Dynamics of Land Use, Environment, and Social Organization in the Sasanian Landscape of Eastern Iraq—Western Iran

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Dynamics of Land Use, Environment, and Social Organization in the Sasanian Landscape of Eastern Iraq—Western Iran

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Anthropology

by

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Abstract

Understanding human-environment interactions has been one of the main challenges in archaeological studies over recent years. Past research on the Near Eastern territorial empires in general, and the Sasanian Empire in particular, primarily emphasized the dominant role of human on landscape transformation. In addition, politically centralized schemes such as agricultural intensification and expansion of water supply systems have been at the center of most of the discussions and remained the main hypothesis of the Sasanian land use practices.

This dissertation investigates population’s diverse responses to environmental variability during the Sasanian period (224-651 CE) across a landscape in eastern Iraq—western Iran. Two coping mechanisms of mobility and intensification, and how they shaped settlement and land use patterns are explored. Intensification is defined as a strategy to increase land productivity and to buffer against production failure risks, while mobility is as an adaptive strategy that takes advantage of spatial and temporal variation in environment and resource availability. Situated between the arid alluvial lowlands of southern Mesopotamia and highlands of the Zagros Mountains, the study area is comprised of a patchwork of microenvironmental zones, where its dynamic and often fluctuating climate can, on one hand, create uncertainties in land use, and on the other hand, create a zone of connection between different lifeways.

With an interdisciplinary approach, I apply remote sensing and geospatial techniques, in conjunction with archaeological field survey, ethnoarchaeological data, and environmental records to reconstruct the past landscape and its anthropogenic and natural elements. Results of this research argue that we need to move beyond the exclusive model of intensification in describing settlement and land use systems of the time. This research takes a critical position against the dichotomized perspective that separates sedentary agriculturalists from mobile
agropastoralists. Results show that the study area was home to an intertwined lifeway consisting of both populations and show an integrated land use based on both intensification and mobility practices.

Finally, although this study only focuses on the Sasanian period, it presents a base to further research on the long-term history of human interactions with the environment.
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Chapter One: Introduction

1.1. Overview and Statement of the Problem

This dissertation investigates the human-environmental interactions during the Sasanian period (224-651 CE) across a landscape along the Sirwan River valleys in the Garmiyan District of Iraqi Kurdistan and Alwand River valleys in the western Kermanshah Province of Iran. Studying past human-environment interactions has become one of the most important research areas in archaeological studies over recent years (Kinith et al. 2014). This topic contributes to our knowledge of long-term patterns in environmental and social changes and has been approached by different models. The more conventional model investigates the correlations between past environmental characteristics and socio-political changes. For instance, “environmentally deterministic” studies emphasize a direct link between environmental degradation and socio-political changes and discuss the power of natural phenomena on social processes. On the other hand, “culturally deterministic” studies emphasize humans as exclusive agents of environmental degradations (Butzer 1982; Weiss et al. 1993; Coombes and Barber 2005). While both of these approaches have been criticized as being simplistic, more integrative approaches indicate that human-environmental interactions do not occur in a simple cause and effect form. The other model, which has been the focus of less attention in Near Eastern studies in general, and Sasanian studies in particular, emphasizes microenvironmental diversity and populations’ different coping mechanisms in response to them, including intensification, mobility, diversification of strategies, storage of resources, and exchange (McIntosh et al. 2000; Halstead and O’Shea 2004). In this dissertation, I study the cultural responses to diverse environmental conditions and investigate whether people transformed the landscape or chose an adaptive strategy.
Over time, the research focus has been shifting from deterministic views in human-environmental interactions and questions about the influence of one factor on the other to the questions about how humans adapted or responded to a variety of environmental conditions. Similar cultural systems, environmental systems are dynamic and one of the most important ways to understand a past society is to recognize its local environmental characteristics. Instead of focusing on one individual strategy, it is important to recognize the full range of mechanisms that societies employed to buffer against environmental variability, reduce risks in production failure, or increase the production. Also, populations could respond to similar conditions of variability with different strategies depending on time and space. In addition, different strategies could be employed by different groups of populations who shared the same landscape (Rosen 2007; Wossink 2009). Among all the diverse strategies, intensification has been closely connected to the rise and development of the Near Eastern late territorial empires, including the Sasanian dynasty. Sedentary agricultural lifeway has often been associated with increasingly complex forms of socio-political organization (Wittfogel 1957; Kirch 1994) and this has been particularly the case of the Sasanian landscapes and archaeological evidence, when settlement patterns and subsistence are seen to intensify during political centralization. However, in order to improve our understanding of the society, we need to study its diverse interactions with the environment. This study focuses on two primary categories of intensification and mobility. While both are cultural responses to environmental variability, each plays a different role in landscape formation and transformation and often create different patterns of settlement and land use (Mace 1993; Marston 2011).
According to the geographical and ecological conditions of the study area, it is located along a “zone of uncertainty”, where it is neither under the category of lowlands, such as southern Mesopotamia and Khuzistan where irrigated agriculture is practiced, nor under the category of highlands of the Zagros Mountains, where rainfed cultivation is a reliable practice. This could bring both risks and opportunities in production and land use practices. Therefore, its dynamic agroecological system makes it of critical importance to consider different land use strategies that could be applied by populations over time (Sanlaville 2000; Wilkison 2000a; Wilkinson et al. 2014).

