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Between the Mountain and the Plain. A case Study of Remote-Sensing Analysis from the Area of Izeh (Khuzistan, Iran)

Francesca Giusto[1], **Enrico Foietta**[2]

1. Department of Historical Studies, University of Torino, Torino, Italy. E-mail: franci.giusto@tiscali.it.
2. Department of Historical Studies, University of Torino, Torino, Italy. E-mail: enrico.foietta@gmail.com.

Abstract:

The study area is located in the central-western area of the Zagros, in the upper basin of the Karun. The work presented here focused on the plain of Izeh and the surrounding mountains, in north-eastern Khuzistan. The plain of Izeh is rich in important archaeological occurrence, such as the sites of Kul-e Farah and Shikaft-e Salman, and has been densely settled almost continuously from the prehistoric period to modern times. The adjacent mountains are giving back several testimonies of the human presence in the area as well, such as the sanctuary of Shami. The way of conducting a remote-sensing analysis in archaeology clearly depends on the characteristics of the landscape. Archaeological landscape studies focused in the past mainly on plain areas, while few researches regarded highlands. Our research area is characterized by different natural features, such as mountain slopes, valleys, highlands, and intermontane plains having a spatial close relationship. This study tries to highlight peculiarities and similarities of how the archaeological features are detectable on satellite imagery for different kind of landscapes. New studies on landscape archaeology are stressing the economic, political, strategical and cultural importance of apparently marginal areas too. A 'holistic' study of the territory evaluating the different ecological niches allow to better understand how man occupied a specific ancient territory and exploited its natural resources. The study is based on the interpretation of different kinds of imagery, such as cartography, satellite images and digital elevation models as well as on published and unpublished surveys and excavation data.

Keywords:

Landscape Archaeology; Izeh; Remote-Sensing Analysis; Highlands; Plains.

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1. Introduction

This paper presents a study of remote sensing-analysis for detecting archaeological features in an area characterized by different types of landscapes, such as highlands and plains. The study tries to highlight peculiarities and similarities of how the archaeological features are detectable on satellite imagery in this very different kind of landscapes. There is an extensive bibliography on the methods of remote- sensing analysis for plain areas in the ancient Near East (for example: Wilkinson 2003, Chapters 3-7; Altaweel 2005; Alizadeh, Ur 2007; Parcak 2009).

As far as mountain areas are concerned, however, a much smaller number of studies can be found (for example: Thomas, Kidd, Nikolovski, Zipfel 2008; Scardozzi 2012; Ansart, Braemer, Davtian 2016; Reinhold, Belinskiy, Korobov 2016) and a solid and consistent methodology still remains to be built.

The study focuses on the plain of Izeh and the surrounding mountains, in the north-eastern part of the Khuzestan province. The plain of Izeh is rich in important archaeological occurrence, such as the famous sites with rock reliefs of Kul-e Farah and Shikaft-e Salman (Henkelman, Khaksar 2014; Álvarez-Mon 2019: 27-38, 42-91) and Hung-e Azhdar (Messina 2015 ed.), and has been densely settled almost continuously from the prehistoric period to modern times (Wright 1979 ed.). The adjacent mountains have given back several testimonies of the human presence in the area as well, such as the sanctuary of Shami (Stein 1940: 141-158; Bucci *et alii* 2018, with bibliography). The first archaeological survey of the Izeh plain was carried out by Sir A. Stein in 1936 (Stein 1940: 128-130, 135-138), while A. Godard in 1937 briefly investigated the Plain of Piyun and excavated few trenches, the results of which have only been partially published (Godard 1965: 153-156) (Fig. 1). Extensive unsystematic surveys were conducted in 1976 under the direction of H.T. Wright (University of Michigan) in the Plain of Izeh (Wright 1979, ed.: 33-130), while in 2008-2009 the *Iranian Italian Joint Expedition in Khuzestan*, directed by V. Messina (University of Torino) and J. Mehr Kian (Ayapir Heritage Cultural Base, Izeh), carried out a brief unsystematic survey in the area around the site of Hung-e Azhdar (Faraji, Mehr Kian, Sourani 2015). The Izeh plain was also investigated in 2007 during a study conducted by M. Jayez (Iranian Center for Archaeological Research) and K.A. Niknami (University of Tehran) aimed at identifying prehistoric evidence in the area (Niknami, Jayez 2012). The plain of Piyun was intensively and systematically surveyed by a mission led by M. Jayez, K.A. Niknami and K. M. Mirzai (Cultural Heritage, Handicrafts and Tourism Organization of Hamedan) in 2008: the data published so far concern only the prehistoric period (Jayez, Mirzai, Niknami 2019).

The limits of the study area [(1)] are formed by the perimeter of a panchromatic high-resolution satellite image Quickbird (©Digital Globe), acquired on 08-05-2009 and The image covers the plain of Piyun, the northern portion of the plain of Izeh with the Lake Miangharan, and includes large portions of the nearby highlands, showing ranges of mountains and few valleys (Fig.1). The chosen study area as limited by the perimeter of the high-resolution image, therefore, cover different types of environments. Thus, it is particularly suitable for the research question, that is to understand how anthropogenic anomalies can occur in different geographical contexts.

having a ground resolution of 50 cm, which was acquired for a previous research work conducted in the Plain of Izeh by the University of Torino (Messina 2015, ed.).

2. The Methodology

For the remote-sensing analysis the QGIS software (version 3.10.6 - La Coruña) was used. The GIS project dataset includes cartography at various scales and satellite and aerial images acquired during a different time-span, as can be seen in Table 1 (Tab. 1). The reference system of the GIS project is WGS84 UTM zone 39N.

Table 1. The dataset of the GIS project.

Type of data	Definition and acquisition	Resolution	Covering of the studied area
Satellite image	Quickbird (©Digital Globe); 05-08-2009	High ground resolution: 50 cm ground cell size	Entirely covered
Satellite images	Google Earth Pro (https://www.google.com/intl/it/earth).	Medium ground resolution	Entirely covered
Aerial images	Bing maps catalogue - Image ©2021 Maxar, ©2021 TomTom (https://www.bing.com/maps/aerial). View with WMS on Qgis	Medium ground resolution	Entirely covered
Satellite images	Google catalogue - Image ©2021 CNES/Airbus Landsat/Copernicus Maxar Technologies, U.S. Geological Survey. (https://www.google.it/maps). View with WMS on Qgis	Medium ground resolution	Entirely covered
DSM	DSM ALOS WORLD 3D - Japan Aerospace Exploration Agency (©JAXA)	Low ground resolution: 30 m ground cell size + 5 m of standard deviation	Entirely covered
Topographical maps – vectorial data	Iranian National Cartographic Center (©NCC)	1:25000	Not entirely covered
Topographical maps	Iranian National Geographic Organization (©NGO), sheets 5953I Īzeh (1999); 5953IV Chamreyhān (1999)	1:50000	Not entirely covered
Topographical map	URSS topographical map (VTU), series SK 42, sheet H-39-4 (1976) (codice: Г-44 III 76-T) (©военно топографическое управление генерального штаба)	1:100000	Entirely covered
Soil map	Iranian Soil and Water Rearch institute, sheet Khuzestan, 1991 (©Soil and Water Research Institute).	1:250000	Entirely covered
Geological map	Iranian Oil Operation Company, sheet 20825E (Kūh-e Āsmārī) (1966) (© Iranian Oil Operation Company)	1:100000	Entirely covered

