Archeologia e Calcolatori
26, 2015, 131-147

PATTERN ANALYSIS OF CHALCOLITHIC SETTLEMENTS IN THE VALLEY OF SARFIROUZABAD, KERMANSHAH, IRAN

1. Introduction

Thanks to the advent of digital devices, applying new techniques for enhancing methodological approaches in archaeology is an academic necessity, not a luxury mode! Archaeology as an academic discipline has a dual spatial-temporal character (Hodder, Orton 1976; Clarke 1977), so that geographic investigation of archaeological data is a vital part of reconstructing ancient ways of human life on the earth. It is because of the above mentioned duality of archaeological data that geographic maps have become an inseparable part of archaeological studies from the very beginning until now (Wheatley, Gillings 2002).

The first step of remote sensing for archaeological purposes started in Iran with the aerial photographic survey conducted by Schmidt (1940) through his flights over some parts of this country in the 1940s. However, this kind of data was always so expensive and was usually inaccessible for the most archaeologists who were interested in surveying an entire landscape through visual observations. It is because of these limitations in gathering functional archaeological geographic data that the appearance of digital technologies should be regarded as a revolution in archaeological methodological approaches. Digital technologies brought with themselves another way of observing the world, which is fundamentally different from the traditional one. One of the significant achievements is the appearance of satellite images that could be published on the web. The integration of satellite data and the Internet should be seen as a true methodologically breakthrough in the capabilities of modern archaeology. An important characteristic of satellite imagery is its unbiased nature in comparison with geographic pre-existing maps, so that it could be altered and manipulated by archaeologists in accordance with their specific problems or questions.

On the other hand, the development of Geographic Information Systems brought in itself a fundamentally different concept of mapping the earth (Wescott, Brandon 2000; Wheatley, Gillings 2002). Integrating such a layered view of the earth's features with satellite imagery has many benefits in archaeology. As archaeologists – consciously or unconsciously – always have a kind of ecological attitude toward their data of interest (Butzer 1982), it is typical for them to integrate multiple attributes of the environments as correlated layers of information about ecological setting of archaeological

sites. As a result, adding GIS facilities to satellite images of a given region easily enables archaeologists to create their own geographic maps originated directly from their specific objects of study.

This kind of digital archaeological methodology is ideal particularly for dealing with surface settlement data in terms of ancient cultural ecology and landscape reconstructions, especially where there is no reliable pre-existed map or any further excavated evidence existed. Integrated satellite low resolution imagery and GIS analyses were applied to reconstruct spatial distribution patterns of Chalcolithic sites in the Sarfirouzabad valley adjacent to Mahidasht inter-mountainous plain of Central Zagros, near Kermanshah City of Iran. The importance of the Chalcolithic period in Iranian plateau as a whole and Central Zagros in particular, rests on the fact that in this period some significant cultural as well as ecological changes paved the way for the development of more complicated forms of subsistence, craftsmanship and land-use. The beginning of intensive agriculture – both of permanent village-based plant cultivation and nomadic transhumant pastoralism – in that period opened the way for a new kind of socio-economic organization and the rise of local and regional chiefdoms.

Pursuing such considerable changes in the settlement distribution patterns in relation to ecological attributes is one of the aims of the present paper. Another aim is to shed light on the situation of the marginal localities of small valleys such as Sarfirouzabad, which are much less known than the adjacent plain of Mahidasht, where most archaeological works have revealed several notable evidences of cultural complexities occurred during the Chalcolithic period. The study ended by providing a series of high-resolution maps of archaeological sites across the study area. A number of products were generated, most importantly the models in GIS format describing the people of the past tendency to interact with the environment (or as the people of the past tended to interact with environment). Another essential product of the model is the generation of a series of geo-archaeological maps of the study area. These maps define the location, age, and integrity of prehistoric landscapes.

2. Archaeology and satellite imagery

Remote sensing means studying an object or a phenomenon from a distance (Wisman, El-Baz 2007; Parcak 2009). The importance of applying satellite remote sensing as a non-destructive tool to uncover remains of ancient human occupation and past cultural landscapes has been highlighted by national and international space agencies such as NASA and ESA, promoted by UNESCO and now recognized by archaeologists and remote sensing scientific community (Lasaponara, Masini 2012, xi). One of the main potentialities of satellite imagery data in archaeology is its usefulness in the creation of new relevant archaeological maps according to specific problems, though it is clear

that a GIS environment does more than just creating new archaeological maps from remote sensing data. Satellite images are helpful in the reconstruction of ancient landscapes, especially where there is a lack of pre-existed large-scale maps. As Campana and Francovich (2007) pointed out, the aerial photographs are used to emphasize the background context of archaeological sites in relation to their environments. In this view, every archaeological site is a node on the network of a specific landscape within which all the natural as well as cultural features are framed. One of the important aspects of satellite imagery data in archaeological studies of human landscape is its capacity to demonstrate such integrity among the points in a given environmental zone. There is a better possibility to reveal the quality of correlations between archaeological points and their surrounding environmental features from above.

Satellite imagery has been used as a technique for archaeological site prospection since the middle 1990s (Wilkinson *et al.* 2006). According to Kouchoukos (2001) this kind of imagery allows archaeologists to establish links between disparate ground observations and leads to developing new theories about regional structure and processes, in order to produce new kinds of evidence for the past social organizations and changes. The process in the Near East leads to look carefully at site locations and environmental distributions and interconnections. In fact, satellite imagery can be used as a tool in landscape representation to determine interrelations between ancient sites and their wider settings at a regional scale. They provide archaeologists with a powerful tool for studying the dynamics of human-environment interaction (Zubrow 2007; Parcak 2009).

