



A Non-destructive Excavation in Parse-Pasargad Archaeological Region

Behnaz Aminzadeh, Ph. D.

Associate Professor, Faculty of Urban Planning, University of Tehran

Firoozeh Samani, M. Sc.

Faculty of Environment, University of Tehran

Behrang Bahrami, M. Sc.

Faculty of Environment, University of Tehran

Abstract

There has been growing concern regarding the proposed Sivand Dam. Its placement in the Parse-Pasargad region, between both the ruins of Persepolis and Pasargad, has worried many archeologists that the dam will flood these UNESCO World Heritage sites. Currently the construction of the dam is postponed until the international teams of archeologists announce that their excavations in the area are finished. The aim of this study is to increase the knowledge about this valuable archeological region, focusing on two case studies, Persepolis and Pasargad. To prevent environmental destruction caused by archeological excavations, a non-intrusive investigation combining complementary technologies has been carried out. A multilayer analysis of the collected data in geology, hydrology, and hydrogeology, along with aerial photographs, remotely sensed air photos, and satellite imagery provided useful information for preparing environmental and historic layers. The use of GIS and image processing technique allowed a highly effective integration of all data, leading to more rigorous correlation of the different results. The results of this study are indicative of three main findings: (1) identification of buried archaeological features in this region, focusing on the two plains of Farvardin and Marghab, the seat of Achaemenian governors, where the Persepolis and Pasargad established (2) a wall and watchtowers surrounding Persepolis, (3) and a natural lakelet in the Pasargad site.

Keywords: achaemenian period, Parse-Pasargad archeological region, Persepolis, Pasargad, remote sensing, guard wall, natural lake, Iran.

حفاری غیر تخریبی در منطقه باستانی پارسه - پاسارگاد

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دکترای شهرسازی، دانشیار دانشکده شهرسازی، دانشگاه تهران

فیروزه سامانی

کارشناس ارشد مهندسی طراحی محیطزیست، دانشکده محیطزیست، دانشگاه تهران

بهرننگ بهرامی

کارشناس ارشد مهندسی طراحی محیطزیست، دانشکده محیطزیست، دانشگاه تهران

چکیده

موضوع احداث سد سیوند و مکانیابی حساس آن در منطقه پارسه - پاسارگاد یعنی بین آثار به جا مانده از تخت جمشید و پاسارگاد، از موضوعات مهم و در عین حال نگران کننده از نظر متخصصین باستان شناسی است، چرا که این امکان وجود دارد که سد با انباشت آب و تغییر سامانه آبی منطقه، باعث تخریب این دو اثر جهانی که توسط یونسکو به عنوان میراث جهانی ثبت گردیده اند، شود. علاوه بر آن احداث امکان کاوش های بیشتر در منطقه را به شدت کاهش می دهد. در حال حاضر احداث سد تا اتمام تحقیقات باستان شناسان در منطقه، به کندی پیش می رود. هدف از این تحقیق افزایش اطلاعات و مستندات باستان شناسی مربوط به این منطقه با ارزش است. مورد مطالعه خاص آن بستر محیطی تخت جمشید و پاسارگاد می باشد. جهت پرهیز از تخریب های محیطی که به واسطه حفاری های باستان شناسی ایجاد می شود، در این تحقیق با استفاده از روش ها و فناوری های تکمیل کننده یکدیگر یعنی کاربرد لایه های متفاوت اطلاعات در زمینه های محیطی از جمله زمین شناسی، هیدرولوژی، و هیدروژئولوژی و نیز اطلاعات باستان شناسی، استفاده از عکس های هوایی و تصاویر ماهواره ای، اطلاعات مورد نیاز جمع آوری و مورد تحلیل قرار گرفتند. کاربرد GIS و پردازش تصویر، امکان ترکیب و همبستگی اطلاعات و لایه های متفاوت محیطی و تاریخی را فراهم نمود. نتایج تحقیق شامل بر سه یافته مهم زیر در زمینه باستان شناسی منطقه است: (1) تعیین پهنه های شامل آثار باستانی مدفون شده در منطقه پارسه - پاسارگاد، که متمرکز بر محیط طبیعی دو پایتخت هخامنشی یعنی دشت فروردین (بستر محیطی تخت جمشید) و دشت مرغاب (بستر محیطی پاسارگاد) است. (2) تعیین احتمال وجود برج و بارو در اطراف مجموعه تخت جمشید، و (3) مکان یابی دریاچه باستانی پاسارگاد.

کلید واژه ها: دوره هخامنشی، منطقه باستانی پارسه - پاسارگاد، پرسپولیس، پاسارگاد، دور سنجی، برج و بارو، دریاچه طبیعی باستانی، ایران.

