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A PCA Analysis of the Impacts of Environmental Factors on Prehistoric Settlement Patterns in Sarfiroozabad, Kermanshah, Iran

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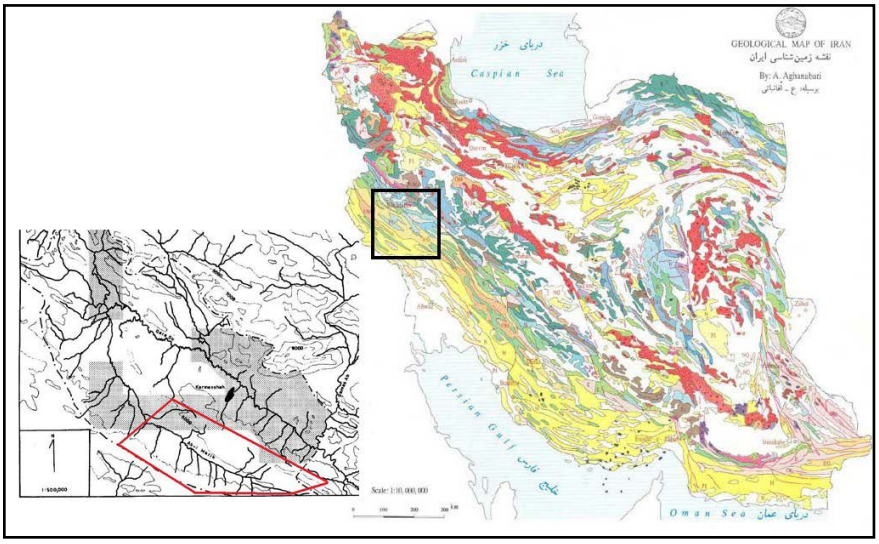
Abstract

This paper explores man-environment relationships during the prehistoric periods. It calculates the main factors affecting the establishment of prehistoric settlements in Sarfiroozabad rural district, south of Kermanshah County, which is south-eastern extension of Mahidasht. The research has been done on the basis of Environmental archaeology according to archaeological surface surveying data. The Principal Component Analysis method has been used to investigate the measure of natural and cultural factors involve in the prehistoric settlement patterns of the region. The general patterns of settlement distribution of the studied region are mainly unchanged through the long-term processes of man-environment relationship. The results also show that the impacting factors on settlement distribution patterns were different in every prehistoric period. The results could be used to reconstruction of man-environment interactions of the region to apply it in contemporary environmental management of it.. An important achievement of the project was dis-covering very earlier occupational evidences than what which was revealed from Mahidasht; re-sulting to a reconsideration of the origins of Neolithic settlements of the region such as Tepe Sar-ab.. In such a way, it could be possible to take into account attributes other than natural ones and consider potential cultural factors affecting settlement locating during prehistoric times. It is not to overleap the natural and environmental factors, but to examine site distributions according to their relations as well; as if each of them is a node on the complicated

network of occupying the valley through different periods. it should probably be impossible to get a comprehensive understanding of prehistoric settlement conditions of the region unless the excavations carried out to establish secure chronology. The current results are mainly based on relative chronology of surface sherds compared to the same material recovered accurately in temporal order from the stratigraphic de-posits of Mahidasht. However there is necessity to have absolute datings of prehistoric evidences of the valley.
Keywords: Environmental Archaeology, Principal Component Analysis, Geomatics, Correlation, Sarfiroozabad.

Introduction

The relationship between human culture and the environment, and their interactions and mutual impacts have been the focus of intense scholarly attention in environmental anthropology and Archaeology (see Dove & Carpenter, 2008; Evans & O′Connor, 1999; Dincauze, 2000). Environmental Archaeology deals with the role of the environment in the genesis and historical evolution of cultures and human societies. Mounds or ancient sites represent the primary data for environmental Archaeology. Archaeologists may reconstruct the cultural and environmental factors involved in past and present environmental processes through conducting surface surveys and identifying archeological sites over a specific geographic area as well as using chronological techniques and the paleoclimatic and paleoenvirnomental findings. The concept of "settlement systems" implies that human settlements (even in prehistory) by no means arose from some random, serendipitous or arbitrary choices, and that they were rather subject to specific patterns stemming from best decisions



Map 1. Location of the geographical sites of Sarfiroozabad, Kermanshah (Askarpour, 2019). ▶

of their occupants attain a most stable dwelling to the possible extent. In individual geographic areas, thus, the distribution of archaeological sites, environmental conditions and contexts, and the developmental level of societies are characterized by significant relations, which are in turn contingent on specific, examinable patterns.