Google Earth is one of the free online providers of satellite imagery data. From an archaeological point of view, this form of remote sensing technology has disadvantages when used alone. However, Google Earth can provide information similar to those given by aerial photographs and, when applied integrally with other tools, more accurate spatial results can be achieved. The application of satellite imagery data is limited here to pick up low resolution data from the Google Earth and adding on it GPS points of archaeological sites to study observable patterns of their distribution over the case area. Obviously, it is a minimum use of remote sensing data in archaeological studies of ancient environments and cultural landscapes; nevertheless, as discussed later, such a limited application of remote sensing data can lead to notable results in reconstructing ancient landscapes and land-uses especially when there is no excavated evidence and further analytical information available.

3. Methodological framework

This paper focuses on the archaeological survey data obtained through the first archaeological surface surveying project of Sarfirouzabad, Kerman-

Fig. 1– A fragmented low-resolution satellite imagery of Sarfirouzabad study area. Resolution: 15 m per pixel.

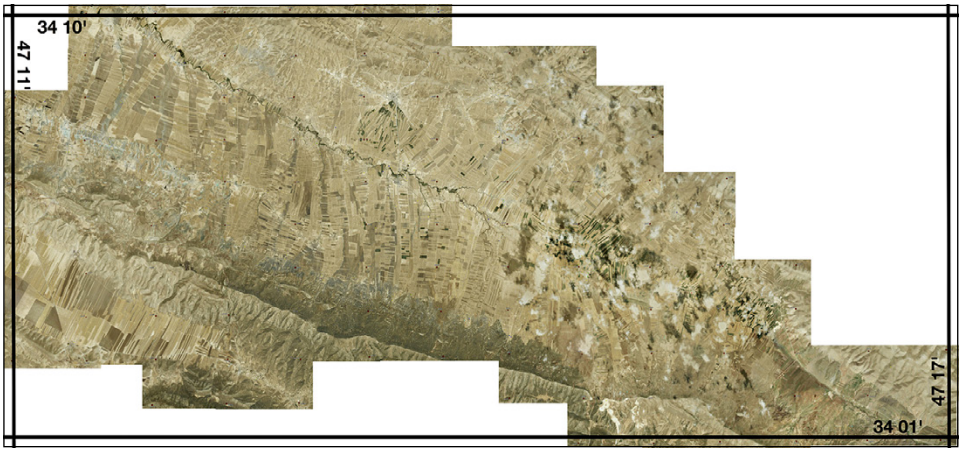

Fig. 2 – Non-fragmented re-mixed image of Sarfirouzabad study area.

shah (Niknami, Askarpour 2013). After adding GPS points of surveyed archaeological sites, the satellite imagery of the area under study was gridded in smaller fragments at a low resolution (about 4 km eye alt.) to be exported separately in JPEG format (Fig. 1). This procedure allowed us to obtain an

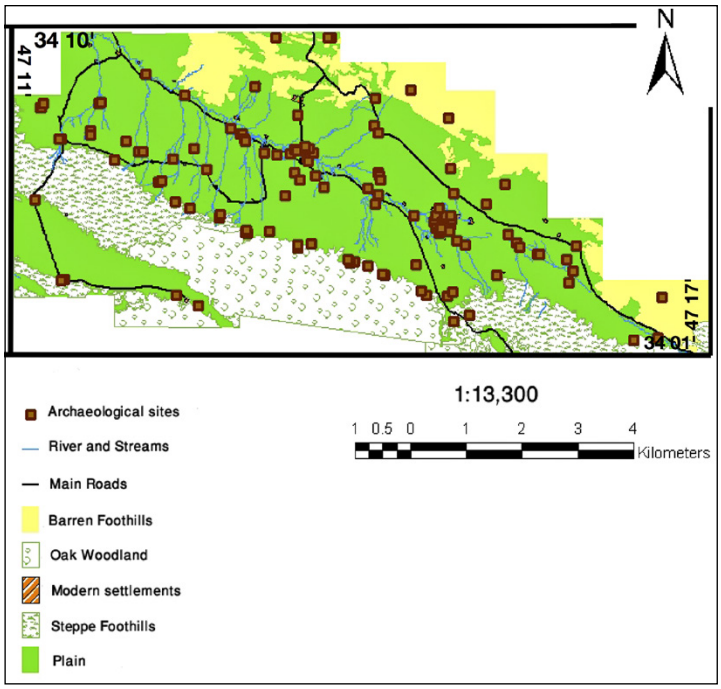

Fig. 3 – Prehistoric sites in relation to the different environs of Sarfirouzabad area.

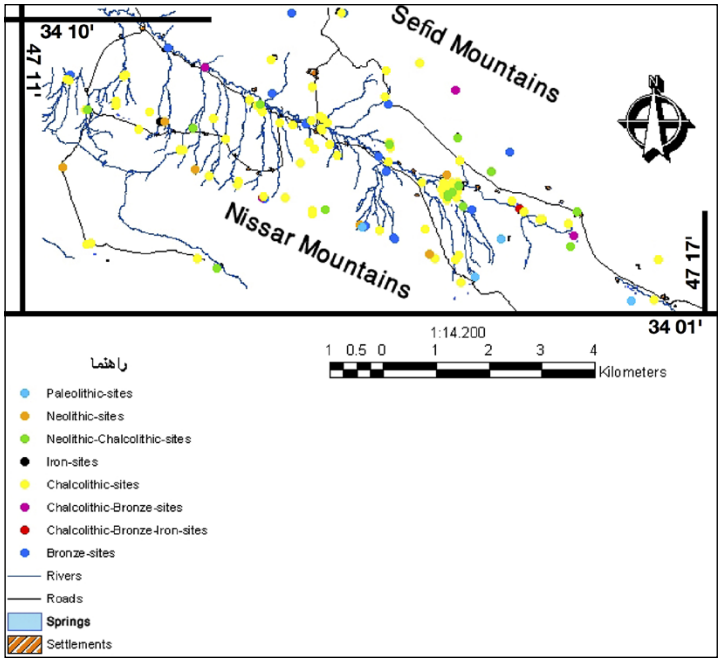

Fig. 4 – Prehistoric archaeological sites in relation to Ab-i Marik River and natural tracks of Sarfirouzabad.