Introduction

The Parse-Pasargad region has been home to many unique archeological features dating back to the third and fourth millennium. The well known discovered areas in this region include Persepolis, Naghsh-e-Rostam, the city of Parse, Pasargad, and the city of Istakhr. In addition to these sites, there are small groups of ruins in this area such as that of the village of Hossein abad. Due to possession of such valuable treasures of historical, cultural, and archeological attractions preserved within its natural setting, the area has been a subject of deep interest and working grounds for many scholars. At the same time, development of the villages close to these sites, construction roads and the proposed railroad, Sivand dam, buildings etc., together with archeological excavations, increasing number of tourists, tourist facilities, and lack of multi-discipline investigations, have led not only to severe environmental damages and landscape destruction but also threatened the life of tribes who for centuries migrated from the southern part of this region to the north, and the natural life of the area. To increase the knowledge about this region without any further damages, it is necessary to use new geophysical and spectral techniques to define the ancient landscape and architectural features of the region.

The objectives of this study are derived from the more recent and different debates about the area. The first is focused on the determination of the ruins around each of the valuable heritage sites of Persepolis and Pasargad, something which was only considered when the area threatened by the construction of the Sivand Dam, and still there is no any documentary account about the whole archeological sites in this region. The second is to find out whether physical boundaries (towers and wall bordering) surrounded the site of Persepolis. This has been questioned by Pope (1947), Koch (1996), and Aminzadeh and Samani (2006). The third objective is related to the location of the ancient lake of Pasargad which has not been adequately addressed (Pope, 1947;

Stronach, 1963), and the only map that has shown the lake belongs to Pope. This study is an attempt to find out these three critical issues in the area by the application of photogeology, and remote sensing analysis.

Natural Features of Parse – Pasargad Region

The area of Parse–Pasargad has developed as an important part of the Great Achaemenian civilization. A mountainous area of the Zagros Range connects the two great plains of Marghab and Farvardin. The landform of this region results from Zagros folding range. The intermountain plains (such as Marghab and Farvardin) have resulted from the soft and fragile formations that have a high amount of humus and are extremely fertilized. The landform is a unique one with cliffs, steep slopes next to vast mountainsides, natural caves, and crack stones and rocks. These plains are situated in the limestone rocks. The Parse–Pasargad region is located in the watershed of Kor and Sivand Rivers. Rainfall occurs intermittently from early autumn through mid-spring. The precipitation regime of the region corresponds to that of the Mediterranean, the main part taking place in autumn and winter. Generally, the climatic nature of the region can be divided into two main categories:

- the plain climate with cold moderate weather, short to moderate growth season and moderate precipitation (Marghab and Farvardin plains)
- the mountainous climate with cold weather, short growth season and heavy precipitation (the south and southwestern parts of Marghab plain to the northern part of Farvardin plain).

One of the main hydro-geologic features of the Zagros region, especially the heights of Mehr Mountain in the Farvardin plain, and the high altitudes of the southern part of Marghab plain is the formation of springs and fresh water. These springs and caves have been an important factor in attracting human inhabitants to the area (Samani, 2002). The ancient river of Sivand entering Parse–Pasargad the

northeastern parts of Marghab, crossed the Marghab plain, passed the Bolaghy gorge and meandering the valleys north of Farvardin, flowed across this plain. The river is known as Polvar-Pasargad River before entering the mouth of Bolaghy gorge, and Sivand thereafter to the Farvardin plain. The satellite images taken from this region demonstrate the reviving Polvar-Sivand River. Along its meandering route, the river nurtures diverse floral and faunal ecosystems of the Zagros region. Various natural or artificial divisions irrigate the fields and gardens of the region. The underground water level is high in this region. This is another factor contributing to development of vast meadows with rich vegetation and human settlements with good conditions for agriculture from the ancient to the present time.

Methodology

This study required a multi-disciplinary approach covering and combining the three main study areas of information. The important discovery of previously historic literary material on the area, the information needed for providing natural layers such as hydrology, geology, geomorphology, pedology, and plantology, and the main focus of the method which is the application of air photos and remotely sensed data. The GIS software together with a suitable database enabled the management, integration and display of various types of data.