Ancient sites represent tangible relics of human dwelling on earth. Through dwelling, human groups provoke alterations in the environment, transforming it into their own home or ecosystem (Odum & Barrett, 2005: 2), which is composed of a set of natural and human subsystems that together underpin man's biological survival (Butzer, 1982; Dincauze, 2000; Schutkowski, 2006; Jones, 2005; Sutton & Anderson, 2010). The correlations between these subsystems lend themselves to analytical appraisal, and archaeological surveys that are currently implemented using mixed method geomatic approaches have the potential to address the topic of human-environment interactions in prehistoric and historical periods as well as their evolution over time.

The preset study sets to examine the role played by environmental factors on the development and complexity of prehistoric settlements in the Sarfiroozabadvalley of Kermanshah. Settlement development and complexity denote the formation of settlement systems consisting of several correlated and interrelated settlements, viz. clustered settlements. It is generally assumed that in different periods of the late prehistory, environmental factors and contexts have significantly acted on the type of subsistence systems, on the one hand, and the complexity of settlements and the materialization of settlement systems, on the other. Particularly in the case of the present study, the main river of the valley, Ab-e Mereg, assumed a prominent place in prehistoric developments governing regional human-environment interactions. The region was covered by archaeological surveys for the first time in 2009 under the direction of one of the present authors (Niknami et al., unpublished, Askarpour, 2012).

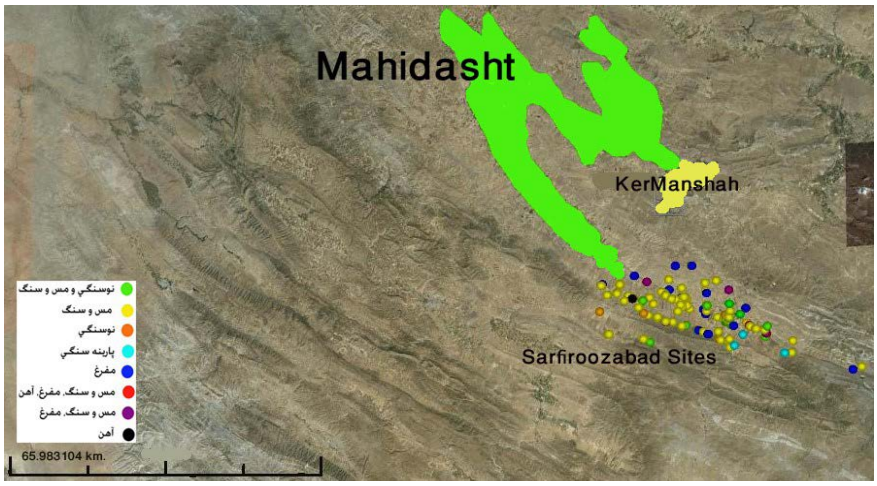
Materials and Methods

As appreciated by archaeologists from way back, archaeological evidence is characterized by a spatial character (Wheatley & Gillings, 2002: 2), and due to this spatiality, it is inevitably tied to environmental phenomena (Ibid: 3; Hall, 1982: 132). Thus, by the 1970s, some archaeologists, most notably David Clark, ventured to describe pinpointing the spatial relations of the archaeological evidence and environmental phenomena as the foremost aim of Archaeology (Clarke, 1977a). In the United Kingdom of the 1910s

and 1920s, authors such as Crawford and Fox reasserted the decisive role of geographic and environmental dynamics in the establishment of settlement patterns (Trigger, 1989: 249). The latter represent the idiosyncratic spatial manifestations of human societies that reflect different strategies they take on in adapting to their surrounding environment (Evans & Gould, 1982: 276). Scholarship on settlement patterns and their relationship would climax in the United States with the ecological approaches advanced by Julian Steward and Willie Arthur Chalfant (Clarke, 1977b: 3). They sought to pin down the causal relations governing the distribution of ancient settlements within a specific geographic environment via simple representation of ancient archaeological evidence in the form of various symbols on distribution maps. The 1960s saw an indispensable swing in devotion to the spatial information in Archaeology and the applied techniques to determine the patterns and spatial relationships of archaeological evidence and environmental phenomena (Wheatley & Gillings, 2002: 5), as result of which the simple use of distribution maps of ancient sites was supplanted by quantitative and computational approaches and techniques (Hodder & Orton, 1976).

An array of methods have thus far been considered and utilized for archaeological spatial analysis. Among the earliest of these is Point Pattern Analysis, the most frequent application of which concerns site catchment analysis (Hall, 1982: 132). A most common approach for this method in archaeological research is exploring cross-site patterns using Thiessen polygons (Hall, 1982: 133). Nearest Neighbor Analysis is another commonly used approach in determining the spatial pattern of sites at a regional level (Hall, 1982: 133).