The study of the remote sensing images was carried out by the two authors maintaining a constant scale of 1: 5000, and consisted of a visual interpretation (Lillesand, Kiefer, Chipman 2004: 193-207; Parcak 2009: 85-88; Lasaponara, Masini 2012: 7-9). The use of three different types of remote-sensing images covering the same territory and acquired in different periods allow to compare diachronically the different evidences identified on the individual images. For example, the possibility of displaying satellite images acquired in different seasons and years on Google Earth proved to be particularly useful. A further tool for comparison and

implementation of information is represented by the 1: 25.000 and 1: 50.000 scale topographic maps of Iranian production and by the 1: 100.000 scale topographic map of URSS production. Specifically, the maps also offer the possibility of diachronic analysis, since URSS cartography was developed for military purposes in the 1970s, while the Iranian one is of recent production.

The data from the various surveys were processed on the QGIS project through the creation of different layers of points. As can be seen in Fig.1, the surveys mainly concerned the plain areas, but did not involve the whole territory examined in this paper (Fig. 1). In particular, the mountainous reliefs surrounding the plain of Izeh, which are taken into consideration in the remote-sensing analysis, have never been surveyed.

The survey maps published by Wright (Wright 1979, ed.: Figs. 11-12, 15-17, 21-24, 26, 36, 39-40, 48-49, 50) do not have associated geographic coordinates: therefore, the maps were manually georeferenced using identifiable points from physical geography (river intersections and relief limits). Thus, the vectorization of the survey data could not be very precise and had to be checked against the features visible on the remote-sensing images in order to more precisely identify the archaeological occurrences. Based on the proximity between the anomalies found through remote-sensing detection and the location of the sites recorded in the maps published in Wright 1979, a process of interpretation was carried out; that is, it has been hypothesized that, if the anomalies are located close to the sites (but not perfectly in correspondence with the latter), the anomalies could describe the archaeological sites identified on the ground in 1976. This operation is clearly not free from risks and require new field survey in order to verify the identification proposed here.

In the present study, only historical sites have been taken into consideration, as prehistoric sites usually do not leave traces easily perceptible throughout remote sensing visual inspection. For example, the survey directed by M. Jayez, K. Mirzai and K. Niknami in the Piyun area (Jayez, Mirzai, Niknami 2019) has identified numerous rock-shelter sites occupied in prehistoric times which, however, seem to show no visible traces on the remote-sensing images.

The study presented here aim at building some preliminary guidelines for interpreting, throughout a remote sensing analysis, the whole man-built landscape, forming the base for future archaeological studies in the area focused on specific periods.

3. The geographical setting

The study area is characterized by two plain areas, the plains of Izeh and Piyun, entirely surrounded by mountain ranges [(2)] (Fig. 2). Immediately to the east, outside the study area, flows the Karun River, one of the most important watercourses of the Khuzestan province.

The plain of Piyun or Pīān has small dimensions and covers an area of about 25 Km [(3)]; it has an elongated shape, develops in a north-west/south-east direction and is almost completely surrounded by mountains. A narrow flat corridor to the north allows to exit the plain and enter the valley of Delī. A group of mountains stretches eastwards, restricting the access to the contiguous plain of Izeh, located immediately to the south, to a narrow flat portion about 500 m wide. To the south-east of the plain of Piyun there is the plain of Izeh or Īẕeh, which is about 140 km^2 wide and is characterized by two seasonal lakes. The plain is surrounded, on its south, east and west sides, by mountain ranges having a north-west/south-east orientation. The plains of Piyun and Izeh have an altitude of 800 m asl approximately and are formed by recent alluvial deposits, not consolidated, dating back to the Quaternary.

The mountains that flank the two plains to the east show altitudes comprised between 1000 and 2000 m asl and have steep slopes. The reliefs to the west are lower and have rounded profiles, with medium altitudes of 1000 m asl; between the mountain ranges there are few small valleys. The southern side of the plain of Izeh is flanked by low reliefs, ranging between 1000-1500 m asl, while further to the south there is the mountain massif of Mungašt, whose peaks reach about 3000 m asl. A group of lower and steeper mountains, high from 1000 to 1500 m asl, stretches in the southern portion of the plain and runs along the lake of Bandān on three sides, forming a sort of pincer. To the south-west and north-west sides of the Izeh plain the reliefs leave two narrow flat corridors that allow to exit the plain towards west. Finally, in the north-eastern portion of the area under examination, the mountains open into a small valley area which constitutes the prelude to the Susan plain; the latter is located further north, outside the study area.

In the plain of Izeh there are two large seasonal lakes, the Lake Bandān, to the south-east, and the Lake Miangharan (known also as Menqar or Īẕeh), to the north-west.[(4)] The lakes collect the water of the seasonal streams that descend from the surrounding mountains, characterizing the plain as an endorheic basin. The two lakes reach, during the rainy season (spring and autumn), an extension up to 20 km^2; however, in summer, due to the high temperatures, they dry up partially or completely, turning into marshes or into arid patches of soil heavily saturated with salt. The permanent springs are mainly found in the mountain zone, while in the plains of Piyun and Izeh there are numerous seasonal karst springs. The precipitations, having an average of 600 mm per year, are abundant enough to allow dry farming.

The plain areas can be classified as semi-steppe, while the surrounding mountains are covered, between 900 and 2200 m asl., by a sparse forest of chestnut, oak and juniper trees. Grasslands are extensively used for grazing (Niknami, Jayez 2012: 8-9, 13-15).

The plains of Izeh and Piyun are covered by a soil of alluvial origin, rich in clay and silts, which is highly fertile.[(6)] Thus, the plains are particularly favorable for agricultural exploitation and are currently cultivated both by irrigation and dry farming: the most common crops are cereals, sugar cane and alfalfa. The mountains surrounding the plains, on the other hand, have thin soils rich in lithic clasts. These latter areas show a low agricultural potential, and are mainly used for seasonal grazing or, in the less steep zones, for dry farming thorough the construction of terraced fields.

