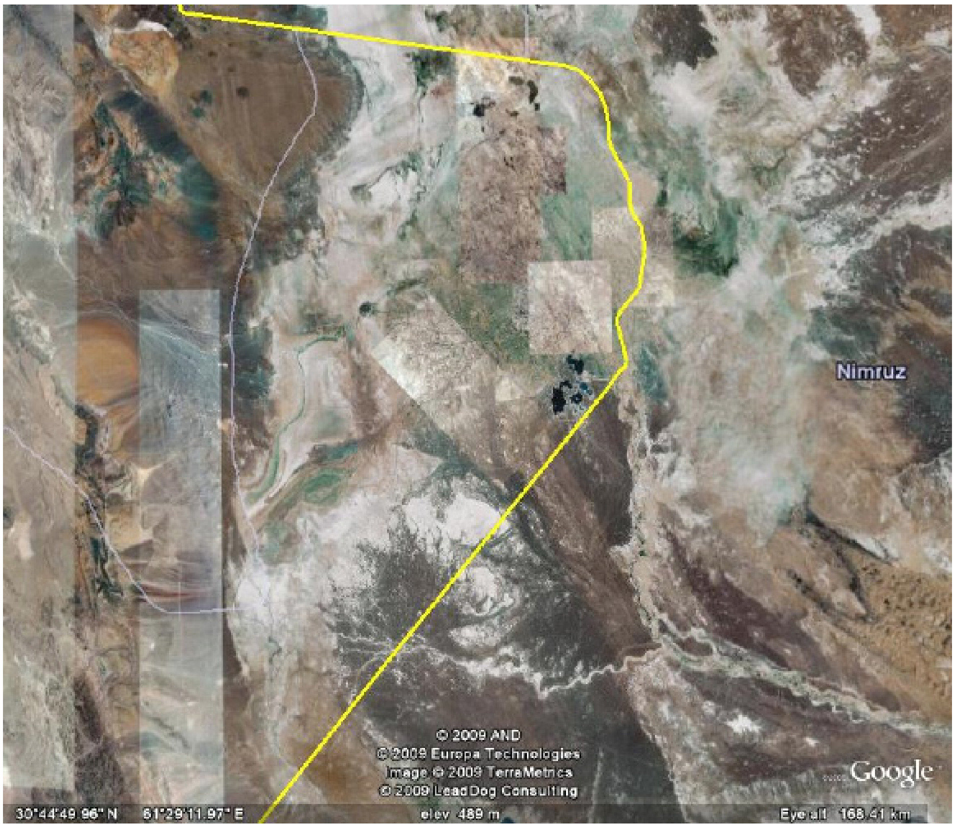

Fig. 1: *Northern Part of the Sistan and Baluchestan Province, Showing Iranian Sistan (After: Google earth, depicted on 12/10/2009).*

stable during the third millennium BC.

One of the most notable features of Sistan's climate is its wind. Although, there are a number of different seasonal winds in this plain, the most important is "The 120 Day Wind" which blows from the northwest to the southeast. It constantly blows for four months between 15th Ordibehesht (5th May) and 15th Shahrivar (6th September) and reaches maximum speeds of 120 km per hour ('see figure 4'). This strong wind not only has impacted the architecture of the Sistan Plain over time, but has also caused the movement of sandy dunes (Mortazavi 2001). This character of the Sistan environment has constantly affected the settlement pattern of this part of Iran. This effect is mostly visible during drought. Dasht-i-Lut may also accelerate the effect of 'the 120 day Wind' on the Sistan Plain, the generic term *Dasht* refers to a relatively firm and dry desert composed of consistently small and compacted rock fragments: pebbles, flints, or, most often, silts (Fisher 1968: 93). Usually, the wind is strong enough to carry sand particles that act as a highly efficient abrasive. Vegetation can be stripped of leaves, bushes and trees distorted, smaller plants crushed, and the growing layer of plants eroded away ('see figure 5') (Fisher 1968: 80). As stated "wind of 120 days" begins in mid-May and continues until mid-September which, combined with the strong heating of the solar radiation at this time of the year, contributes to extreme evaporation from the surface. Huntington describes the Sistan environment during the first 20 century as followed: "In Sistan the waters of the Helmand support scores and perhaps hundreds of villages. In such a country, the conditions of life are extremely hard. Strange as it may seem, when the average population is less than 10 to the square mile the country is overpopulated. There are thousands upon thousands of square miles of fine-soiled plain which would be highly fertile if only they could be supplied with water. Every where the cry goes up for water, and there is no wa-