In the present work, quantitative and statistical analyses and diagrams replace the site distribution maps right from the beginning to provide purely quantitative models, irrespective of how the sites are distributed over the study area. The pioneer of the approach was Martin Hall, who embarked on multidimensional scaling analyses of the sites on Zululand of South Africa (Hall, 1982). Regarding the Iranian sites, quantifying trends in the analysis of settlement patterns would be discussed for the first time at a seminar on Patterns of Settlement and Cultural Development in Western Iran held in the United States in 1977 (Niknami, 2010), whose proceedings would be published in the volume Archaeology of Western Iran (Hole, 2002). In his article “Western Iran in the Partho-Sasanian Period: The Imperial Transformation, ” Robert J. Wenke meticulously applied multidimensional scaling analysis to demonstrate the



◄ **Map 2. Distribution of prehistoric sites of Sarfiroozabad, Kermanshah, by periods (Askarpour, 2019).**

environmental and human contexts involved in the Arabs advance into interior Iran from the southwest (Khuzestan) in a correlated, matrixial form (Wenke, 2002). The present study builds on this new approach to environmental Archaeology, with the notable exception that it replaces the Principal Component Analysis (PCA) with the Multidimensional Scaling Analysis.

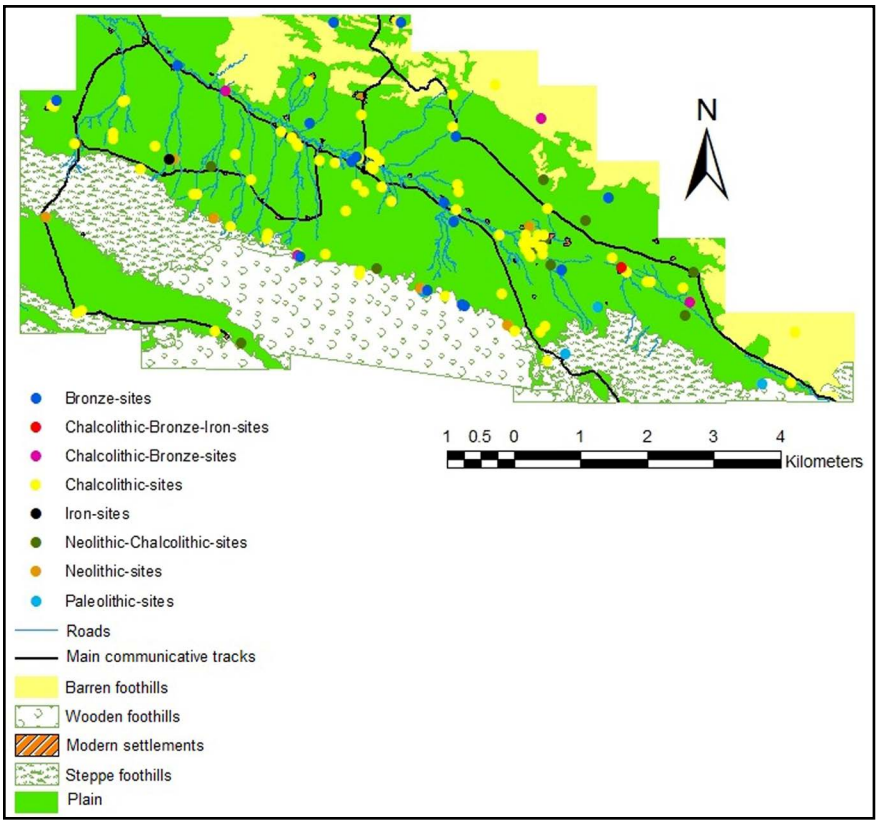
The paper draws on the findings from the archaeological survey of Sar Firuzabad, Kermanshah (Fig. 1), carried out under the direction of K. Niknami (Niknami et al., unpublished). Sarfiroozabadrepresents an eastern extension of Mahidasht, which is a fairly well-known territory archaeologically (Braidwood & Howe, 1960; Braidwood et al., 1961; Young & Smith, 1966; Smith, 1967; Levine, 1974; Smith, 1974; Levine; & McDonald, 1977; McDonald, 1979; Hesse, 1982; Braidwood et al., 1983; Henrickson, 1983; Henrickson, 1989). The Ab-e Mereg is the major running water source of the area, flowing westward across the valley. The study area is hemmed in by the ranges of Sefid Kuh to the north and Nesar to the south. Surveys in the region have brought to light archaeological evidence dating back as early as the mid-Paleolithic. Of the total of 332 sites identified in these surveys, 162 belong to prehistory. For the purposes of the present study, some 122 sites were sampled and analyzed in virtue of higher reliability of their relative chronologies. The sample represents different prehistoric periods, including the Paleolithic (ca. 21, 000 years ago), Neolithic (12, 000 to 7, 000 years ago), Chalcolithic (7, 000 to 5, 000 years ago) and Bronze Age (5, 000 to 3, 000 years ago) (Map 2).