The advances in new sensor technology, computers, and image processing software resulted in the technology becoming widely accepted for different branches of earth surface investigation as well as archeology and landscape analysis. Remote sensing data and image analysis are used as major tools in investigating natural formations and man-made structures (Ben-Dor *et al.*, 1999; Ustin *et al.*, 1999; Elbaz, 1997; Flower, 1994; Ebert, 1984 and Kruckman, 1987). Wilkinson (2003) mentions to the basic imaging system useful for the landscape archeology, while studying the application of this technique in the Near and Middle East. In order to

achieve the aim of this research, various integrated thematic datasets were used. This research postulates a combined processing of ETM+ remotely sensed data produces thematic images, significantly enhances the understanding of archeological resources, localities, and their historical-evolution by geo-environmental variations. The principal component analysis has been applied to define collapsed clayey matrix, allochthonous carbonate rock fragments and cultivated characteristics. As differences in soil texture are revealed by fractional temperature variations, it is possible to identify loose soil that once was a prehistoric agricultural field or now covers buried ruins. In many cases, the buried structures can be detected in infrared photographs and images, which better define landscape patterns and vitality of the vegetation. The archeological residues mainly consist of limestone fragments that were cemented by argillaceous silty-sandy material matrix. These components show localized physical and chemical differences compared to the surrounding soil cover. These phenomena, which appear to be partially caused by differences in particles and composition of dumped (collapsed/distributed) materials between these residues, and off-site soil, are used to local archeological features sites within the study area. In order to identify the exact locations of differing features, a global positioning system (GPS) of Garmin+3 type was used. Providing new maps based on different information layers led to the possibility of reconstructing the environmental setting and delineating natural and man-made features of the studied area.

Case Studies

-Persepolis

Environmental setting: The landform of the area is a combination of high to medium mountains and plains. The mountains are of moderate height and exhibit uniform trending structures with bedded cliff-forming features resembling natural walls. They belong to the High Zagros with similar folded rock units. Rahmat

Mountain to the north consists of southward dipping limestone beds with karstic characteristics, including water seepages and springs, which supplied fresh water for human occupants and agriculture. The most important plain of the area the Farvardin is surrounded by Tashk Lake to the east and cliff forming ridges to the north (Krinsely, 1970). The fertile soil and relatively abundant water resources have resulted in an extensive and well developed agriculture system. The fertile soil, abundant surface water, and widespread meadows are major factors in attracting a variety of societal forms; urban, rural and tribal. The natural landscape, environmental conditions, and geomorphologic features were the major criteria for settling the Persepolis and the city of Parse by the Achaemenian Empire in this plain.

Architectural Features: Persepolis was built by Darius the Great, embellished by his son Xerxes and Grandson Artaxerxes and virtually destroyed by Alexander the Great. This complex was a ritual space, a sacred national shrine, and a potent setting for the spring festival, the Nou-rouz (Koch, 1996; Ghirshman, 1976; Godard, 1962 and Herzfeld, 1941). It comprised of a group of impressive palaces built in the city of the Achaemenian Empire (560-330 BC), the Parse. Persepolis is marked by a large 125,000 square meter terrace, partly artificial and partly cut out of mountain, with its east side leaning on Kuh-e Rahmet. The other three sides are formed by a retaining wall, which varies in height with the slope of the ground.

Historical Reference: Archeological studies of Persepolis began in the early 19th century with different groups supervised by Schmidt (1957), Pope (1947), Koch (1996), Herzfeld (1941) and Ghirshman (1976). There are considerable literatures on the architectural features of the Persepolis, but the question of the existence of towers and wall bordering of the site has not yet been adequately addressed. Based on discovered documents and clay boards, Koch suggests that the Sofa (Royal Palace), was in fact the treasury and archive storage place of the Achaemenians and therefore a wall would have been a prerequisite to

guard it. This feature has been recorded in Babylonian boards documenting repairs made to the wall and watchtowers in 522-488 BC (Koch, 1996). Referring to principles of Achaemenian architecture as evidence, other archeologists such as Godard (1962) disagree, and believe that walls and towers could not have been constructed at Persepolis.

To date, no excavation has been made to prove or disprove the existence of watchtowers and wall around Persepolis. Although the remnants of a wall have been found on the northwest ridge and north of Persepolis, the available records and maps of the are inadequate to define the full heritage site. The current proposed boundary definitions of the site by Sami (1972), masked the original extension of the Parse, and thus formed a misleading data base on which developments around Persepolis (e.g. tents, motels, parking, and farming) were planned and built very close to the site.

Pasargad

Environmental setting: Pasargad is situated in the Marghab plain with a landscape that is a combination of green cultivated fields, vast pasture lands, and sporadic villages, stretching along the Pasargad-Shiraz road, with some remnants of ancient buildings. This plain has an altitude of 1840m above sea level, rising to 1870m. In the northern and eastern sections it turns into low hills and plains, and is bounded to the south and southwest by the elevated areas of Bolaghy gorge. The Polvar river has a north-to-south flow direction within the Marghab plain, and gently meanders into Bolaghy gorge towards the south. Seivand is a part of the Polvar, and flows from Bolaghy gorge to the Farvardin plain and the ancient city of Estakhr. The presence of natural features and mountainous terrains in the west and southwest, and the hills in the north and east of the Marghab plain, have made it an enclosed space surrounded by natural partitions. Undoubtedly, this and the availability of favorable land, water resources, and suitable defensive features, were important reasons for the selection as the setting for the capital of the first Persian Empire, the Achaemenian kings.