The largest city in the area is the city of Izeh, which forms the capital of the county (shahrestān) of Izeh; in the plain of Piyun there is the town of Piyun or Pīān or Pošt-e Pīān. The other modern settlements are quite small and are mainly located at the foot of the reliefs.[(7)]

4. Remote sensing analysis

Remote sensing analysis has included the detection of different types of man-built occurrences of different chronology, for understanding the entire archaeological landscape of the area. With the use of contemporary cartography, it has been possible to sort the recent and still in use man-built structures (inhabited areas, isolated buildings, canal systems, roads and more), focusing mainly on the ancient or ruined structures and anomalies

4.1. Settlements and productive areas

Tappeh (T1-T6)

Tappeh are the first type of anomalies discussed here and identified possibly as settlements in the area of the plains of Izeh and Piyun (Figs. 3-4). These remains appear on the panchromatic satellite image as marks

of light or dark color, clearly identifiable from the surrounding area with strong defined limits. In all the identified cases, a three-dimension of the element is recognizable; meanwhile their shape can be both circular or ovoid. The dimensions of the six tappeh detected in the area are 61.000 m^2 (T1); 30.000 m^2 (T2-Choga Kal); 23.000 m^2 (T3); 14.300 m^2 (T4); 1929 m^2 (T5); 8800 m^2 (T6). Their shape is the result of a process of progressive accumulation of material used for their construction, made of mud-bricks or mud above the basement and foundations (see also Messina, Mehr Kian 2019: 41; Messina 2020: 95-99). A last Tappeh (T6) was identified by crossing data between the hillshade model and satellite images in the area north-east of the Lake Miangharan. This anomaly, clearly visible on the hillshade model, was only partially identified by photo interpretation.

4.2 'Group A' and 'Group B'

In the mountain area, and specifically in the valleys between the mountain chains, there are further types of evidence attributable probably to ancient settlements, which can be grouped into two main categories defined in this paper as 'Group A' and 'Group B' (Fig. 3) (Giusto 2021: 22-29).

The areas belonging to 'Group A' are presented as groups of buildings composed by several rooms of which the plan is clearly identifiable. The walls appear as thin light-colored lines with sharp outlines associated sometimes with black lines, which represent their shadow. Therefore, the buildings appear as partially ruined, but the elevation of the walls seems to be partially still standing. Given the state of conservation, it is plausible that this group of structures is 'quite recent'. The identification as modern buildings is also confirmed by the comparison with the Iranian cartography on a scale of 1:50.000, where these ruins are marked in this way [(2)].

The areas of 'Group B' appear as clusters of structures with one or more buildings in a more advanced state of destruction in comparison with 'Group A'. The plan of the buildings remains usually visible, but the elevation of walls cannot be distinguished. Compared to 'Group A' the structures are more tenuously detectable through photo identification. The lines that define the walls layout are marked with a lighter color on the panchromatic image in comparison with 'Group A' structures. The walls are usually without close shadows for the advanced degree of destruction and have a less pronounced tonal difference in comparison with the color of the nearby surface.

These two groups of settlements has not been yet found in the plain environment according to the study of panchromatic satellite image at a scale of 1:5000. Taphonomic factors could explain this lack. Given that the mountain areas are much less inhabited and exploited than the plains of Piyun and Izeh, the ancient buildings have probably a better conservation over time. At last, the evidences identified in 'Group A' and 'Group B' belong all to structures for which the main construction material is the stone[(2)] The intrinsic characteristics of the material allows probably a better conservation (and therefore visibility) of the buildings in areas that are not particularly populated, differently to the structures built in mud-bricks (see also Wilkinson 2003: 42).

4-3. Stone mounds

Stone mounds are another type of anomaly identified in this research, which seems peculiar of mountain and piedmont areas (Fig. 3). This type of anomaly appears as particular accumulations of stones with different shape and direction in comparison to other stone elements of the surrounding landscape (Giusto 2021: 46-47). In fact, nevertheless in the mountain areas the surface is usually covered of stones and boulders, these stone mounds are clearly recognizable as man-built remains. Long parallel stone mounds are usually visible along and on cultivated fields:

these must be identified as the accumulations of stone material pushed and grouped after the repeated cleaning of the cultivated fields (Wilkinson 2003: 53, 55, Fig. 4.5). Furthermore, the fields built on terraces, if not in use, show the presence of the collapses of stones originating from the decay of the retaining walls. If there are stone accumulations that differ from the stone mounds arranged in parallel lines, which have a greater development in extension rather than in length and an irregular shape, these are plausibly identified as collapsed stone buildings.

This class of anomalies is recognizable, however, only if the stone mounds are numerous and developed in width. Thus, they can be interpreted as a possible indication for the presence of clusters of buried buildings.

4.4. Small white marks

This type of anomaly appears on the panchromatic satellite image as light marks of small size. Dark linear traces are recognizable sometimes inside them, defining probably the layout of single or multiple rooms. The comparison with a satellite image from Google Earth acquired on 04-24-2021 (coordinates: 31°51'38.23 "N; 49°51'11.91" E) can be useful for defining this type of anomaly, showing the destruction of buildings at least partly constructed in stone with varying degrees of decay near the south part of the Lake Miangharan. Thus, the small white marks can be interpreted as the result of the whole buildings destruction process. The shape of the marks can be rectangular, square, rhomboid or ovoid. These are generally between 60 and 200 m^2 wide. Differently from other types of anomalies encountered in this work, small light marks are found in both the environments discussed in the study. The marks are found in the plain, mainly in the cultivated areas or near modern settlements, and in the mountains only within agricultural areas. Most of the anomalies showing these characteristics have been identified in the plain and foothills area (valley areas), increasing as one approaches to the modern settlements (Fig. 3). Therefore, it appears that the visibility of these anomalies is related to taphonomic processes: the plowing of fields have often affected the stone structures, displaced and broken the material and dragged the fragments into the surrounding area, creating in some cases a sort of ‘trails’. The fact that these anomalies are concentrated near modern settlements suggests that there is a continuity in the choice of settlement areas during different historical periods. Two areas, respectively the lands located east of the lake and the Piyun plain, are particularly interesting for the exceptional high concentration of these small light marks.

4-5. Large light marks

Another type of anomaly is constituted by extensive light-colored marks characterized by faint limits in comparison with that of the small light marks. Unlike the tappeh, this type of anomaly does not show any evident three-dimensionality. Usually these marks occur in groups and are larger, compared to the areas covered by the ‘small white marks’. These large marks are easily detectable on color satellite images, while are less recognizable on the high-resolution panchromatic image. In lowland areas of the plains of Piyun and Izeh wide slight light marks are spread over almost the entire surface of the plains (Figs. 3-4), testifying extensive destruction processes of structures made with stone parts (basement and foundations). In the present work, only those that were particularly evident has been detected from the analysis of Google Earth, as they have a clearly lighter color in comparison with the surrounding surface.