Agricultural intensification, as one of the forms of agricultural change, has been at the center of most of the Sasanian studies concerning settlement pattern and land use practices. Intensification, defined as obtaining higher outputs by means of increasing capital inputs (Brookfield 1972; 2001) has been proposed as the primary cultural response to environmental variability and the main hypothesis of land use and production system in majority of the Sasanian studies (e.g., Neely 1974; Wenke 1975-1976; Christensen 1993; Wilkinson 2003; Adams 2006). It has also been closely associated with the expansion and development of the central state. In particular, irrigation systems as one of the main capital investments have been recognized as one of the primary signatures of the Sasanian landscapes and have been recognized as the main water management strategy to cope with certain environmental conditions in arid and semi-arid regions. Moreover, in discussions of intensification, its incentives are either related to the environmental conditions or sociopolitical forces. Mitigating product failure, increasing production, meeting the food demand of a growing state, controlling larger territories, or increasing tax revenue are among the important sociopolitical incentives of intensification, while its long-term environmental
consequences can include soil degradation, changes in resources availability or resource diversity (Stone, Netting, and Stone 1990). In addition to the causes of intensification and record of its capital investments, its environmental, economic, and sociopolitical consequences, either at local or regional levels, have usually been the focus of less attention. By increasing or stabilizing production, intensification triggers economic development. Additionally, it can help the expansion of political power, bring population transfers and demographic changes, or impact longer-term suitability in land use and production by changing environmental characteristics of a landscape.

After its introduction by Brookfield (1984), the concept of capital inputs was developed in the fields of environmental and cultural ecology as well as in archaeology (Kirch 1994; Fisher 2009). Capital inputs are divided into two main categories of landesque capitals such as irrigation systems, agricultural fields, terraces or micro-level elements such as soil management strategies, and working capitals such as labor, skills or technology (Brookfield 2001). These investment inputs aim at increasing land productivity or removing constraints, often endure for long periods of time, and leave long-term environmental effects. While these built elements are among the most noticeable archaeological remains that demonstrate the past land use, they also reveal important knowledge on chronological sequences and societal aspects. Working capital inputs are more fluid in space and are more challenging to be identified in archaeological records. However, landesque capital inputs are more fluid in time and fixed in space and because they oftentimes leave permanent signatures on the land, they are easier to identify through archaeological fieldwork or remote sensing analysis. Furthermore, fallow length, working hours, area of land under irrigation, storage tools and buildings, and regional settlement data are among the
archaeological indicators of intensification that are discussed in Chapter 3. In this dissertation, settlement distribution, artifacts, and evidence of agricultural activities are recorded as the spatial manifestations of agricultural intensification.

There are two theoretical perspectives discussing the correlation between intensification and sociopolitical organization: centralized or top-down, and decentralized, or bottom-up perspectives. The political centralization model views changes in land use and subsistence in relation to the influence or presence of a central authority. This model views intensification as one of the main strategies to increase production and distribute surplus. In addition, the occupation of marginal or peripheral regions is explained as a product and consequence of the central state schemes. Examples of the political centralization model include the relation between the development of complexity and socioeconomic context of water management systems (Wittfogel 1957; Adams 1981). According to this theory, collapse of the complex agro-hydraulic systems is interpreted based on the collapse in the political power of a central state.

On the other hand, decentralized perspective views changes in land use and production as results of internal organizations and as community-based formations. Instead of the presence of a central authority in land use decision, this model emphasizes the decision making of local communities (Doolittle 1984; Knapp 2003; Erickson 2006). In contrast to the top-down approach, this model regards the organization and structure of the systems as heterarchical. It emphasizes smaller-scale communities that rely on local ecology and indicates political authorities are either absent or have little influence in the organization of the landscape. Additionally, this model discusses the degree of autonomy among local communities and in their interactions with the central states. Example of this
approach includes Lake Titicaca Basin intensive agricultural systems that did not confine to the central state influences (Erickson 1993). Contrary to the political centralization, this model considers agricultural and irrigation systems stable, even at the time of social or political collapses.