Architectural features: Pasargad is situated some 130 km North-East of Shiraz, and 87 km northeast of Persepolis. It was the first capital of the Persian Empire. The construction of the capital city by Cyrus the Great, begun in 546 BC was left unfinished, for Cyrus died in battle in 530 BC. Pasargad remained the Persian capital until Darius began assembling another in Persepolis. The archaeological site covers 1.6 square kilometres, and includes a structure commonly believed to be the mausoleum of Cyrus, the fortress of Tall-e Takht sitting on top of a nearby hill, and the remains of two royal palaces and gardens. The most important monument in Pasargada is undoubtedly the tomb of Cyrus.

Historical Reference: Research and excavations of the Pasargada complex date back to the early 19th century. Stronach (1963) pointed to the works by Flandin, Coste, Stolze, Dieulafoy, Curzon, and Sykes and Jackson who had given attention to the Tomb of Cyrus the Great. Other scholars, namely Schmidt (1940), Herzfeld (1941) and later Sami (1959) have excavated the entire archeological area inside and outside the Tomb.

The current literature is mostly focused on archeology of the site. Thus the environmental and natural characteristics, site peculiarities of its historical landscape, and real boundaries have not well investigated. Nevertheless, there are a few studies that mention the presence of a local lake close to Pasargad, and excavations of the site show several waterways in and around this complex (Pope, 1947; Stronach, 1963 and Sami, 1972). Yet the only map that has shown the presence of a vast catchments dam belongs to Pope, who illustrates this, in the northern part of the complex extending to the outer fortifications of Pasargada. The review of the literature shows that the location of the large lakelet, as interpreted by Pope (1947), has holocene fan deposits consisting of conglomerate facies rocks. His interpretation is doubtful, as the location he mentioned has not indicated favorable hydrologic and hydrogeologic characteristics and associated lake sediments. No other scholars or

archeologists made note of the presence of such a dam in the area.

Results

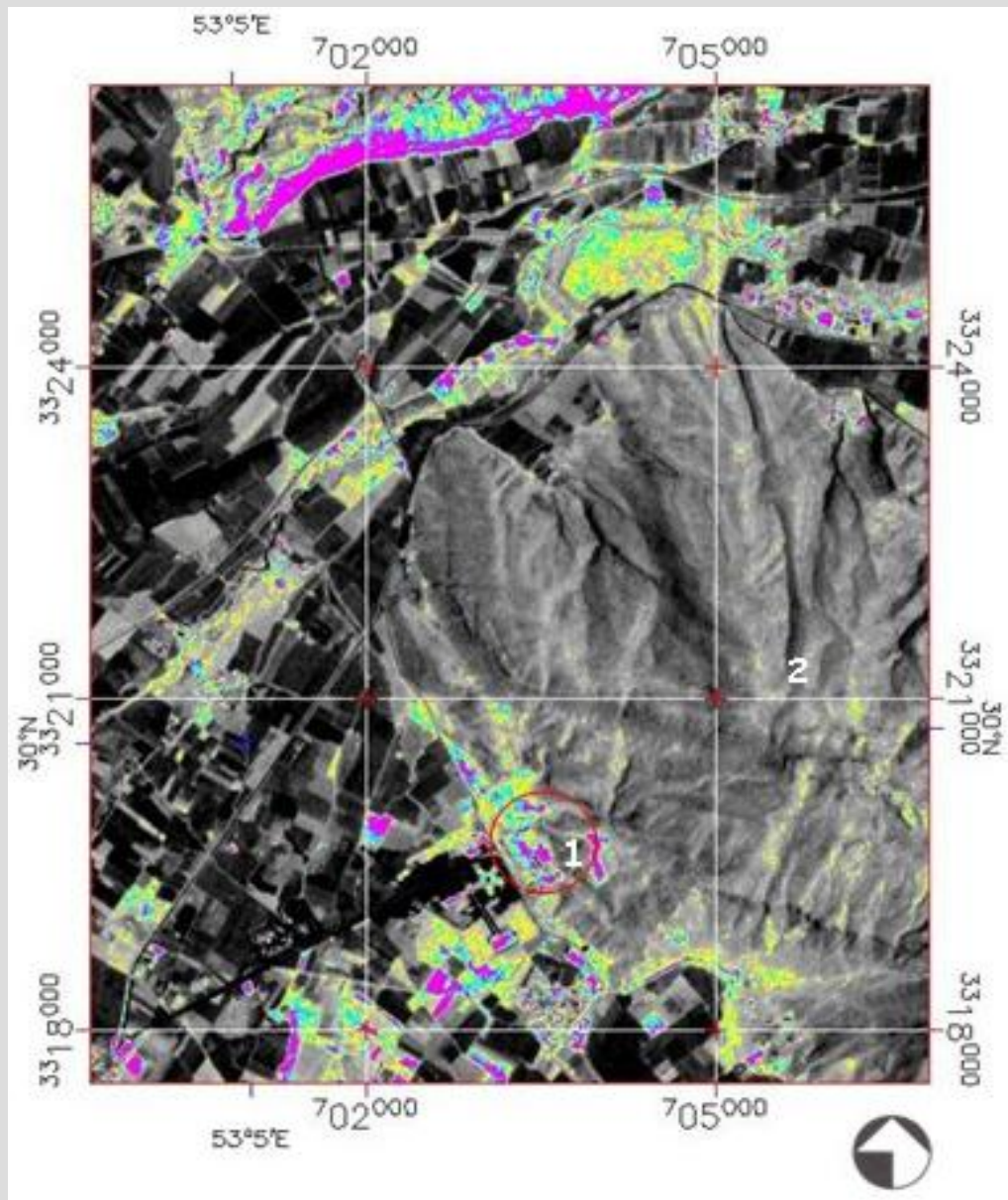
Based on photogeology and remote sensing image analysis, this region possesses special geomorphology with large farmlands, scattered villages and natural features. Extensive development of different geomorphologic features such as high escarpments and steep slopes close to lowlands, karstic caves, and structural deformations and dissected bedded units present a unique natural landscape. The interpretation of air photos and satellite images indicate scattered excavation, extensive construction, and land-use modifications in this area especially around the two important archeological poles of this region the Persepolis and Pasargad (Figure 1).