These type of anomalies seem to be more easily identifiable in mountain areas. They are present in fact in the valley areas under cultivation (Fig. 3). It is possible that this type of signs testifies the presence of settlements involved in more intense dissolution

processes of the masonry than the 'small white marks' and the settlements of 'groups A and B'. It is possible to suggest that the large white marks are ancient in comparison to the other described anomalies, having been subject to erosive phenomena for a longer period of time, or having been subjected to stronger taphonomic processes.

4-6. Texture anomalies – man-used areas

In mountain areas it is also possible to distinguish another type of anomaly, the so called 'texture anomaly' (Fig. 3). These are characterized by areas in which the surface is free of stones ('clean'), in correspondence with which the panchromatic image shows a fine texture; the area thus defined may also have more or less extensive light streaks or patches, perhaps a sign of buried structures (Giusto 2021: 32, 47-48). These signs seem characteristic of an anthropized area, suggesting the past presence of settlements - permanent or seasonal and no longer preserved - or cultivated fields or areas dedicated to grazing.

4-7. Water structures

Some structures can be recognized in the Izeh and Piyun plains, that can be interpreted as *qanat* on the basis of the identification of the shaft wells [(2)]

In particular, a structure of this type was found immediately south of the corridor that connects the plain of Izeh with that of Piyun on the side of the road between the modern settlements of Dehno and Badamzar. The structure is visible for a total length of 3.5 km. On the basis of topographic maps at a scale of 1: 50,000 and the DSM at 30m (JAXA), the terrain gradually slopes from north to south, confirming the suggestion that it may be a *qanat*. Furthermore, at the beginning of the *qanat* line to the north, Iranian cartography[(1)] reports the presence of a pump well, attesting the existence of a reachable groundwater at this point. The *qanat* seems to end in the south, near the modern town of Miangharan, where several anomalies are reported.

A second *qanat* can be found near Tappeh no.4, which is located north-east of the lake. On the ground, at least three different traits of *qanat* are marked, perhaps in relation to each other. These develop in a north-east/ south-west direction. The first part starting from the north-east has a length of about 100 m and touches the tappeh. The second extends for 450 m; finally, the last part has a length of 170 m. The direction of the *qanat* flow follows the slope of the terrain, as the water structure seems to start from the slopes of the Chiv mountains (which border the eastern part of the Izeh plain) towards the lake. A last hypothetical *qanat* is identified in the mountainous area west of the Izeh plain, in a small valley area. The *qanat* has an east-west direction and is visible on satellite images for a length of 130 m. It crosses an area currently under cultivation, as can be seen from the Iranian cartography on a scale of 1:50.000 [(1)]

The plain, as already indicated in the paragraph about the environment, has a strong agricultural potential thanks to the numerous seasonal waterways that convey the waters to the lake of Miangharan and Bandān and to its soil. The simultaneous use of *qanat* and wells could already guarantee a high level of agricultural production during ancient times, certainly higher in comparison with the mountain and foothills areas.

In the mountains, it was not possible to identify other water management structures with the exception of the possible *qanat* described above concerning specifically a valley area. That different water supply systems were used in this complex landscape is however underlined by the infrastructural occurrences of the area north of Piyun. Here, in several cases, it has been possible to identify systems of small dams that obstruct seasonal waterways or run-off areas for the storage and hinging of surface water towards the cultivated fields [(2)]

5. An archaeological focus

A comparison between the anomalies detected in this paper and the sites identified through archaeological surveys shows a partial overlap of the selected sites (Wright 1979 ed.; Faraji, Mehr Kian Sourani 2015). In particular, several correspondences are recorded between the anomalies defined as

'large white marks' and the sites identified by Wright in 1976 (Fig. 4, Tab. 2).

Table 2. Anomalies and Wright survey correspondences

Anomalies nos.	**Chronology**	**Bibliography**
11	Close to a Seleucid-Parthian and a Parthian-Sassanian sites	Messina, Mehr Kian 2019: 43, 45-47, Fig. 6; Messina 2020: 106-107, Fig. 8.
12	Transitional-Middle Elamite and Ilkhanid and Timurid sites; close to two sites of Parthian-Sassanian period.	Bayani 1979: 100, 102, Fig. 40; Eqbal 1979: 114, 116, Figs. 48-49; Wright 1979c: 124, Fig. 50;
17	Two sites of the "Archaic period" and one site of Early Uruk period.	Shahideh 1979: 42-43, Figs. 15-16; Wright 1979b: 59, Fig. 26; Messina 2020: 107-108.
18	Close to sites of Proto-Elamite, Sukkalmahhu, Seleucid-Parthian, Parthian-Sassanian, Ilkhanid and Timurid periods.	Sajjidi 1979: 93, 94, 96, Fig. 36; Bayani 1979: 100, Fig. 39; Eqbal 1979: 114, 116, Figs. 48-49; Wright 1979c: 124, Fig. 50.
19	Seleucid-Parthian; close to Parthian-Sassanian site	Eqbal 1979: 114, 116, Figs. 48-49.
22	Close to two sites of the Sukkalmahhu period and of the Parthian-Sassanian period.	Bayani 1979: 100, Fig. 39; Eqbal 1979: 114, 116, Fig. 49
Tell no.4	Two sites of Seleucid-Parthian and Parthian-Sassanian period; close to Ilkhanid and Timurid sites	Eqbal 1979: 114, 116, Figs. 48-49; Wright 1979c: 124, Fig. 50; Messina 2020: 107, 108, Fig. 8.

The archaeologists who carried out the survey on the ground describe the sites covered by the anomalies defined here as 'large white marks' as low tells. From the analysis of satellite images and areas, as well as from the hillshade model at 30m, however, no significant differences in elevation and color are detectable compared to the rest of the terrain such as to identify them as tappeh on the basis of a remote sensing analysis. Therefore, it is possible that, after the 1976 survey, the area has undergone heavy alterations and that agricultural works have leveled the land, partly destroying the archaeological evidence. What is visible as 'large white marks' would therefore represents the trace of the decay of groups of ancient buildings. The presence of similar large white marks in valley and mountain areas, always in correspondence with cultivated fields, suggests that even these anomalies perhaps identify buried archaeological remains.