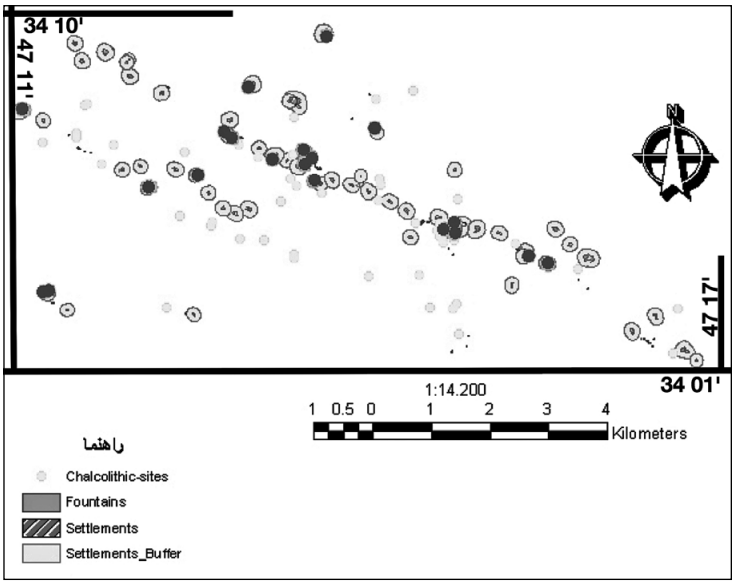

Fig. 5 – Distribution of modern settlements in Sarfirouzabad.

overall image of the region by defined resolution. Photoshop then merged the exported files and the resulted non-fragmented image of Sarfirouzabad was produced (Fig. 2). The next step was to import the resulted file into ArcGIS in order to digitize it and make an appropriate archaeological map of the area on the basis of the questions at hand. After the geo-referencing and projection of the image, digitizing process followed. The first desired outcome was to determine different kinds of zones and environs within the region under study. We need to clarify how prehistoric sites distributed over different parts of Sarfirouzabad. In this process, Sarfirouzabad was divided into four distinct zones including "plain", "barren foothills", "oak woodland", and "steppe foothills". The illustration of these zones could be seen in Fig. 3.

Another important issue to be pursued was to define the position of prehistoric sites in relation to the main river of the valley; Ab-i Marik is a river running in the middle of the valley westward to join Qara Su, one of the important rivers of Central Zagros. So, in order to achieve this result, the river and its main streams were digitized (Fig. 4). The main natural tracks of the valley – that necessarily formed some kinds of communicative roads connecting the valley with other inter-mountainous valleys of the Central Zagros Mountains – were as important as the rivers and the distribution of prehistoric sites relating to them (Fig. 4). These natural tracks were critical

parts of the cultural landscape of the inhabitants of the Near Eastern highlands through the history, especially those who adopted nomadic ways of life, but also for establishing trading contacts with lowlands of Susiana and Mesopotamia during late prehistoric and proto-historic periods (Gilbert 1983; Potts 1993). For determining correlations between the distribution of Sarfirouzabad prehistoric sites and the natural communicative tracks, those tracks were digitized and added to the resulted map.

The continuity of land-use and exploitation of fertile zones of the region under study, through times until the present, for food and capital surpluses production, is an important issue in the management of natural resources, especially in the developing countries (see Parcak 2009, and references therein). As a result, it was important for us considering what parts of Sarfirouzabad are settled nowadays as well as analyzing correlations between the distribution of modern settlements in the region, in comparison with prehistoric times. Therefore, digitizing current settlements of Sarfirouzabad was aimed at comparing their distribution pattern(s) with that of prehistoric sites (Fig. 5).

After digitizing and creating the archaeological map using low resolution remote sensing data, some simple GIS analyses and queries were manipulated. These analyses include:

– Analysis of site-points to investigate the sites spatial distribution patterns relating to the different environs of the area;
– Thiessen Polygon analysis to examine spatial relations between site/points of the Chalcolithic period;
– Buffer analysis (1000 m distance buffering) to discover the meaningful relationship between the sites and the main features discussed above.

4. Results

As a trend observed in different parts of the Central Zagros inter-mountainous valley (Hole 1987; Wilkinson *et al*. 2006; Alizadeh 2010), Sarfirouzabad was highly populated during Chalcolithic period compared to the earlier or later times. As can be seen from Fig. 5, there has been a sudden abrupt increase in the settlements during the Chalcolithic period, so that about 77% of the prehistoric sites of the area (totally 122 sites) have been occupied by the Chalcolithic peoples. The aim of the paper is to show different aspects of Chalcolithic site location and distribution in the area to explore socio-economic development of Sarfirouzabad inhabitants of the period. There is no need to say that all of results and conclusions which could have been achieved through the above-mentioned analyses are absolutely based on surface archaeological data, not having been undertaken excavations so far.

4.1 *Distribution of Chalcolithic sites in different environment*

One of the major characteristics of the Sarfirouzabad area during Chalcolithic period is the occupation of previously uninhabited areas, especially northeastern barren foothills. However, it is expectable that the majority of Chalcolithic sites were located on the more fertile localities of the plain and on the southern foothills (totally 77% of them).