Buried Archaeological Features in Parse-Pasargad Region

Different material such as sand, cultivated soil, plants, ruins, and various rock types each have distinctive reflects of infrared spectrums on electromagnetic radiation emitted at different rates. Conventional RGB composite images of 147; 531; and 742 have been used for regional landscape, geomorphological and geological analysis to evaluate environmental setting of Parse-Pasargad region where most of the archeological sites are located. On the basis of this analysis, traces of previous human activities (agriculture or housing) are recognized. The Farvardin plain were the Parse city and Persepolis palaces are located indicates an intensive cultivation zone controlled by fertile soil cover and natural-artificial irrigation system. The high biomass content and cultivation activities have masked the historical residues due to intense EMR in different ETM+ bands. To deal with this problem ETM+ panchromatic band 8 has been processed to enhance limestone bedrock; mixed rock fragment and mud matrix in archeological residues in higher spatial resolution. Figures 2 and 6 shows the detected ancient ruins in the Farvardin and



Figure 1- Parse-Pasargad region. Processed image indicating geographical setting, geological environment, geomorphological features, drainage pattern and vegetation covers of Farvardin and Marghab plains. The numbers indicate the locations of Perspolis (1) and Pasargad (2).



Legend:

- 1: Persepolis
- 2: Rahmat Mountain

Figure2- Farvardin plain and its surrounding areas. This image is a density –sliced version of Landsat ETM+, band 8. The magenta-green-yellow colors are assigned to archeological residues of collapsed constructions. The band-like magenta zone on the top is found to be debris flow, and scree, mixture of reworked limestone fragment, and clay-silty-sandy materials.

Marghab plains and their surrounding areas. The high density and scattered distribution of the buried features on this area show that the region, as a whole, is an archeological site.

The Guard-wall and Watchtower in Persepolis

Studies using black/white photographs and processed ETM images over the Persepolis suggested that there was a change in soil tone related to slight topographic rises, and collapsed construction materials over buried structures. This difference produces some weak linear patterns with little spots of chaotic texture. These spots could be related to the remnants of guard towers along the palace wall, where a portion of it is visible on the mountain slope, on the northern margin of the site. Original air photos and relevant processed image represent the remnants of linear feature expressing ancient guard-wall and highlighted spots resembling to the location of watchtowers surrounding the Persepolis. The image analysis findings in this study indicate features that help trace these elements around the site. These features have the following characteristics:

- Linear anomalous tone with circular spots indicating material (rock, mortar, clay, gravel) with different composition and texture to the natural context.
- Existence of a slightly higher relief, indicating a ruined structure and dumped materials.
- Existence of bare spot forms, dissection features different from the background landscape indicating differences in material composition, plant ground cover and abundance of rock fragments. There are 34 circular patches with different sizes (small and large), where 17 features are located on the east and northeast hilly parts, and the other 17 are scattered over the plain. It seems that the size and pattern of watchtowers had been designed and constructed according to their defense usage (Figures 3 & 4).