Only six tells were detected, which are relatively few compared to the extent of the investigated area and to other lowland contexts of Khuzestan, for instance the Susiana (Wenke 1976; Alizadeh 1992 with bibliography). Even taking into account the probable correspondence between some sites

surveyed on the ground and anomalies of the 'large white marks' type, it must be stressed also that several archaeological sites identified by the survey directed respectively by Wright and by the *Iranian-Italian Joint Expedition in Khuzestan* at Hung-e Azhdar valley (plain area) are in no way distinguishable on the photo interpreted images (see also Messina, Mehr Kian 2019: 41; Messina 2020: 106-107).

In the mountainous area, the survey carried out in the area of Hung-e Azhdar by the *Iranian-Italian Joint Expedition in Khuzestan* identified a fortress and traces of a building with preserved foundations of stone walls (Faraji, Mehr Kan Sourani 2015: 72-73, 75, 78, Figs. 12-15, 18-19). These sites are not visible through remote sensing, suggesting that precise archaeological evidence is often difficult to identify through photointerpretation.

The visibility of the remains of 'ancient' settlements in mountain areas is however not impracticable as it is testified by the structures cataloged in this research as 'Group A' and 'Group B'. These particular remains highlight clearly how in mountain areas different materials and building techniques makes an easier preservation and consequently an easier detection by remote sensing.

It seems plausible, in the light of the research carried out, that the anomalies identified as large light marks in lowland areas are attributable not so much to different types of settlements, but rather to a lower state of conservation: here, in fact, the taphonomic processes due to the operations of cultivation have more profoundly changed the state of conservation of the remains [(1)]

It is possible to propose a dynamic of progressive destruction of buildings that involves a transformation from ruins ('Group A' settlements) to semi-buried buildings ('Group B' settlements) to completely or almost buried structures no longer recognizable in plan (anomalies of type 'Large white marks').

6. Conclusions

The use of a homogeneous remote sensing method including mountainous and lowland environment has allowed to underline some specificities and similarities valid for the studied area.

In the first place, it must be stressed that the visibility of settlements in mountain areas is sometimes easier than in the plain at a scale 1:5000, plausibly due to the stone building technique and the lower degree of man use in the mountain habitat.

In the plain of Izeh, few limited ancient settlements are tappeh, easily recognizable on the remote sensing, while most of the known archaeological sites are identifiable by photointerpretation as 'large light marks', whose archaeological value is confirmed in some cases by previous archaeological surveys. The same type of anomaly is also recognizable in the mountain area, where it presumably represents similar evidences.

The anomalies here defined as 'small white marks' are found both in the mountains and in plains, but mainly in cultivated zones. Their interpretation is doubtful. Given their size and probably the presence of stone for the well identifiable white color, they must be considered in origin as structures possibly with a reduced constructive effort composed by one or two rooms.

The results of this preliminary research of a territory in which different types of environments coexist without solution of continuity, proved that it is necessary to adopt an integrated approach, which considers the landscape in a holistic manner, without arbitrary divisions between lowlands and highlands. If, in fact, there are differences between the two areas for the settlement pattern and for the use of different types of infrastructures and resources, there are alsomany similarities, which are usually underestimated by scholars. For example, it was possible to find elements of the water management structures (qanat) both in the

plains of Izeh and Piyun and, in the mountainous territory, inside a valley area.

The picture drawn within this study forms the first step for new investigations on the ground which will be able to understand the

dating of the evidences detected on remote sensing images. This paper will allow in the future to a better understanding also of the different ancient landscapes, which are now difficult to reconstruct for specific chronological framework.

7. Footnote

1. Dimensions of the study area: 21,74 Km (N-S) x 20,14 Km (E-W), area 437,84 Km2.

2. For the description of the orography of the area the following sources were employed: topographic maps 1: 50.000 produced by the Iranian National Geographic Organization (NGO), sheets 5953I Īzeh (1999), 5953IV Chamreyhān (1999) (©NGO); Wright 1979a: 37; Niknami, Jayez 2012: 7-10. For the geology the following source was employed: geological map produced by the Iranian Oil Operation Company, scale 1: 100.000, sheet 20825E (Kūh-e Āsmārī) (1966) (© Iranian Oil Operation Company).

3. For the description of the hydrology of the area the following sources were employed: topographic maps in scale 1: 50.000 produced by the Iranian National Geographic Organization (NGO), sheets 5953I Īzeh (1999), 5953IV Chamreyhān (1999) (©NGO); Wright 1979a: 37-38; Kalantari, Pawar, Keshavarzi 2009: 25-26, 32-33; Nasseri, Alijani,
Mirzaei 2009: 101-103; Niknami, Jayez 2012: 11-13; Faraji, Mehr Kian, Sourani 2015: 63.

4. For the description of the soil types the following sources were employed: soil map produced by the Iranian Soil and Water Research Institute, scale 1: 250.000, sheet Khuzestan (1991) (©Soil and Water Research Institute); Kalantari, Pawar, Keshavarzi 2009: 27; Nasseri, Alijani, Mirzaei 2009: 101.

5. Topographic maps produced by the Iranian National Geographic Organization (NGO), scale 1: 50.000, sheets 5953I Īzeh (1999), 5953IV Chamreyhān (1999) (©NGO).

6. Topography at scale 1: 50.000 elaborate by the National Geographic Organization (NGO): sheet 5953I Īzeh (1999), sheet 5953IV Chamreyhān (1999) (©NGO, Iranian Army Force).

7. On the use of stones as construction material in mountain areas: Watson 1979: 241-243, 282-284; Yakar 2000: Chapt. 4; Wilkinson 2003: 48, Tab. 4.1. During the permanence in the area it was possible to see that in the mountains near Izeh several modern buildings are fabricated with stones.

8. For the qanat see: Beaumont 1971; English 1998; Wilkinson 2003: 47, 155-161, Tab. 4.2, 4.4, fig. 8.2

9. Topography 1: 50.000 elaborated by the National Geographic Organization (NGO):
sheet 5953I Īzeh (1999) (©NGO, Iranian Army Forces).

10. Topography 1: 50.000 elaborated by the National Geographic Organization (NGO): sheet 5953I Īzeh (1999) (©NGO, Iranian Army Forces).