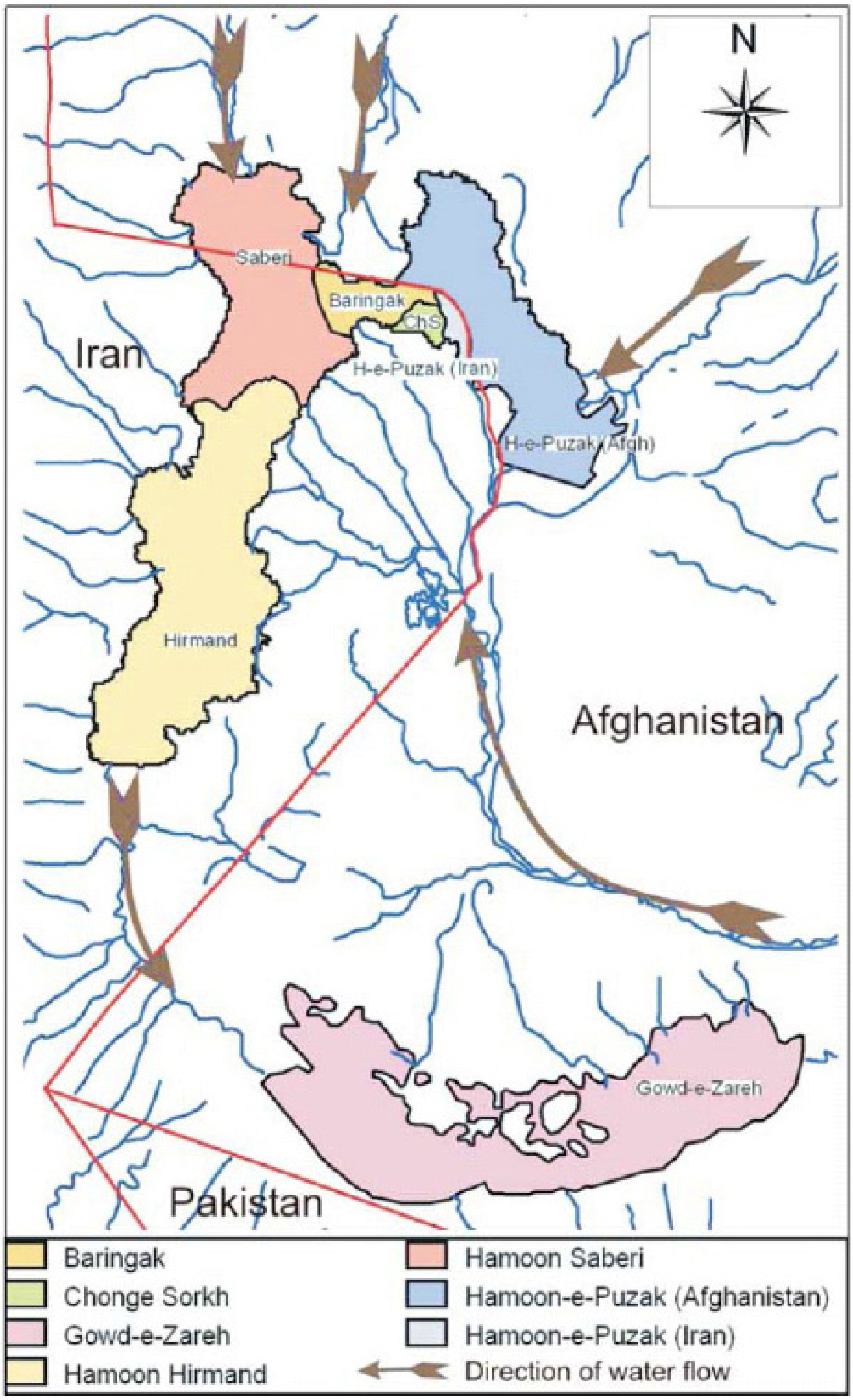

Fig. 3: *The Study Area, Showing direction of water flow (After: UNEP 2006: 17).*