4.2 *Spatial distribution of pottery styles*

Another important characteristics of Chalcolithic in Central Zagros as a whole and especially in the region under study, is the appearance of different painted pottery styles through early (J wares), middle (Dalma, Dalma Ubaid, BOB and Seh Gabi) and late phases (Chogha Maran) (Henrickson 1984, 1985; Henrickson, Vitali 1987). The investigation of the distribution of these styles over the area revealed a kind of non-random pattern related to the size of sites and their location in the valley. For example, as shown in Fig. 6 a-c, Dalma-Dalma Ubaid painted style of early Chalcolithic, as well as Seh Gabi of the middle phase are mostly concentrated on the surface of sites located in the eastern parts of the valley near the Ab-i Marik River. A similar pattern is also found for the distribution of Red White and Black ware-Chogha Maran style of the later phase.

A considerable difference between the distribution of earlier pottery styles and the later ones is a reduction of site density during the later phases, which occurred over the area, as indicated by the distribution of Siahbid potsherds. As we will see in the next part, it is a marker to indicate reductions occurred in the number of permanent settlements in favor of professional mobile pastoralism adaptations (Abdi 2003). It is remarkable that the area size average of the sites which contained such evidences on their surface was considerably larger than the others (from 0.6 to 0.9 ha). On the other hand, distribution of the styles beyond their concentrated locus of eastern riversides is very low. It seems that the dynamics of cultural change during the different phases of the period showed highly in some limited zones of the valley; mainly on the alluvial fan of Ab-i Marik River located in the eastern part of the valley. Further spatial analysis will better prove such a proposition.

4.3 *Spatial models of Chalcolithic distribution patterns*

Thiessen Polygon method was applied as in some archaeological projects (e.g. Roper 1979), to show spatial catchment of the Chalcolithic sites and define each site/point's area of influence. It is an appropriate method of analysis to predict possible zones of rapid socio-economic dynamics, especially in the lack of any archaeological excavation data. As shown in Fig. 7, during

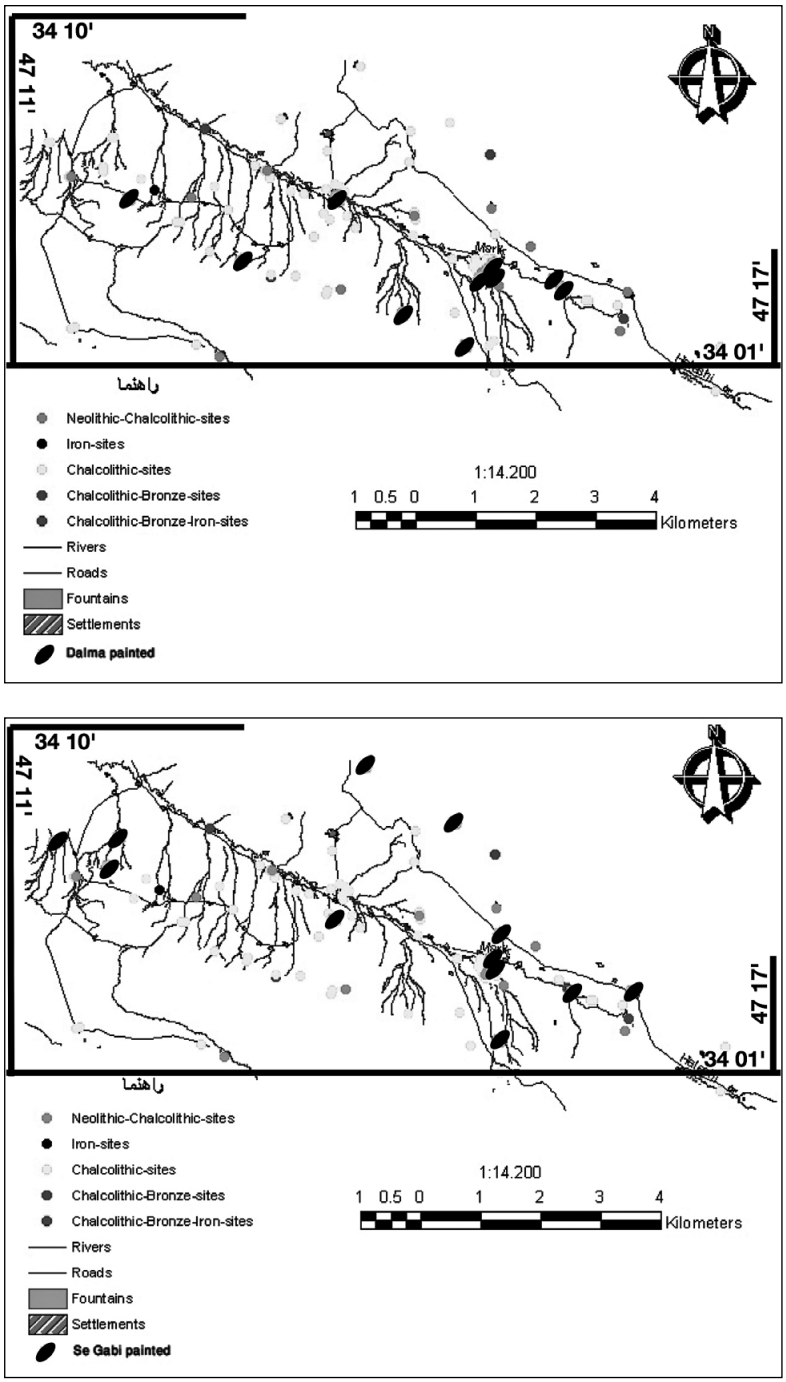

Fig. 6 a, b – Distribution of different Chalcolithic pottery styles in Sarfirouzabad area.