11. On this kind of hydrologic structure see for example: Bruins 2007; Wilkinson 2003: 139, 189, 191-193, Fig. 89.

12. For a study on the taphonomic processes involving archaeological occurrences in western Iran: Niknami 2007.

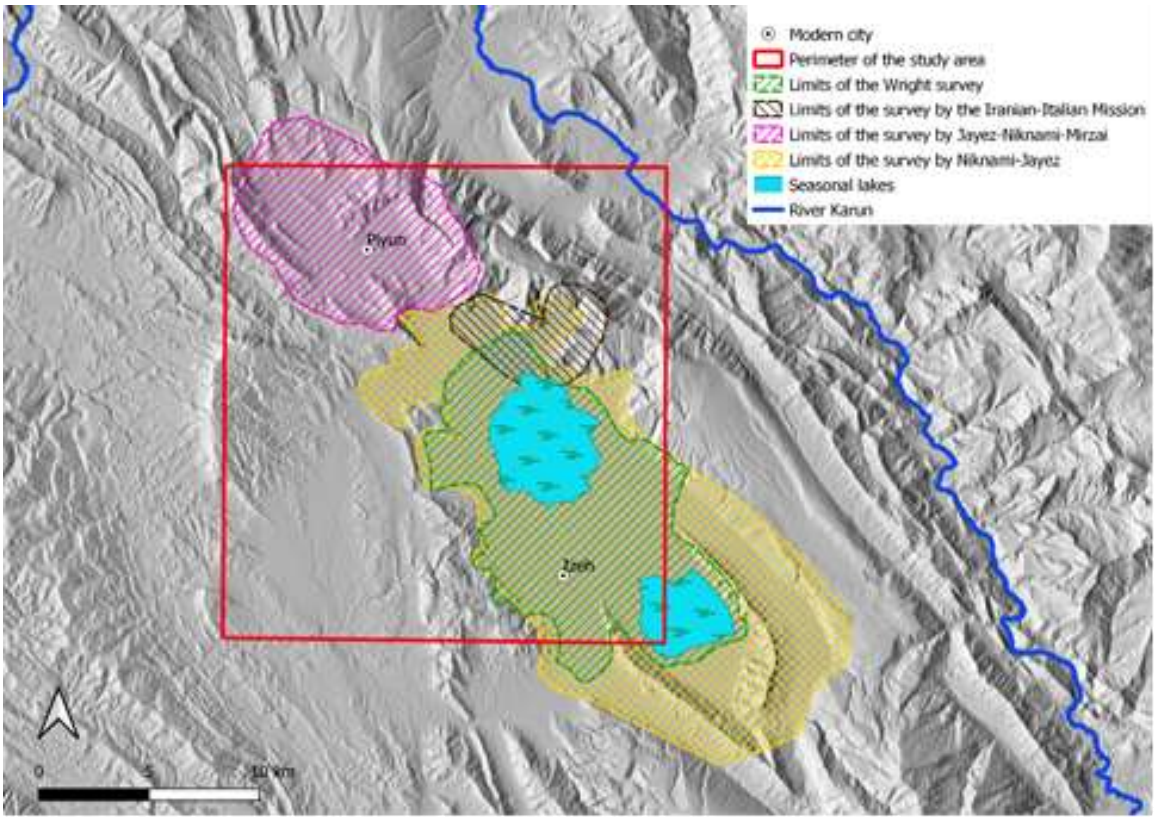

Fig. 1. The limits of the study area and the areas of the past surveys

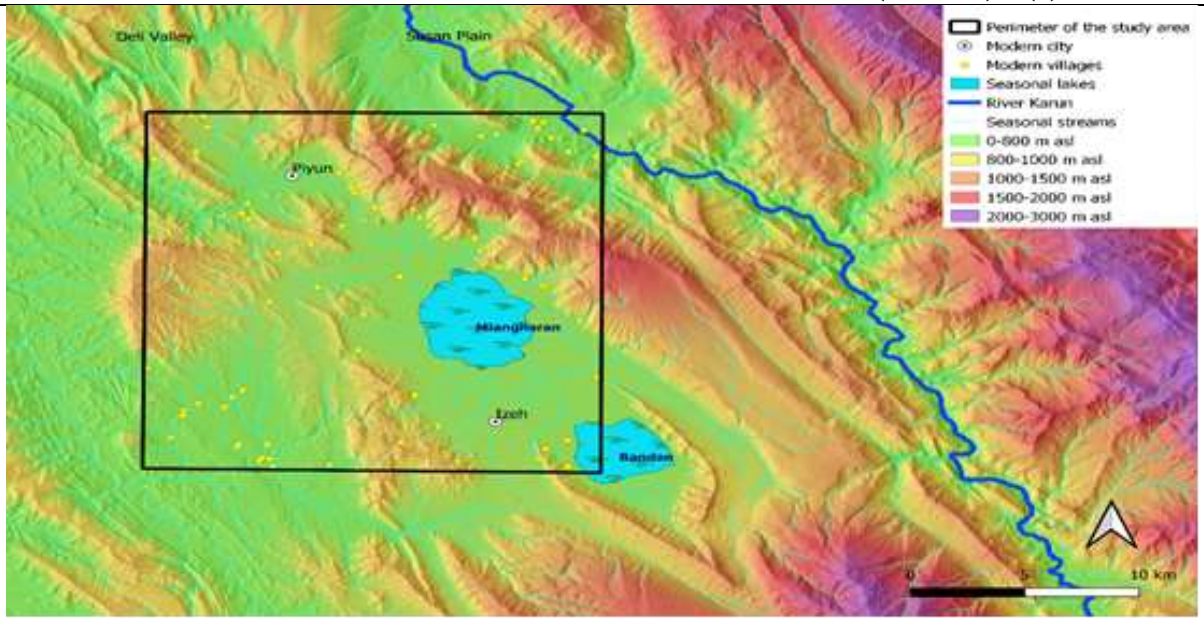

Fig. 2. Geography of the area of study

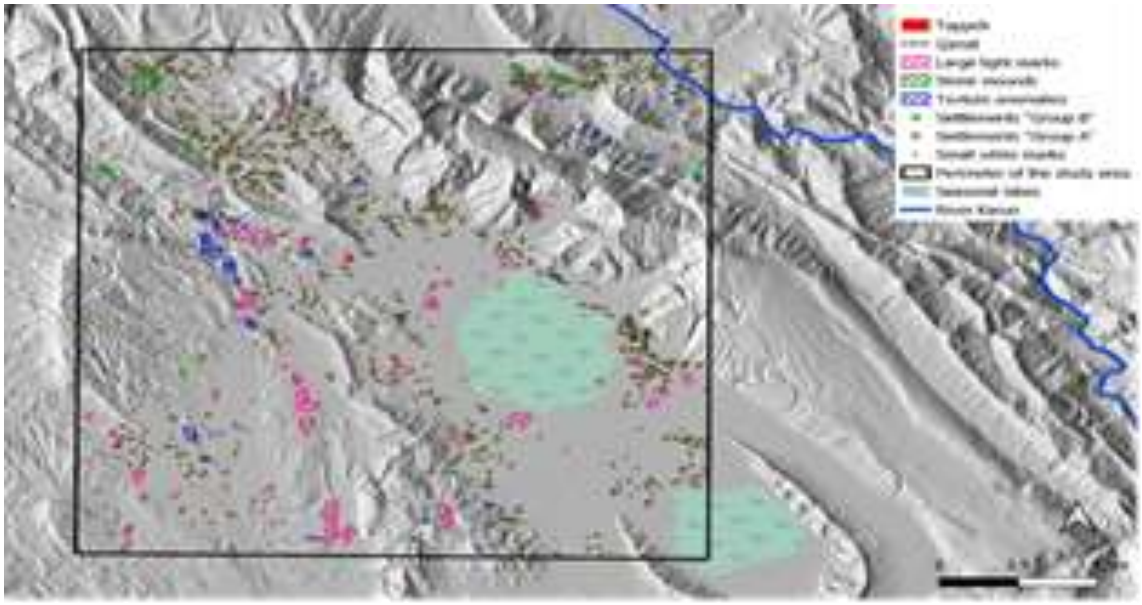

Fig. 3. The anomalies detected in the study area.

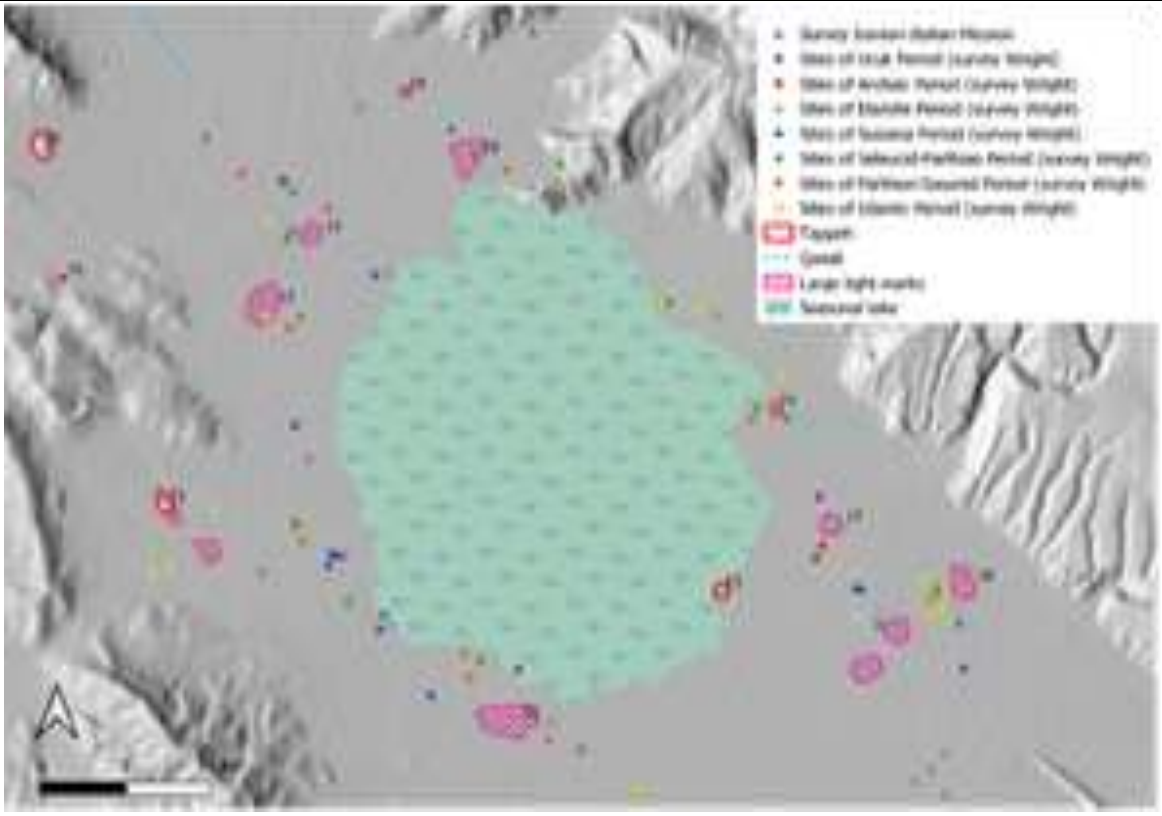

Fig. 4. Comparison between some of the det
ected anomalies and the archeological sites individuated by the ground surveys.

8. References

Alizadeh, Abbas. (1992). Prehistoric settlement patterns and culture in Susiana, southwestern Iran. The analysis of the F.G.L. Gremliza survey collection, University of Michigan: Ann Arbour.

Alizadeh, Karim, Ur, Jason, A. (2007). Formation and Destruction of Pastoral and Irrigation Landscapes on the Mughan Steppe, North-Western Iran, Antiquity, 81(311), 148-160.

Altaweel, Mark. (2005). The Use of ASTER Satellite Imagery in Archaeological Contexts, Archaeological Prospection, 12, 151-166.

Álvarez-Mon, Javier. (2019). The Monumental Reliefs of the Elamite Highlands. A Complete Inventory and Analysis (from the Seventeenth to the Sixth Century BC), Eisenbrauns: University Park.