Fig. 4: The Study Area, Showing direction of water flow (After: UNEP 2006: 17).

Fig. 5: *Showing sands carried by strong wind, sands may cover the archaeological sites (After: Penning and Beintema 2006: 49).*

ter." (Huntingtun 1905: 226)

It seems that these circumstances were seen during prehistoric times. Indeed, measurements indicate that evaporation exceeds 4000 mm per year over some areas in eastern Iran and western Afghanistan, which ranks among the highest rates recorded around the globe associated with this hyper arid climate and the strong persistent wind speeds which dry out the topsoil, as well as the high erodibility and an absence of vegetation, dust storms often occur over the Sistan Basin in late spring, throughout summer and early autumn. In particular, the bed of Hamoun Lake over northern and western parts of the basin , which is mainly fed by the Helmand River (also known as the Helmand River) originating from the Hindu Kush Mountains, is the most important source of dust affecting eastern Iran and western Afghanistan). The Hamoun Lake is often dry as a result of long periods of drought which began in 1999 The number of dusty days over the basin has rapidly increased since 1999 when most of the Hamoun Lake turned to desert (Alizadeh-Choobari 2014).

As the area is located in the global transitional climatic area, which is generally located between tropical and subtropical areas, the study area has constantly been faced with periodical changes including dry and humid during worm glacial period ('see figures 6-7'). Flooding and character of Sistan's soil have also affected the ancient settlements in the area. The most important characteristic of the Sistan's environment is a variation in river water systems due to the impermeable nature of its soil. The continuous cycle of intense floods, extensive sedimentation and swift vaporization, which has been repeated during the centuries, has produced this important character of Sistan's environment. The clayey character of Sistan's soil did not allow the Helmand to form a continuous riverbed. As a result of this feature, Piperno and Tosi believe that the collapse of Shahr-i-Sokhta was a result of localized environmental changes, which began in the beginning of the second millennium BC with the drying of the Helmand River delta upon which the town depended (Piperno and Tosi 1975: 186). During periods of aridity, the burden of deposit caused an uninterrupted growth in the level of the riverbed, which was thus unable to hold the bulk of the waters in periods of flood. Therefore, the direction of the river constantly shifts in a clockwise direction in the Northern Hemisphere because of the earth's circuit. The primitive riverbed of the Rud-i-Biyaban with an east-west axis was changed to a north-south direction, further evidence of the environmental character of Sistan (Tosi 1969: 286). This shifting, which occurred during the early centuries of the second millennium BC, caused the desiccation of the whole area and made it no longer suitable for farming and large settlement (Lamberg-Karlovsky & Tosi 1973: 28). The appearance of certain entomological species in the sequence of Shahr-i-Sokhta further testifies to the drying of the ancient Rud-i-Biyaban (Costantini, Tosi and Taglianti 1975: 249-255).

A theoretical view on gap

For many years, archaeologists tired to discover periods between the end of Urbanization at Shahr-i-Sokhta and Achaemenid period at Dahan-e-Gholaman (Mortazavi 2007). This gap has long been a subject of discussion that has not yet come to an end. Many archaeological surveys have been carried out and a number of sites such as Tepe Taleb Khan have been uncovered with the aim of discovering evidence between the above periods. The period after collapse of Shahr-i-Sokhta, that is generally called "Post-Urban" has been also known in other regions such as Mesopotamia, Egypt and India. For example, the post-urban period is associated with the characteristic style of the pottery first discovered in Cemetery H at Harappa (Allchin 1995a: 33), it was also witnessed in Jhukar after collapse of Mohenjo-daro (Wheeler 1959: 114; Chakrabarti 1995: 124). It seems that during the early of the second millennium BC, a larger regional environmental changes happened between the Mediterranean Sea and the Indus Valley, however, the civilization located around the Nile River in Egypt may have also been affected by the same environmental factors. It is notable that the huge environmental catastrophes during the first centuries of the second millennium BC have different effects in different regions and this is because of different environmental characteristics of each region. For example, the settlements, which are located in the Sistan Plain, collapsed rap-