Evaluations of centralized and decentralized models have presented their limitations. The top-down approach has been criticized due to its unilinear approach and lack of addressing local diversities. Additionally, it underestimates the decision-making power of local communities. The most important limitation of the approach that relates to this dissertation is the fact that it neglects the non-sedentary or non-agriculturalist groups. It also neglects the presence of different social classes in creating the whole society and its complex land use. The example of the class of Dehghan during the second phase of the Sasanian dynasty and its role in land management and land ownership, in particular in areas beyond the core political and economic zones of the empire, is further discussed in Chapter 3. This class that is still poorly known to us consisted of local governors who played important roles in centralized agricultural plans through agricultural tax management and land ownership. While this top-down model has remained as the most established narrative of correlations between intensification and social organization during the Sasanian period, one of the limitations of the bottom-up model concerns the fact that it does not discuss the intentions of investment in land use and agricultural intensification. Besides the criticisms of both models, it should be noted that a central state or political authority could have a shifting presence across a landscape and play different roles in land use and production systems over time. Furthermore, the state’s ability to control over different areas or manage different landscapes could also vary. In addition, I argue that while the agricultural
intensification, specifically the centralized political model, has been the main hypothesis of the Sasanian land use practices, we need to think beyond this model in order to better examine different coping strategies as responses to environmental variability and microenvironmental diversity.

How past societies responded to different environmental conditions and whether they chose adaptive strategies or transformed the landscape has been at the center of many archaeological studies in recent years. Land use practices and mechanisms to buffer against variation and risk can take different forms; however, contrary to intensification, the subject of mobility has been the focus of much less archaeological studies. To date, Sasanian scholars have collected data almost exclusively on the sedentary agriculturalists and the role of intensification in the past social, political, and economic aspects. There are multiple reasons for this limited perspective. Archaeological studies have primarily focused on excavations of sites or studies of urban areas. Even surveys that were conducted in areas beyond the political and economic core zones have recorded settlements and other landscape features with a perception of sedentary lifeway and their land use activities. Additionally, older perspectives suggested rural countryside, or marginal and peripheral areas as homogeneous, and as simple suppliers of food, other goods, or labor to centers. While this view is widely rejected, alternative perspectives focus more on variability in both smaller-scale social and environmental elements (Stone, Netting, and Stone 1990). Plus, evolutionary thinking in anthropology used to link agriculture with progress and social complexity and considered a hostile relationship and competition over resources between the two groups. Moreover, past studies generally assumed a distinction between the two practices and believed that populations chose mobility at the times of negative demographic
change. These also perceived mobility as a static system that does not contribute to the landscape formation or transformation (Adams 1981). In addition, there have been challenges in detecting traces of mobility in archaeological remains. Sites of mobile groups have been exclusively and incorrectly assumed as ephemeral campsites. As a result, non-sedentary lifeways have either been neglected or incorporated to the studies through limited historical records written by governments or from the perspective of urban elites. This resulted in a limited understanding of the important role of these populations, their interactions with the sedentary groups, and finally their broader role in the society such as in subsistence, production, exchange, and trade route connectivity. How these populations lived and moved across a landscape, and how they viewed and organized the landscape are also still poorly known (Porter 2012). To better realize the local landscape organization across the study area, this dissertation attempts to recognize populations practicing different forms of intensification and mobility.

Based on different spatial and temporal scales, mobility can take a variety of forms. Additionally, the motivation of movement can range from environmental factors to cultural forces. The pattern of movement and the interactions between sedentary and non-sedentary groups also happen in different ways. Mobility is an adaptive land use strategy that allows populations and livestock to benefit the spatial and temporal variability of natural resources (Wendrich and Barnard 2008). It can range from highly mobile groups when the entire of a population move, to a lifeway that only a smaller number of the population moves seasonally. Different terms to characterize mobile groups are defined in Chapter 3. In this study, I use the term **agropastoralism** that includes *semi-sedentary pastoralism* and *semi-nomadic pastoralism*. This term also involves the three factors of agriculture, pastoralism,
and mobility. There have been some misconceptions about agropastoralism in historical and past archaeological records. One of the most important misconceptions argues a dichotomy between sedentary agriculturalists and mobile pastoralists. Past scholarship has viewed these groups as distinct and often with a hostile connection and constant competition to obtain or control resources. This dichotomy does not explain the integrated connection between the two groups in terms of land use, settlement locations, and subsistence practices. Multiple archaeological and ethnographic studies across the Near East present the highly variable degree of involvement in agriculture and pastoralism, as well as the variable degree of mobility or sedentism. Both intensification and mobility are strategies in response or adaptation to changes in cultural or environmental conditions and should not be viewed as mutually exclusive. The degree of their integration, as well as the power relations between mobile-sedentary interactions, are further discussed in Chapter 3. Models describe that both strategies can be integrated across a landscape at household or community levels (Tapper 1979a; Cribb 1991: 23-27). Also, land use practices can shift between agricultural and pastoral activities at times (Watson 1979). Even in the cases of agricultural expansion and intensification across marginal or peripheral landscapes, two main hypotheses should be considered: one, the presence of imperial policies of central states that forced sedentarization of mobile groups because of political or economic reasons, and two, peaceful and more gradual sedentarization of mobile groups because of the presence of favorable climatic condition and resource availability.