A simple GIS-based analysis reveals the localization and distribution patterns of the regional prehistoric sites (Map 3). The Sarfiroozabaddistrict consists of several environmental subzones: the lands flanking the Ab-e Mereg, the plain and agricultural lands, the

Attribute	Description
1	Site located at an altitude of less than 1500 m a.s.l.
2	Site located at an altitude of less than 1600 m a.s.l.
3	Site located at an altitude of less than 1700 m a.s.l.
4	Site located at an altitude of less than 1900 m a.s.l.
5	Site located on the limits of the river (1000 m)
6	Site located in the plain
7	Site located in the wooden foothills
8	Site located in the Steppe foothills
9	Site located in the barren foothills
10	Site located on the limits of the communicative tracks (1000 m)
11	Site located on the limits of the modern settlements (100 m)
12	Site located on the limits of its contemporary settlements (100 m)
13	Site located on the limits of settlements of the past period (100 m)
14	Occurrence on the site of painted potsherds
15	Site size less than 0.1 ha
16	Site size less than 0.5 ha
17	Site size less than 1 ha
18	Site size more than 1 ha

Table 1. Complications studied and calculated in present study (Askarpour, 2019). ▶

southern forest foothills, the southwestern steppe foothills, and the northeastern barren foothills. The Paleolithic sites are scattered over the forest foothills. During the Neolithic period, the sites proceeded up to the steppe foothills, the plain and even the lands flanking the river, but they still remained separated by significant distances. The Chalcolithic period witnessed an unprecedented and intense upsurge in the number and distribution of settlements throughout the study area, while by the Bronze Age many of these settlements would be



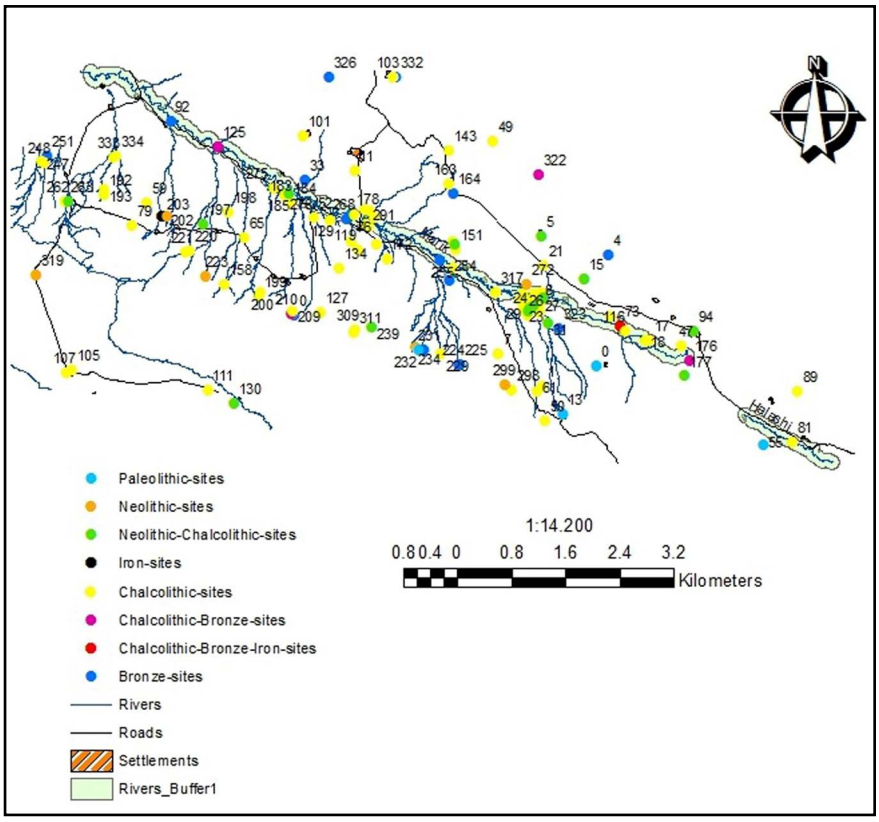
Map 3. Distribution of Sarfiroozabad sites in different zones by periods (Askarpour, 2019). ▶

Rotated Component Matrix[a]			
	Component		
	1	2	3
Altitude	.846		
Environment	.789		
Road		.773	
Contemporary Settlements		.769	
Clustered Settlements			.529
Past Period Settlements			.910
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 4 iterations.			