The Pasargad Laklet

The geomorphologic characters, deposited fine clayey sediments on flat plains of the area, and depth of groundwater level, vegetation cover, rate of vegetation growth, moisture content of the soil and its type all are having different reflectance and recorded electromagnetic emanations. These differences recorded in aerial photographs and satellite images are the most powerful tools for delineating and separation of geologic environments. The alluvial coverage of the area indicates a high energy and flooding streams which have deposited alluvial type fan deposits containing detrital large grain clastic sediments with low context moisture and poor vegetation coverage. Marghab plain is a floodplain characterized by dendritic pattern drainage stream that recharges the surface waters into Bolaghy gorge which is the main run out system for Polvar River and Marghab plain (Figure 5). The major rock units belong to folded Zagros sedimentary sequence; mainly consist of limestone, dolomite, marly- clayey limestones, and shales. The major rock units according to their ages (from bottom to top) are Surmeh, Fahlyan, Gadvan, Daryan and Kazhdomi formations (James & Wind, 1965 and EP-NIOC, 1979). The geomorphologic features are being controlled by their lithological nature, which is composed of massive-thick bedded component carbonate units, and soft, incompetent shale, and marl sequences. The massive karstic limestone's units are the major escarpment forming cliffs, having several caves, caverns, and holes with different dimensions. There were many karstic spring, in the past, but by tectono-eustatic uplifting, and decreasing of water precipitations they have disappeared. Geologically Pasargad is located on the open syncline where Kazhdomi formation is exposed. This rock unit composed of clayey limestones and shales which are impermeable beds forming a substratum unit for descending water. This character facilitates shallow depth water accumulation in overlying gravely- sandy sediments to form shallow depth aquifers. The tributaries of Seivand and Polvar



Figure 3- Perspolis. Processed air photo applying Laplacian 5x5 convolution and classification for enhancement of earth surface covers (mixture of limestone fragment, calcareous and argillaceous matrix). Red and dark bluish green color assigned to collapse residual material. Location numbers (A, B, C, D, E ...) referred to remnants of ancient guard wall and watchtowers.

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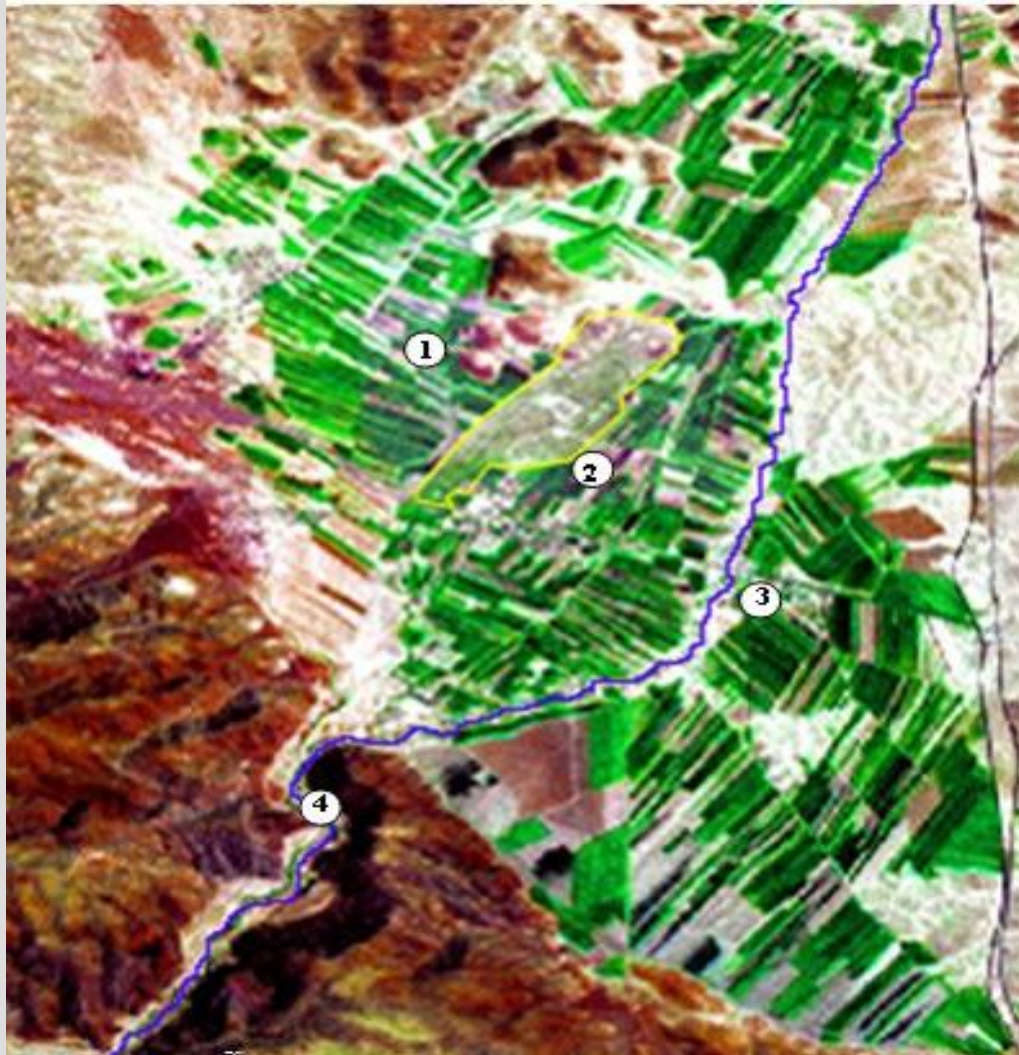