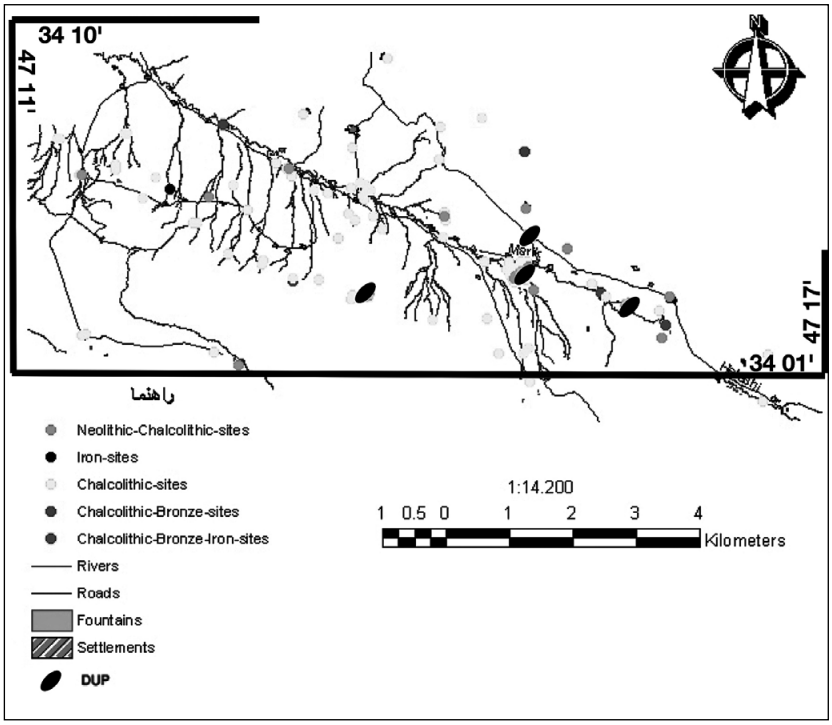

Fig. 6c – Distribution of different Chalcolithic pottery styles in Sarfirouzabad area.

Chalcolithic period the spatial influence of the point/sites reduced dramatically, mainly as a result of abrupt growing of the settlements. There are two trends observable in the Chalcolithic site distributions. One is the clustering of the sites in the river sources and the other is the linear distribution of the sites throughout the northern foothills of the Kuh-i Nissar, located in the southern part of the region.

The catchment space of the Chalcolithic sites increased in the northern part of the district as well as in the space between the southern shore of the river and northern foothills of the Kuh-i Nissar. As quantitative data show, there is a noteworthy difference between point/sites concentrated orbicularly around each other near alluvial fan of Ab-i Marik River from the point/sites which have been arranged linearly along the southern foothills of the valley; the former has an average area of more than 0.6 ha while the later consisted of about 0.4 ha. This considerable difference could be a sign of the existence of at least two different socio-economic systems during the period with their own specific pattern of spatial distribution.

4.4 *Chalcolithic sites and attributes of landscape*

Buffering Chalcolithic point/sites in relation to main attributes of Sarfirouzabad landscape (Ab-i Marik River, natural communicative tracks, modern settlements) is the final aim of the paper, in order to yield appropriate results for the reasons that caused the distribution patterns of prehistoric settlements of the valley.

As mentioned above, Ab-i Marik River and its streams are the main water source in Sarfirouzabad. It seems that one of the above mentioned distribution patterns (that of "orbicular" arrangement of the point/sites around each other) took place directly in relation to the river and its alluvial fan on the eastern part of the valley (Fig. 7). It means that the rise of more complex forms of settlement patterns is almost entirely relevant with the river and its fertile surroundings.

Another main feature of the landscape in relation to Chalcolithic point/sites of the valley is natural communicative tracks. Buffering analysis shows that about 30% of Chalcolithic point/sites of the region are located on the limits of communicative tracks (Fig. 8), for which some consideration should be made here. First, neither orbicular nor linear patterns of site distribution were properly or completely located on the limits. Secondly, according to quantitative data, average area of point/sites located on the limits of such tracks appeared to have been about 0.1 ha lesser than the others. It seems that locating near such communicative features of the valley had not more priority for prehistoric communities of Sarfirouzabad than other features (like easy access to water resources in one pattern and being on the limits of multi-resource areas of foothills in another one).

Modern settlements and their spatial distribution pattern over the region can reveal some facts about the land-use pattern of the continuity as well as a long-term exploitation of the fertile sources. Some parts of the region, which have been in use in the ancient time and were largely exploited by the Chalcolithic peoples, nowadays remain completely unexploited. Thus, the analysis of the relationship between the modern settlements and those from Chalcolithic, can be used to generate theories about spatial settlement and organizational patterns across the landscape. As shown in Fig. 6, the majority of modern settlements are distributed along the Ab-i Marik basin in a linear format. This arrangement of site distribution reveals that settlements were benefited equally from the river in terms of agricultural activities. However, when compared to the Chalcolithic settlements, the distribution of occupations was clustered near the specific agriculturally fertile parts of the valley. Although less than 30% of Chalcolithic point/sites located on the limits of modern settlements (100 m buffers), the trend of selecting riversides for occupation is always a favorable setting not only for the Chalcolithic people but also for the modern ones.