◄ **Table 2. Reduced agents using the PCA method (Askarpour, 2019).**

abandoned, with only a few persisting across the whole valley.

Two major environmental factors have worked on the distribution of prehistoric sites in the Sarfiroozabadvalley: the Ab-e Mereg (Map 4), and the natural lines of communication (Map 5). The Paleolithic and Neolithic sites generally stood far from the Ab-e Mereg. Yet, in



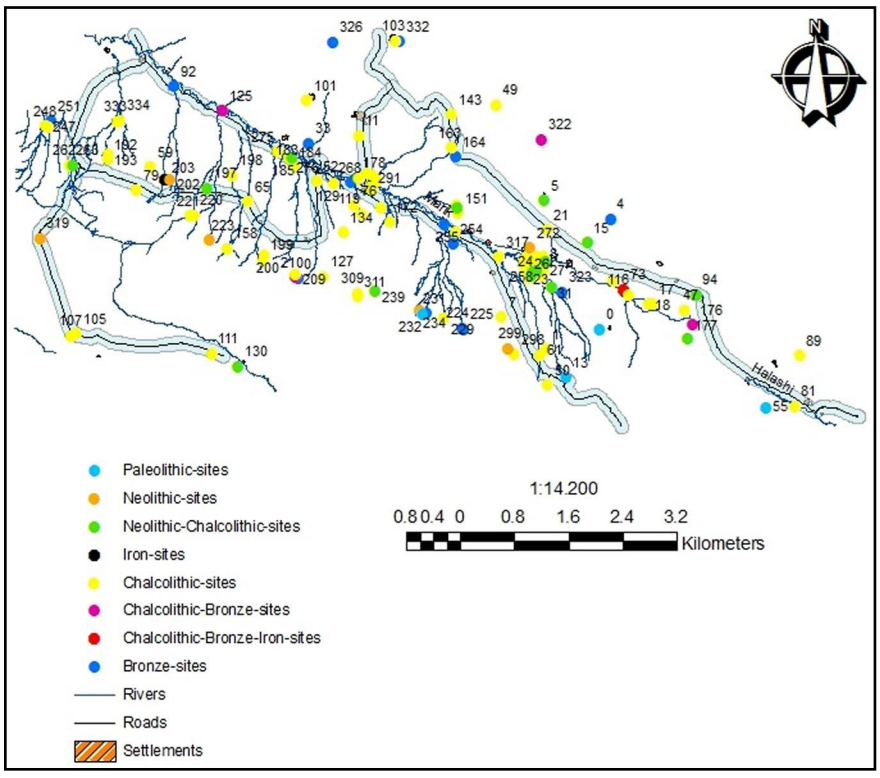
◄ **Map 4. Distribution of prehistoric sites of Sarfiroozabad in relation to the area of main natural passages (Askarpour, 2019).**

the Chalcolithic, with the increased population and higher reliance on crops, the concentration of settlements augmented significantly along the river, where the first settlement systems began to emerge. The settlements near the natural lines of communication similarly increased over time, particularly during the Chalcolithic and Bronze Ages, suggesting that local residents attempted to establish contacts with neighboring areas.

This study builds on assessing natural and cultural phenomena (Table 1) in relation to each other and in a correlated network. To this end, the presence or absence of natural and cultural phenomena at any individual site was determined and indicated in a table, and then the most important phenomena affecting the distribution of prehistoric sites in the area were identified via PCA methodology (Table 2).

Findings

The results of PCA measurements showed that the following three factors were the major determinants in the distribution of prehistoric settlements in Sar Firuzabad: environmental factor (F1), communicative factor (F2), and the cultural factor of spatial interrelationship of settlements (F3). Then, the correlations between these three factors were calculated, yielding the following results:



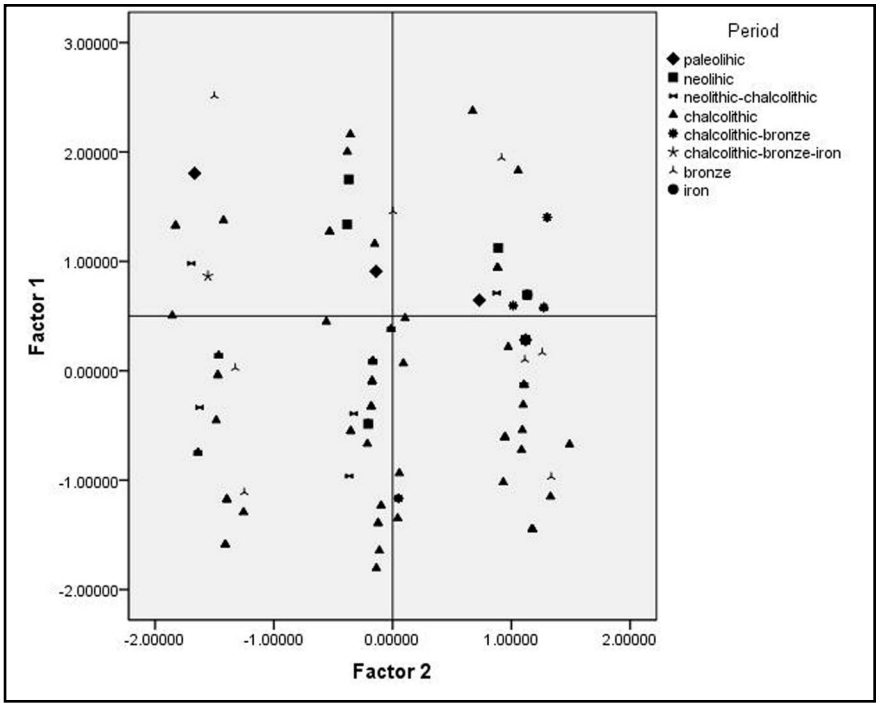
Map 5. Distribution of prehistoric sites of Sarfiroozabad in relation to the area of Ab-merk river (Askarpour, 2019). ▶

a. Neolithic settlements (7, 000-5000 BCE) in the valley appear to incline more towards F1-F3 (Fig 2) and F2-F3 matrix (Fig. 3). These settlements are all widely scattered and placed a considerable distance from each other, and most of them fall far from the main lines of communication (natural mountain passes).

b. Most of the Bronze Age sites were affected by F1 and F2. The related settlements cover more than half a hectare in area and are generally scattered between elevations of about 1, 600-1, 700 meters. Some 67% of these sites were isolated settlements and lay close to the main lines of communication.

c. The bunched settlements (those located close to each other to form settlement complexes) mainly tended towards F2 and were distributed both far from the main lines of communication and outside the boundaries of the present-day villages and rural districts. About 59% of such sites lie on the plain, and almost all of them date to the Chalcolithic.

d. The F1-F3 correlation matrix is indicative of a positive correlation between the "isolation" of settlements from each other and their distribution within the boundaries of the main lines of communication. In other words, the isolated settlements lying far from contemporaneous centers have a greater tendency to be localized close to the lines of communication and distant from the main river. Such settlements mainly show a Chalcolithic or Bronze Age date.



◄ **Chart 1. Correlation matrix of one (environmental)and two (communication) factors studied (Askarpour, 2019).**

e. The F1-F2 correlation matrix (Fig. 1) reveals a positive correlation between "the location of settlements within the boundaries of earlier sites" and "the clustered nature of those settlements." This means that prehistoric settlements were generally developed in parts of the valley that already hosted human communities in preceding periods. These settlements belong invariably to the Chalcolithic Ages, and interestingly, they are mostly sited far from the main lines of communication, though being close to the main river.

f. In prehistoric archaeology, painted pottery represents a defining characteristic of the ethnic identity of human groups in that the emergence and advance of painted ceramics is seen as a hallmark of the progress and complexity of local and regional social systems. Now, by examining the presence/absence of the painted sherds in the surface pottery assemblages from the prehistoric sites of the Sarfiroozabadvalley, we find that they occur in higher frequencies in the settlements associated with F2. In other words, a positive correlation exists between the presence of painted pottery and their location in the lower parts of the valley, their proximity to the main river and their clustering. This observation is a further attestation to the fact that the invention of painted pottery in prehistory was a consequence of the arrival of complex settlement systems and increased inter-settlement ties among the societies, a fact that in turn was widely affected by environmental capacities.