Legend:

Remnants of guard wall and watchtowers

Purposed of guard wall and watchtowers

Figure 4- The map depicting the place of guard wall and watchtowers surrounding the Persepolis.



Legend:

1: Marghab Plain 2: Pasargad 3: Polvar river 4: Bolaghy gorge

Figure 5- Processed satellite image of the Marghab plain shows the Locations of Pasargad and Bolaghy gorge.

rivers have trellis pattern. The Polvar river in Bolaghy gorge follows a trellis pattern which is caused by weak zones in bedrock that differ in their resistance to erosion. The trellis pattern usually, indicates that the region is underlain by alternate bands of resistant features of same valleys are short narrow segments walled by steep rock slopes or cliffs. These are called "water gap" (Samani, 2002). The river in effect, flows through a narrow notch is a ridge that lies across the course of the river. This narrow notch, before degradation had acted as a barrier or natural dam to form a water reservoir (local lake) on the upstream part (Marghab plain) where the Pasargada is located (Figure 6). The boundaries of the lakelet have been defined by geologic evidence, agronomic criteria, and processed aerial images, reveal differences in the texture of green vegetative cover in comparison to the general texture of the surrounding plain. Considering the existence of the lakelet in the western and southern areas, and the position and orientation of the Tomb of Cyrus the Great, it can be concluded that the original entrance road was different from the present location.

Conclusion

With an interdisciplinary approach, this paper tries to introduce a process of environmental analysis for the archeological sites. The readers whether archeologists, geologists, or environmentalists will find a common ground which constituted the shaping of the historical landscapes. Collecting different sources of environmental data such as geology, geomorphology, hydrology together with using remote sensing data and black and white air photos, with limited spectral and spatial resolutions, helps to understand the natural and built landscapes of archeological sites. The advanced high resolution (both spectral, and spatial), remote sensing data (ASTER, IKONUS, IRS, etc.) and hyper spectral surveying assimilates other types of archeological data to process analyzing, and helps to better understand the features, their patterns, textures, size, association, and so on. The results of this study