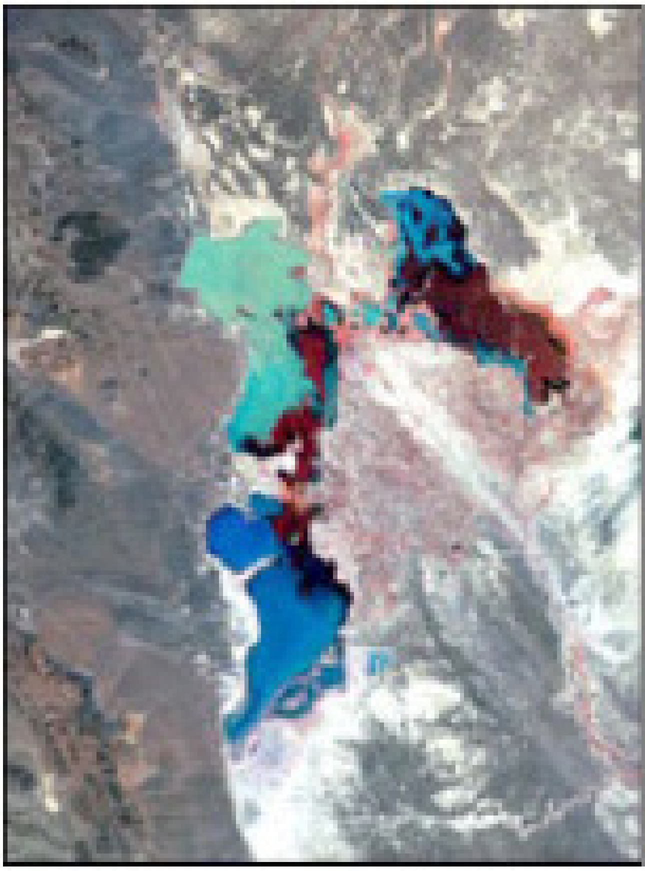

Fig. 6: *In 1976, The Hamun wetlands were still thriving. Dense reed beds appear as dark red, while tamarisk thicket fringing the margins of the upper lakes shows up as pick. Bright red patches represent irrigated agriculture, mainly wheat and barely. The lakes flood to an average depth of half meter denoted by lighter shades of blue, while dark blue to black indicate indicates deeper water is not exceeding four meters (After: Weier 2002: 7).*

Fig. 7: *: By 2001, the Hamun wetlands had vanished after central and south Asia were hit by the largest persistent drought anywhere in the world. The only sign of water in this scorched landscape of extensive salt flats (white) is the Chah Nimeh reservoir in the center right of the image, which is now only used for drinking water. Degraded reed stands in muddy soil are visible as dark red in the southern end of Hamun-i-Puzak (After: Weier 2002: 7).*

idly; while traits of collapse around the Nile River are less obvious than the Sistan Plain.

Tainter states that the end of an urban community may be seen as a transformation of the features or behaviors that characterize a cultural entity (Tainter 1988: 40). These features are typically those that form an urban community such as craft specialization, specific styles of art and public architecture or monumental building, tradition of literature and music, elite class, and commercial relations (Childe 1979: 16; Coningham 1995:55; Tainter 1988: 40). Therefore, it may be stated that when a society loses its power and stability for some reasons, it will gradually collapse. Whatever happens after collapse is as significant as the process of collapse itself (Yoffee 1991: 7). After collapse, for example, there is often a decrease in various activities, such as, trade, craft-specialist production, population, manufacturing and literacy (Renfrew 1979: 481). It seems that after collapse of Shahr-i-Sokhta, all urban traits were disappeared and complexity at Shahr-i-Sokhta reduced rapidly. It seems that during the Post-Urban period, the Sistan Plain was not occupied by a complex society.