g. In this valley, there are three types of settlements that exceed

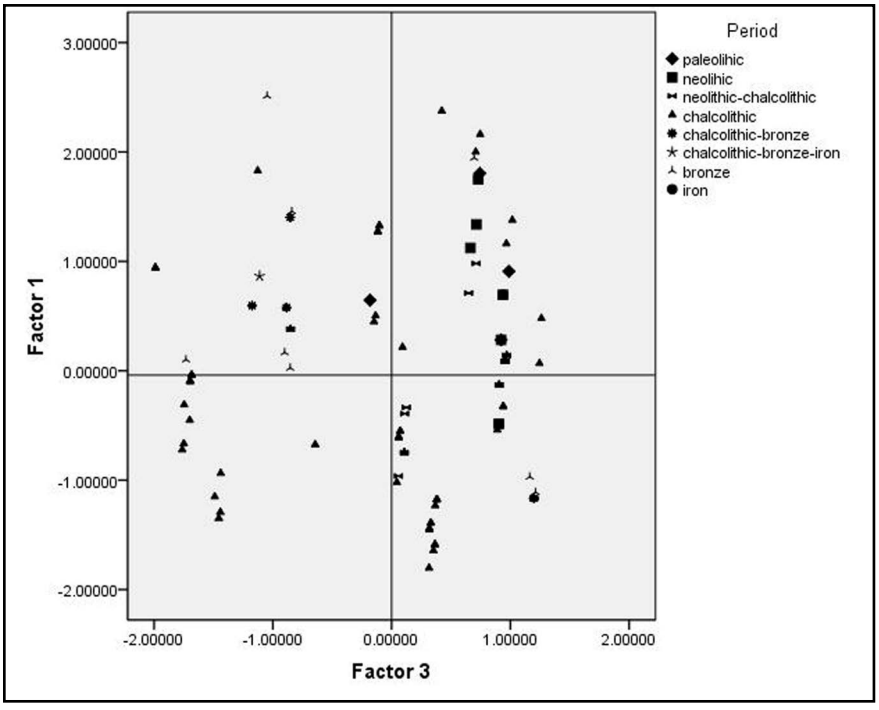


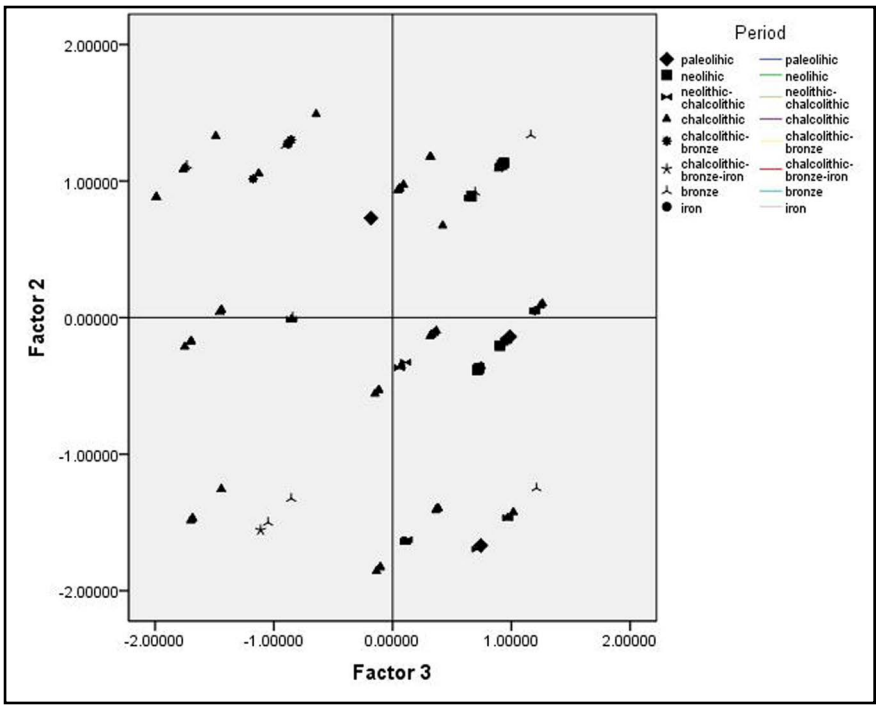
Chart 2. Correlation matrix of one (environmental) and three (cultural) factors studied (Askarpour, 2019). ▶

a hectare in area (ranging from small to larger villages). The first group consists of the detached settlements, which are centered in the lower parts of the plain close to the main river, and belong to the Chalcolithic era. The second concerns the clustered settlements, concentrated in the higher parts of the valley and mountain slopes and dated to the Chalcolithic and Bronze Ages. And, the isolated settlements situated on the main river and belonging to the Bronze Age make up the final group.

Discussion

Having examined the three influential factors on the distribution and location of the prehistoric settlements of Sar Firuzabad, we can now more easily embark on appraising the environmental patterns for that distribution and positioning as well as their chronological evolution. Two issues are to be addressed in this respect: one is the evolution of the subsistence and economic systems of prehistoric inhabitants of Sarfiroozabadbased on environmental capacities, and the other is the evolution of the local settlement patterns in different prehistoric periods.