Ansart, Arnaud, Braemer, Frank, Davtian, Gourgouen. (2016). Preparing an Archaeological Field Survey: Remote Sensing Interpretation for Herding Structures in the Southern Levant, Journal of Field Archaeology, 41(6), 599-712.

Bayani, Mohammed I. (1979). The Elamite Periods on the Izeh Plain, in Henry T. Wright (ed.), Archaeological Investigations in Northeastern Xuzestan, 1976, The University of Michigan: Ann Arbour, 99-105.

Beaumont, Peter. (1971). Qanat Systems in Iran, Hydrological Science Journal, 16(1), 39-50.

Bruins, Hendrick, J. (2007). Runoff Terraces in the Negev Highlands during the Iron Age: Nomads Settling

Down or Farmers Living in the Desert?, in Benjamin A. Saidel, Eveline J. van der Steen (eds), On the Fringe of Society: Archaeological and Ethnoarchaeological Perspectives on Pastoral and Agricultural Societies, BAR: Oxford, 37-55.

Bucci, Ilaria, Cellerino, Alessandra, Faraji, Mehdi, Foietta, Enrico, Giusto, Francesca, Mehr Kian, Jafar,

Messina, Vito, Rouhani Rankhoui, Mana. (2018). Preliminary Report of the Third Season of Excavation of the Iranian-Italian Joint Expedition in Khuzestan at Kal-e Chendar, Shami (8th Campaign, 2015), Parthica, 20, 59-78.

English, Paul W. (1998). Qanats and Lifeworlds in Iranian Plateau Villages, Yale Forestry and Environmental Studies Bulletin, 103, 187-205.