As stated, after the collapse, people of Shahr-i-Sokhta may have formed small groups and functioned as transhumant groups. Unfortunately, transhumant groups leave little evidence other than campsites (Cribb 1991: 212) and are thus less archaeologically visible. It seems that the Sistan

Plain has not witnessed evidence of a complex society until the emergence of Dahan-e-Gholaman, or at least it has not yet been discovered. But it is hard to believe that a complex society as large as Shahr-i-Sokhta was active between the early second millennium BC and middle of the first millennium BC.

Looking for the gap

As noted, the period that is called "The Gap" in this paper, has long been a matter of much discussions in the archaeology of Southeast Iran, especially in the Iranian Sistan. It seems, nowadays, archaeological surveys and sporadic excavations are not able to answer the questions related to this gap. In fact, environmental factors that were explained above, will not allow us to find small sites, because it is argued that after collapse of a complex society, that society will get smaller. Therefore, complexity, which varies in different societies, declines as urban traits disappear or there is less investment in the epiphenomenon of complexity (Tainter 1988: 4). Economic activities such as trade are greatly reduced, and the process of information among people slows. The ruling elites may change but usually the working groups learn how to dwell and afford continuity (Renfrew 1979: 482). In this situation, size of a society decreases as its complexity decreases. For example, in relation to the rich archaeological records of the Mature Harappan settlements, the Late Harappan period was certainly a far poorer cultural period in the Indus Valley as all the scale and diversity of the Mature Harappan disappeared in the Late Harappan period (Lahiri 1992: 130). Less centralized regulation causes less control and integration of varied economic and political groups by elites (Tainter 1988: 4). General features of systems collapse are the collapse of central administrative organisation of the early society, the disappearance of the traditional elite group, the collapse of settlement shift, centralized economy and population decrease (Renfrew 1979: 482).

Size of Shahr-i-Sokhta decreased dramatically from 80 hectares in period III to 5 hectares in period IV (Tosi 1975: 141). After this period, no evidence of settlement has been seen in the area until Achaemenid period during the middle of the first millennium BC. In this paper, it is believed that environmental factors such as wind, river diversion and flooding have prevented the settlements to get bigger. After collapse, the settlement's size decreased and it seems that population of Shahr-i-Sokhta moved as small groups. In this situation, movement of sandy dunes by "The 120 Day Wind" and flooding covered may have covered many ancient sites ('see figure 8'). These sites that were probably small are not visible and have been hidden under sandy dunes or silt of frequent flooding.

With these environmental problems, it is very hard to discover sites dated to the gap. It is believed that archaeological surveys will not be able to trace evidence of living in this gap. Because sites, which are mostly small in size, might have been covered by sandy dunes and silts of flooding. Pottery fragments are the most common evidence in each site after Neolithic period. When sites are covered by the environmental factors, it means all data such as ceramics also disappear. As sizes of the settlements are small, they might be easily covered by sandy dunes or flooding.

A combination of archaeological surveys, remote sensing and GIS techniques could identify this gap. On the other hand, archaeologists using remote sensing techniques will be able to find small sites. Remote sensing can be used as a methodological procedure for detecting, inventorying, and prioritizing surface and shallow-depth archeological information in a rapid, accurate, and quantified manner. In fact, archaeologists who are looking for evidence in the gap, try to survey the area without using remote sensing techniques. They might stand on the sites, but as the sites have been covered by different environmental factors, archaeologists are not able to see them. But with using different techniques of remote sensing, archaeologists could see most evidence and the effect of environmental catastrophe. Remote sensing techniques have proven to be very useful in the search for archaeological sites. By using the remote sensing, archaeologists are able to see all factors in one page as a whole system. They could easily make a relation between different parts of the environment. While with older systems, archaeologists are not able to make con-