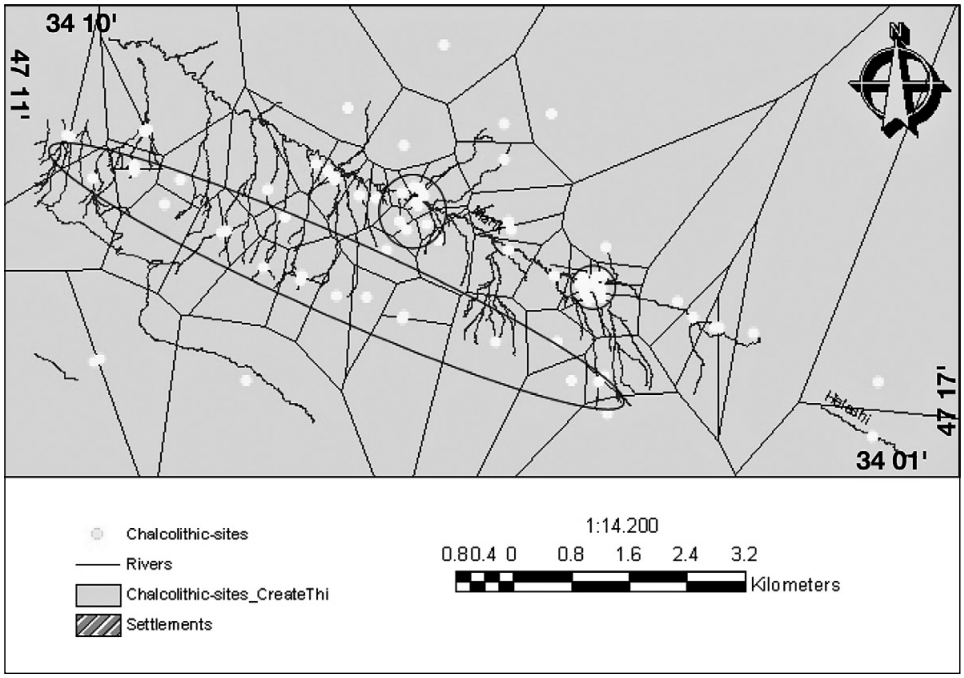

Fig. 7 – Distribution of Chalcolithic sites and different patterns of distribution.

The more complicated and disturbed pattern of Chalcolithic sites compared to the modern one may be in part the result of the frequently settling-abandoning of Chalcolithic sites through the different phases of this period. Different patterns of settlement, site locations and landscape feature between the Chalcolithic and the modern period, as stated, may be due to the different subsistence, social and cultural systems of both communities or as a consequence of some factors such as population pressures (Smith, Young 1983) and climatic conditions (Niknami *et al*. 2013). It is obvious, however, that large part of the modern Sarfirouzabad, especially its southern foothills, are now unpopulated while the same areas witnessed a great amount of sites during the Chalcolithic period.

5. Discussion

The Chalcolithic era in Near East highlands is a time of fundamental social, economic and cultural changes, such as development of complex forms of social and economic organization; exploitation of metal as a new raw material; reorganization of social fabric in the architectural record; rise of

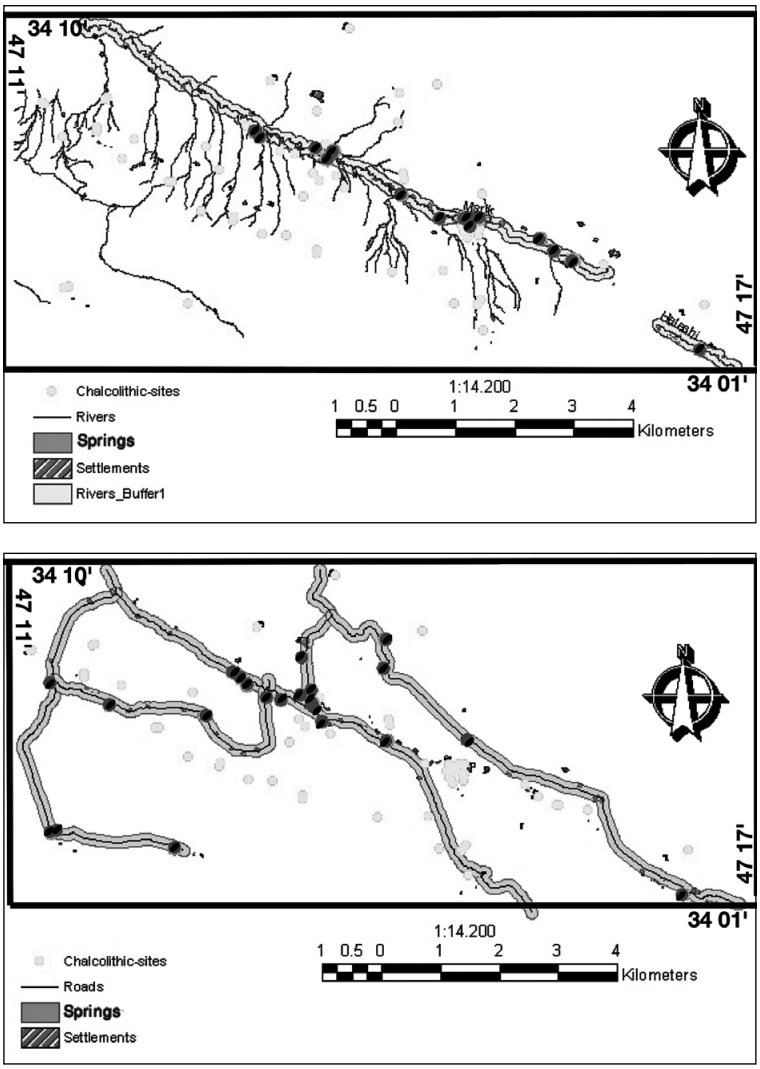

Fig. 8 – River and natural tracks buffering in relation to the Chalcolithic sites of Sarfirouzabad.

population; an increasing differentiation of agricultural and craft production; and the exploitation of secondary products (Helwing 2013).