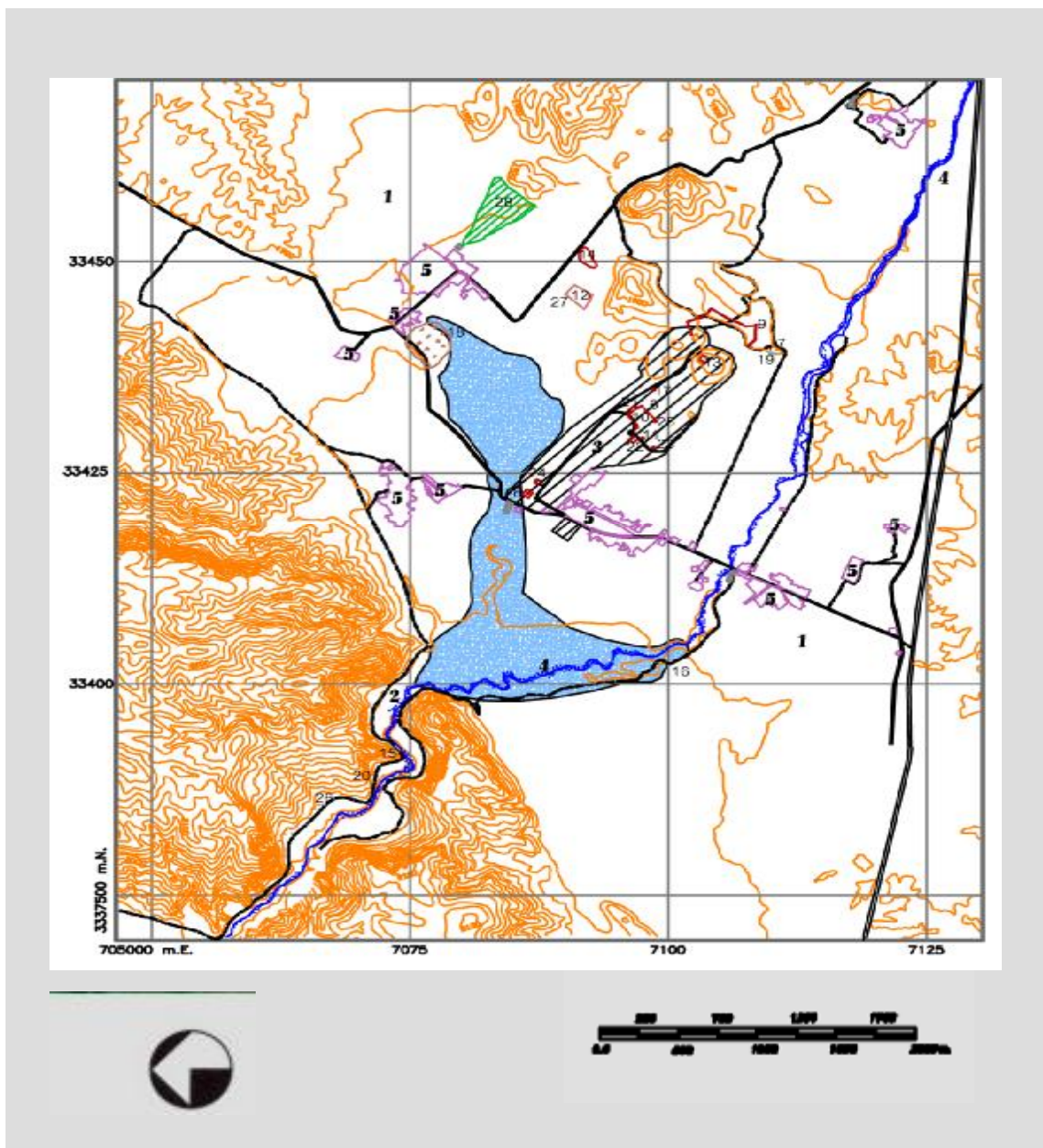
using different age air-photos and ETM+ images are indicative of the following features:

- The Parse-Pasargad area had been a unique environment consisting of plain and mountain landforms to form intrinsic farmlands and structure for settlement of Achaemenian kingdom.
- The present Persepolis site is a small sector of a vast area where the capital city (the Parse) and satellite villages had been located.
- There are some remnant and residues of a guard-wall and watchtowers surrounding impressive palaces of Achaemenian Empire, the Persepolis.
- There was a local lakelet at the entrance of Bolaghy gorge and the Polvar River, which played a major role in irrigating the gardens of Pasargad. Shallow groundwater tables and high humidity soils have resulted in development of pastures surrounding the lakelet, used for grazing horses and domestic animals.
- The location and orientation of the Tomb has been influenced by the lakelet landscape and access roads.

In order to precisely define the location of the irrigation system, housing patterns and the social life as reflected in the setting of the various elements of the Parse- Pasargad landscape further surface and subsurface studies are recommended. These studies may be carried out by analysis of land cover, surveying the remnants of ruined materials, and integration of information from different sources. For detailed analysis and defining of the ancient lakelet in Pasargad region, as well as the hidden features and collapsed buildings, shallow geophysical surveying methods are recommended.

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Legend:

- | | | | |
|-------------------------|---------------------------|-------------------------------|-----------------------------------|
| 1: Marghab plain | 8: Cyrus Tomb | 15: King rock road | 22: Audience Hall |
| 2: Bolaghy gorge | 9: Outer fortification | 16: Do Talloon | 23: Entrance Hall |
| 3: Pasargad | 10: Charbagh Garden | 17: Stone tower (Zendan) | 24: Caravansera |
| 4: Seivand river | 11: Bridge | 18: Achaemenian crockery | 25: Small Pavilion |
| 5: villages | 12: Takht-e Gohak | 19: Sassanian inscription | 26: Ancient graves |
| 6: Old lake | 13: Platform (Tale Takht) | 20: Yazdi Cave (Ghar-e Yazd)i | 27: Sacred area |
| 7: Sassanian fire place | 14: Tale khari | 21: Private Palace | 28: ruined place (Islamic period) |

Figure 6- Pasargad. general plan of the palaces, tomb, archeological remnants and old lake on the Marghab plain based on the ETM+ process image of the site.

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