The results suggest that "environment" and environmental factors were among the major determinants in the distribution of prehistoric sites. The main river of the valley, Ab-e-Mereg, was the core of rapid changes in the settlement schemes of the prehistoric populations from the Neolithic to the end of the Bronze Age. It is clear that the



◄ **Chart 3. Correlation matrix of two (communication) and three (cultural) factors studied (Askarpour, 2019).**

earliest settlement systems (consisting of a group of settlements with partially superimposed boundaries and spatial relationships) appeared along the river in the eastern parts of the valley in the Chalcolithic period.

In light of our findings, the isolated and clustered settlements exhibit contrasting distribution patterns: the former are concentrated along the main lines of communication, higher elevations, close to the foothills, and remote from the earlier settlements, while the latter lie far from the main lines of communication, in the lower parts of the valley, next to the main river and within the precincts of the past settlements. Another differentiating point is the frequency of painted sherds, which occur in higher abundance on the clustered settlements.

Mortensen, with regard to Mahidasht of Kermanshah, points out that the distribution of the Neolithic settlements show a tendency for clustering (Hole, 2002). Yet, our findings suggest that the bunched positioning of the prehistoric settlements depended on the environmental circumstances. In the case of Sar Firuzabad, the clustering occurs only in the eastern parts of the valley and near the main river, while in the remaining parts the Neolithic sites are detached and spaced apart.

During the Chalcolithic period, the population of the valley experienced a sudden increase due to the influx of new peoples (Hole, 2002). The incidence is attested in the archeological record by the appearance of two distinct pottery traditions, viz. Dalma Ware and Ubaid Ware (Young, 1963) in northern and western Iran. This population surge leads to two different distribution patterns in the region: one is the advent of settlement systems characterized by sites with overlapping boundaries and arranged in a “circular” outline in the proximity of the main river of the plain, invoking an agriculture-based subsistence. And, the second is the “linear” distribution of settlements along the southern foothills, which contain auspicious natural pastures for livestock. The Chalcolithic settlements along the main river display a higher average expanse than those arranged linearly along the southern slopes.

As a hallmark typical to the prehistoric intermountain valleys of the Central Zagros (Wilkinson, 2003: 184-185), including Mahidasht, the arrival of the mid-Holocene climatic regime associated with an increase in the average annual temperature since about 5, 000 years ago and the predominance of warmer, drier conditions in the region led to the replacement of farming with the specialized livestock raising as the underlying subsistence strategy at the dawn of the

Bronze Age. In the previous Chalcolithic period, settlement systems had formed along the permanent river of Sarfiroozabadand relied on plant cultivation by means of permanent water resources. However, due to the climatic change coupled with the population rise in the Middle and Late Chalcolithic, most of the permanent settlements across the valley were abandoned, giving way to temporary nomad camps. The scarce surviving permanent sites (about 5 of which were identified) were not but isolated settlements that could have functioned as chiefdoms or seasonal marketplaces.

Henrickson (2002) suggested that with the advent of the Bronze Age communities on the highlands (Central Zagros) became politically independent of the lowlands (Khuzestan and Mesopotamia). As already indicated by Nissen and Lutzeier (1990), during this period many settlements would vanish despite the persistence of a small number of them. This meant the emergence on the highlands of a different political system based on nomadism, on which environmental factors still left deep impressions.

Thus, in the Neolithic period, first a mixed economic and subsistence pattern was established in landscapes characterized by the diversity of natural resources, causing a sprinkled distribution of settlements. In the Chalcolithic period, two specialized subsistence patterns would develop from that mixed pattern: one was the specialized agriculture in the lower parts of this intermontane valley with sustainable resources that gradually led to complex settlement clusters; and the other was the specialized nomadic pastoralism in the higher elevations that gave rise to the temporary, detached settlements. The same patterns would endure, albeit in a more limited extent, during the Bronze Age, with the only discernible difference that the settlement systems established in the previous period now either disappeared or assumed a novel configuration that is yet to be grasped by scholars.

The ecology of Sarfiroozabadis the product of long-term processes, which in turn were fashioned by the continuous and correlated interactions of its entire animate and inanimate constituents, and human decisions to settle the region were also among the factors precipitating transformation of its environmental forms over time. Since these processes are still in full swing and human factors seem to continue to take an important place in future developments of the region, the regional environmental planners, having understood the history of its developments, are expected to envisage the "contexts, structures and dynamics" of the imminent local transformations (Niknami, 2004), and to make allowances for them in their future

policies, especially with respect to future models of human settlement and a subsistence system befitting that landscape.

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