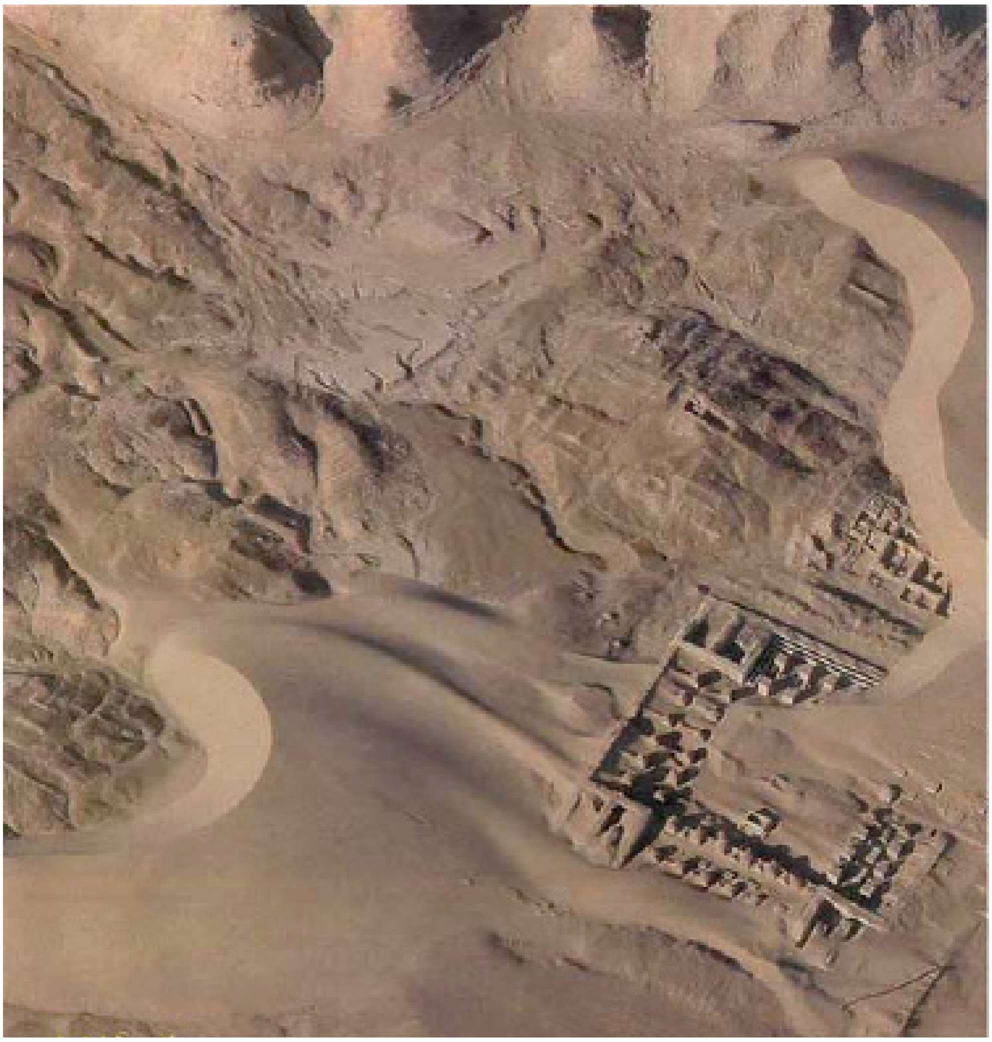

Fig. 8: *Dahan-e-Gholaman, An Achaemenid Period Site, Showing sands have covered the site. (Photographed by Cultural Heritage Organization of Zabol).*

nection between sites and their environments. .