Early Chalcolithic assemblages of Central Zagros can be roughly dated back to the early or middle of the 5th millennium BC in the Mahidasht (Henrickson 1985). Chalcolithic period in this region has been divided in three

phases of cultural change from the appearance of different pottery styles. This period is characterized by a general trend towards more intensive settlement in the valley (Levine, Mcdonald 1977). At the advent of Chalcolithic period in Central Zagros, the increase in the number of sites is a general feature of inter-mountainous valleys (Hole 1987).

Levine and Mcdonald (1977) examined Chalcolithic changes in the region on the basis of ecological and climatic interpretations. They suggested that during most of the Neolithic, Mahidasht was experiencing a gradual warming which reached a period of optimum temperature by the 5th millennium BC. Sites were located near readily utilizable sources of water. About 4000 BC a slight drop in temperature increased humidity that in turn resulted in a reduction of settlements dependence on the ground water and irrigations. Newly established sites are located mainly on well-drained soils and far from any possible source of irrigation water. Sarfirouzabad is an extension of Mahidasht and it is located on a higher elevation. It is important that earliest occupational evidence of the region were not present in Mahidasht, while Sarfirouzabad survey project recorded many of the pre-Chalcolithic sites of pre-pottery Neolithic or even earlier (Niknami, Nikzad 2012). It is also important that except some few sites – notably Pa Chaqa, located in the alluvial fan of Ab-i Marik which stands out as almost the largest prehistoric sites of the valley – other prehistoric sites of Sarfirouzabad rarely reached more than 1 hectare in size.

Again, another significant difference between Mahidasht and its eastern extension of Sarfirouzabad is the lack or at least rarity of J ware that is assumed as an indication for the beginning of the Chalcolithic in the area. It could be explained by assuming a local independence for Sarfirouzabad pottery tradition, by yet an unknown pottery style in the early phases of Chalcolithic period, although testing such an assumption requires conducting more detailed archaeological investigations in the region by means of stratigraphic excavation of key sites of the valley.

In sum, the general trend in population growth of the region during the middle phase of Chalcolithic may account for an increase in the number of sites across the area. In addition, surveyed data indicated multiple occupations of sites meaning that some earlier sites were re-occupied by the new arrivers of Chalcolithic because of the shortage in the favorable fertile lands. Thus, it seems that people was inevitably forced to move from their previous sedentary life to the higher elevation areas in the Zagros piedmonts to take what is known as Zagros pastoralism way of life. It is worth to mention here that one of the cultural evidence for such an increase in settlements and population growth in the Central Zagros comes from the appearance of two non-local pottery traditions known as Dalma and Ubaid, originated from the West and North respectively (Henrickson, Vitali 1987). Our

observation proved that the density of these incoming pottery styles in the marginal lands of Ab-i Marik River is considerably higher than in other parts of the valley.

Two different settlement patterns observable in Sarfirouzabad during Chalcolithic period could be interpreted as evidence for the existence of two different subsistence systems. One is based on agricultural permanent villages and is nearly hierarchically concentrated as a system of orbicular pattern in the alluvial fan of Ab-i Marik River, while the other system detached linear pattern of site distribution of small pastoralist campsites located along the southern foothills. Both of these patterns have been recognized through a geomatics analysis of remote sensing archaeological surface data as discussed in the earlier part of this paper, but it should be proved by more detailed archaeological investigations.

According to the results achieved, it is now possible to extract a predictive model for the Sarfirouzabad site distributions in Chalcolithic. We can focus on the certain locations of archaeological sites of the valley, if we are to understand in more depth the socio-economic characteristics of Chalcolithic landscape.

6. Conclusions

This study was mainly concerned with Landscape Archaeology in general and reconstruction of Prehistoric archaeological settlement patterns in particular in Central Zagros. The aim of this paper is to show how useful may be even a minimum application of remote sensing data in the study and reconstruction of ancient cultural landscapes and settlement heritage. This knowledge requires understanding interactions of past peoples with their environments. The use of low resolution satellite imagery as a basis for more in depth investigation of archaeological surface data helped us to understand spatial distribution of Chalcolithic sites of Sarfirouzabad according to its socio-economic characteristics. At the end, it could be suggested that it is very significant to conduct some geomatics studies on the archaeological surface data before planning excavation projects, to build up appropriate predicting models (Neubauer 2004) similar to those achieved here using satellite imagery combined with GIS spatial analyses.

Kamal Aldin Niknami

Department of Archaeology, University of Tehran, Iran
kniknami@ut.ac.ir

Vahid Askarpour

Islamic Art University of Tabriz, Iran
vahaskarpour@alumni.ut.ac.ir

Acknowledgements

In 2005 we were granted to conduct an archaeological survey by the Iran National Science Foundation (INSF), whose support for this research we hereby gratefully acknowledge. The authors would like to thank all the members of the survey team for their kindly cooperation. Grateful thanks to the Cultural Heritage Organization of Kermanshah whose support made possible our access to the site locations.

REFERENCES

Abdi K. 2003, *The early development of pastoralism in the Central Zagros Mountains*, «Journal of World Prehistory», 17, 4, 395-448.

Alizadeh A. 2010, *The rise of the highland Elamite State in Southwestern Iran*, «Current Anthropology», 51, 3, 353-383.

Butzer K.W. 1982, *Archaeology as human ecology: Method and theory for a contextual approach*, Cambridge, Cambridge University Press.