Eqbal, Haydeh. (1979). The Seleucid, Parthian and Sasanian Periods on the Izeh Plain, in Henry T. Wright (ed.), Archaeological Investigations in Northeastern Xuzestan, 1976, The University of Michigan: Ann Arbour, 114-123.

Faraji, Mehdi, Mehr Kian, Jafar, Sourani, Yalda. (2015). Survey at Hung-e Azhdar, in Vito Messina (ed.), Hung-e Azhdar. Research of the Iranian-Italian Joint Expedition in Khuzestan, Parthica, 17, 63-79.

Giusto, Francesca. (2021). Sacred Landscapes of Ancient Iran: The Sanctuaries of Elymais and their territory, Unpublished PhD Thesis, University of Torino (in Italian).

Godard, André. (1965). The Art of Iran, translation: Michael Heron, Frederick A. Praeger Publishers: New York.

Henkelman, Wouter, Khaksar, Sepideh. (2014). Elam's Dormant Sound: Landscape, Music and the Divine in Ancient Iran, in Linda C. Einex (ed.), Archaeoacustic: The Archaeology of Sound,Create Space Independent Publishing Platform: Myakka, 211-231.

Jayez, Mozhgan, Mirzai, Khadijeh, M., Niknami, Kamal A. (2019). Introduction of Late Pleistocene Cultural Material of an Intermediate Region: Paleolithic Sites of Pion and Izeh Plain between Central and Southern Zagros, Southwest Iran, Quaternary International, 512, 52-66.

Kalantari, Nasrolah, Pawar, N.J., Keshavarzi, Mohammadreza. 2009. Water Resource Management in the Intermountain Izeh Plain, Southwest of Iran, Journal of Mountain Science, 6(1), 25-41.

Lasaponara, Rosa, Masini, Nicola. (2012). Remote Sensing in Archaeology: From Visual Data Interpretation to Digital Data Manipulation, in Rosa Lasaponara, Nicola Masini (eds.). Satellite Remote Sensing. A New Tool for Archaeology, Springer Nature: New York, 3-16.

Lillesand, Thomas M., Kiefer, Ralph W., Chipman, Jonathan W. (2004). Remote sensing and image interpretation, Wiley: New York.

Messina, Vito. (2020). From Susa to Mal-e Mir. Settlement Patterns in ancient Elymais, in Bruno Genito (ed.), Living in a Territory. Four Lectures from a Workshop Held in Naples, 6 May 2017, Palazzo Corigliano, Scienze e Lettere: Roma, 87-118.

Messina, Vito (ed). (2015), Hung-e Azhdar. Research of the Iranian-Italian Joint Expedition in Khuzestan, Parthica, 17, 13-228.

Messina, Vito, Mehr Kian, Jafar. (2019). Anthrosols detection in the Plain of Izeh, in Yousef Moradi (ed.), Afarin Nameh. Essays on the Archaeology of Iran in Honour of Mehdi Rahbar, RICHT: Tehran, 39-48.

Nasseri, Hamid R., Alijani, Farshad, Mirzaei, Leila. 2009. Environmental Characterization of a Karst Polje: An Example from Izeh Polje, Southwest Iran, Environmental Earth Sciences 59(1), 99-108.

Niknami, Kamal A. (2007). A Stochastic Model to Simulate and Predicting Archaeological Landscape Taphonomy: Monitoring Cultural Landscape Values Based on an Iranian Survey Project, Archeologia e Calcolatori, 18, 101-120.

Niknami, Kamal A., Jayez, Mozhgan. (2012). Stone Age Archaeology of Izeh Plain, Kuzistan, Iran, Lambert Academic Publishing: Saarbrücken.

Parcak, Sarah. (2009). Satellite Remote Sensing for Archaeology, Routledge: London-New York.

Reinhold, Sabine, Belinskiy, Andrey, Korobov, Dimitriy. (2016). Caucasia Top-Down: Remote Sensing Data for Survey in a High-Altitude Mountain Landscape, Quaternary International, 402, 46-60.

Sajjidi, Mansur. (1979). The Protoelamite Period on the Izeh Plain, in Henry T. Wright (ed.), Archaeological Investigations in Northeastern Xuzestan, 1976, The University of Michigan: Ann Arbour, 93-98.

Scardozzi, Giuseppe. (2012). Integrated Methodologies for the Archaeological Map of the Ancient City and Its Territory: The Case of Hierapolis in Phrygia, in Lasaponara, Rosa, Masini Nicola (eds.). Satellite Remote Sensing. A New Tool for Archaeology, Springer Nature: New York, 129-156.

Shahideh, Elahe. (1979). The Archaic Period on the Izeh Plain, in Henry T. Wright (ed.), Archaeological Investigations in Northeastern Xuzestan, 1976, The University of Michigan: Ann Arbour, 42-49.

Stein, Aurel. (1940). Old Routes of Western īrān. Narrative of an Archaeological Journey, MacMillan and Co.: London.

Thomas, David C., Kidd, Fiona J., Nikolovski, Suzanna, Zipfel, Claudia. (2008). The Archaeological Sites of

Afghanistan in Google Earth. AARGnews, 37, 22-30.

Watson, Patty J. (1979). Archaeological Ethnography in Western Iran, The University of Arizona Press: Tucson.

Wenke, Robert J. (1975-1976). Imperial Investments and Agricultural Developments in Parthian and Sasanian Khuzestan: 150 B.C. to A.D. 640, Mesopotamia, 10-11, 31-121.

Wilkinson, Tony J. (2003). Archaeological Landscapes of the Near East, The University of Arizona: Tucson.

Wright, Henry T. (ed.). (1979). Archaeological Investigations in Northeastern Xuzestan, The University of Michigan: Ann Arbor.

Wright, Henry T. (1979a). Comments on the Geography of the Izeh Plain", in Henry T. Wright (ed.), Archaeological Investigations in Northeastern Xuzestan, 1976, The University of Michigan: Ann Arbour, 35-38.

Wright, Henry T. (1979b). The Uruk Period on the Izeh Plain, in Henry T. Wright (ed.), Archaeological Investigations in Northeastern Xuzestan, 1976, The University of Michigan: Ann Arbour, 59-63.

Wright, Henry T. (1979c). The Islamic Era on the Izeh Plain, Henry T. Wright (ed.), Archaeological Investigations in Northeastern Xuzestan, 1976, The University of Michigan: Ann Arbour, 124-126.

Yakar, Jak. (2000). Ethnoarchaeology of Anatolia. Rural Socio-Economy in the Bronze and Iron Ages, Tel Aviv University: Tel Aviv. Eys.