GIS is best thought of as a dynamic database for spatial data. Reconstructing prehistoric human environments requires a detailed knowledge of the natural setting, especially the distribution, productivity and reliability of edible resources. To handle such complex data, archaeologists are increasingly turning to computer-based mapping systems- Geographic Information System- when looking at how settlements were distributed in relation to each other and to environmental features such as rivers, topography, soils and vegetation cover. The development of GIS makes it possible to organize complex spatial data arranged as a series of separate layers, one for each kind of information- sites, soils, and elevation and so on. Relationships between data in various layers can then be analyzed, allowing archaeologists to address questions about human land-use with large numbers of sites and many environmental details (Renfrew and Bahn 2001; 260). Therefore, it is notable to state that with applying remote sensing and GIS techniques, we are able firstly to have different views of different environmental and archaeological features of the Iranian Sistan Plain, based on remote sensing techniques, and secondly to gather all these features in maps and layers by using GIS technique. In this case, archaeologists have all data related to each other and can interpret the "Gap" through deductive reasoning.

Traditional Remote Sensing archaeological applications have dealt, and still deal, with the production of maps and DEMs and with the acquisition of data related to physical and environmental parameters for the detection of potential buried structures. As already said, the growing public interest with respect to themes related to the preservation and exploitation of cultural heritage, particularly archaeological assets, has recently directed Remote Sens¬ing applications above all towards the multi-temporal monitoring of exist¬ing archaeological sites and their surrounding areas, to study the evolution over time of the most significant environmental and anthropic parameters (change in the use of soil, characteristics of vegetation, urban sprawl, thermal anomalies, etc.). In both cases, data acquired by means of Remote Sensing techniques must be subsequently implemented into GIS which, after having modeled, analyzed and interpreted them, should enable archaeologists and public administration to provide adequate responses and decisions.

The most recent development in the applications of remote sensing in archaeological investigations is the use of radar imagery. Radar images are uniquely able to penetrate the desert sand cover to reveal the courses of ancient rivers and streams in the near surface, which reflect surface water flow during previous humid phases of climate. The Radar waves to penetrate desert sands and reveal the underlying topography, the surface materials must be dry and fine grained. Moisture reflects radar waves and interferes with their penetration ability, and the size of sand grains has to be less than one-fifth of the wavelength of the radar waves (El-Baz *et. al.* 2007). The above condition of dry and fine grained of surface is satisfied in Sistan plain.

Among the sensors used for archaeological applications, it is worth mentioning also the LiDAR (Light Detection and Ranging) and the high geometric resolution satellites, which have come into use in the last decade. A further application of Remote Sensing is the use of thermographs from radio-controlled systems, allowing the acquisition of data related to small archaeological areas from low flying heights. Modern thermo-cameras available in the market are capable of detecting thermal gradients of some degrees centigrade and CCD sensors with which these cameras are equipped have, nowadays, very small dimensions, which in any case permit accurate thermal analyses.

Conclusion

To sum up, it is suggested that in order to step over the gap and see the area from above by using different techniques of remote sensing and GIS. Archaeologists should not step in the gap, because they will be lost in the environment and they will not be able to find relations between system of environment and sites that are located within this system. By applying remote sensing and GIS in archaeology, we can examine how people adapted to their environment throughout time, how they experienced environmental shift and why cultures come and go. For New Archaeology, culture was a system. A system was defined by David Clarke as 'an intercommunicating network of attributes or entities forming a complex whole. In fact, system thinkers look for different elements or subsystems and study the relations between them. Subsystems are interdependent; they are linked to one another and explained by function. Therefore, archaeologists can examine the links between subsystems in terms of correlation rather than simple causes. System thinkers avoid the problems of mentalism and mono-causal explanations. (Johnson 2000: 67-73). Although System thinking, therefore, appears to be a very strong way of thinking about cultures in the past, it can also be applied for reconstructing the human past of the Iranian Sistan. With applying remote sensing and GIS techniques, we are able to think systematically and to avoid mono-causal explanation for the Gap between end of Shahr-i-Sokhta and Dahan-e-Gholaman. These techniques could be applied in our system thinking as potential source of optimism. The above techniques are able to regularize archaeological and environmental data to have a better interpretation of the above gap.

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