Campana S., Francovich R. 2007, *Understanding archaeological landscapes: Steps towards an improved integration of survey methods in the reconstruction of subsurface sites in South Tuscany*, in Wiseman, El-Baz 2007, 239-261.

Clarke D.L. 1977, *Spatial Archaeology*, London, Academic.

Gilbert A.S. 1983, O*n the origins of specialized nomadic pastoralism in Western Iran*, «World Archaeology», 15, 1, 105-119.

Helwing B. 2013, *The Chalcolithic of Northern Iran*, in D.T. Potts (ed.), *The Oxford Handbook of Ancient Iran*, Oxford, Oxford University Press, 79-93.

Henrickson E.F. 1984, *Ceramic styles and cultural interaction in the Early and Middle Chalcolithic of the Central Zagros,* «Iran», 23, 63-108.

Henrickson E.F. 1985, *An updated chronology of the Early and Middle Chalcolithic of the Central Zagros Highlands, Western Iran*, «Iran», 23, 63-108.

Henrickson E.F., Vitali V. 1987, *The Dalma tradition: Prehistoric inter-regional cultural integration in Highland Western Iran*, «Paléorient», 13, 2, 37-45.

Hodder I., Orton C. 1976, *Spatial Analysis in Archaeology*, Cambridge, Cambridge University Press.

Hole F. (ed.) 1987, *The Archaeology of Western Iran: Settlement and Society from Prehistory to the Islamic Conquest,* Washington D.C., Smithsonian Institute Press.

Kouchoukos N. 2001, *Satellite images and Near Eastern landscapes*, «Near Eastern Archaeology», 64 (1-2), 80-91.

Lasaponara R., Masini N. 2012, *Satellite Remote Sensing: A New Tool for Archaeology*, New York, Springer.

Levine L.D., Mcdonald M.M.A. 1977, *The Neolithic and Chalcolithic periods in the Mahidasht*, «Iran», 15, 39-50.

Neubauer W. 2004, *GIS in archaeology - The interface between prospection and excavation*, «Archaeological Prospection», 11, 3, 159-166.

Niknami K.A., Askarpour V. 2013, *A GIS modeling of prehistoric site distribution in the Sarfirouzabad Plain of Kermanshah, Northwestern Iran*, «International Journal of Heritage in the Digital Era», 2, 3, 343-360.

Niknami K.A., Irandoust H., Tahmasebi A. 2013, *Environmental and cultural factors influencing Parthian archaeological site distribution in the Sarfirouzabad Plain of Kermanshah, Northwest of Iran*, «International Journal of Geosiences»,4, 69-77.

Niknami K.A., Nikzad M. 2012, *New evidence of the Neolithic period in West Central Zagros: the Sarfirouzabad-Mahidasht Region, Iran*, «Documenta Praehistorica», 39, 453-458.

Parcak S.H. 2009, *Satellite Remote Sensing for Archaeology*, London, Routledge.

Potts T.F. 1993, *Patterns of trade in third-millennium BC Mesopotamia and Iran*, «World Archaeology», 24, 3, 379-402.

Roper D.C. 1979, *The method and theory of site catchment analysis: A review*, «Advances in Archaeological Method and Theory», 2, 119-140.

Schmidt E.F. 1940, *Flights over Ancient Cities of Iran*, Chicago, University of Chicago Press.

Smith P.E.L., Young T.C. 1983, *The Force of number: Population pressure in the Central Western Zagros*, in T.C. Young, P.E.L. Smith, P. Mortensen (eds.), *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia Presented to R. J. Braidwood*, Studies in Ancient Oriental Civilization 36, Chicago, The Oriental Institute of The University of Chicago, 141-162.

Wescott K.L., Brandon R.J., (eds.) 2000, *Practical Applications of GIS for Archaeologists: A Predictive Modelling Toolkit*, London, Taylor and Francis.

Wheatley D., Gillings M. 2002, *Spatial Technology and Archaeology: The Archaeological Applications of GIS*, London, Taylor and Francis.

Wilkinson K.N., Beck A.R., Philip G. 2006, *Satellite imagery as a resource in the prospection for archaeological sites in central Syria*, «Geoarchaeology», 21, 7, 735-750.

Wiseman J.R., El-Baz, F. (eds.) 2007, *Remote Sensing in Archaeology*, Interdisciplinary Contributions to Archaeology Book Series, New York, Springer.

Zubrow E. 2007, *Remote sensing fractals and cultural landscape: An ethnographic prolegomenon using U2 imagery*, in Wiseman, El-Baz 2007, 219-235.

ABSTRACT

The advent of new technologies has had a profound impact on the evolution of archaeological methodological approaches, allowing archaeologists to refine traditional assessments about the nature of past human societies and to expand their theoretical horizons. GIS-based technologies are among the new technologies aimed at reconstructing spatial-related aspects of past human communities. The paper illustrates the use of some ArcGIS tools supplemented with satellite low-resolution images to produce a layered workable archaeological map suitable for analyzing specific issues such as ancient cultural ecology and landscape reconstruction. Integrated satellite imagery and GIS analyses are applied to reconstruct spatial distribution patterns of the Chalcolithic period in Central Zagros as seen from the Sarfirouzabad valley adjacent to Mahidasht inter-mountainous plain, near Kermanshah, Iran. The search for considerable changes in the settlement distribution patterns relating to the ecological attributes is one of the aims of the paper, using GIS-based methods such as Thiessen polygons analysis, site-point spatial distribution analysis and buffer analysis. The results are discussed through categories covering distribution of Chalcolithic sites over the different environs of the study area, spatial distribution of pottery styles, and spatial models of Chalcolithic distribution patterns.