The perspective advocated in this dissertation considers that populations practicing mobility have not been separated from sedentary ones but have been spatially and socio-politically integrated. The practice of this lifeway should be viewed based on its flexibility
and freedom that communities had in premodern times. It was a risk management that could be an alternative strategy for production or buffering against risks in product failure.

Mobility can be practiced either in horizontal or in vertical patterns. Horizontal movement occurs between the summer and winter camping areas at the same elevation; however, vertical movement occurs between summer and winter pastures located at different elevations and ecological zones. Agropastoralists of the Zagros Mountains region practice vertical mobility, use highlands in summer and lowland areas in winter (Hole 1978). In a vertical pattern, populations use land and resources in reaction to the environmental and sociopolitical conditions. This vertical movement is defined by the term “enclosed nomadism”, which causes regular contact between the mobile and sedentary populations during their seasonal movements (Rowton 1974). This contact with sedentary populations specifically happens in their winter settlements in lowlands, with whom the agropastoralists had interdependent economic contacts. The archaeological features examined in this dissertation relate to both intensification and mobility practices and the mobile agropastoralists have had a vertical movement pattern whose spatial and sociopolitical relations with sedentary populations have shifted over time. Fixed summer and winter settlements were in the form of tents or mudbrick houses with stone foundations. Winter settlements in the lowlands had a combination of tents amidst the mud houses. In both lowland winter house and summer camping areas in highlands, populations could use tents or built houses. Chapter 5 presents further details of ethnoarchaeological records from the region that create a base for analogies between the historical evidence and ancient records. This data helped to understand the traditional land use and settlement pattern.
In past regional surveys of southern and northern Mesopotamia, agropastoralists were assumed to have separate patterns of land use practices and settlement locations from the sedentary populations. In the southern Mesopotamian surveys, dense settlements recorded in the alluvial plains are interpreted to be evidence of sedentary lifeways with intensive agricultural practices, while mobile agropastoralists are believed to have lived outside of this zone. However, with better recognition of microenvironmental diversity and proximity of different microenvironments to each other and interactions between both populations in different social, political, and economic aspects, reassessment of past surveys can potentially change this perspective. Chapters 4 and 5 present the data collection and analysis to understand the patterns of settlement and land use by different populations and their interactions with the environment. Few archaeological surveys and excavations in the broader Zagros region have discussed the remains of agropastoralism (e.g., Hole 1974, 1975, 1978; Rosen 1987; Abdi 2003; Alizadeh and Ur 2007). In some studies, a distinction between the two practices assumed that populations chose mobility at the time of negative demographic changes (Adams 1981). Recent and more sophisticated perspectives and advances in archaeological survey methods have corrected these assumptions and other ones such as the invisibility of this group in archaeological remains. Intensive survey coverage, application of remote sensing tools for identifying landscape features, survey in diverse microenvironments and instead of exclusive emphasis on urban areas, monumental features, or immediate hinterlands of cities, as well as change in the perspective that all the mounded settlements are evidence of a sedentary lifeway, are some of the most important recent improvements that have helped a more complete and accurate picture of past societies.
Indicators of both mobility and sedentism, including shelter types and material remains, are explained in Chapter 3. In brief, in a mixed landscape containing sites of both sedentary and mobile groups, sites attributed to the non-sedentary groups are small in size and contain low-density surface material remains. Surface ceramics are some of the most important materials that can be used to understand the function and test the sedentary or non-sedentary nature of a site. Two main types of ceramic vessels are evidence of mobility. Small portable ceramics, and large storage jars. Small ceramics are lightweight and could be carried during the seasonal movement, and large vessels could remain at the seasonal settlements, in particular in the winter settlement in lowlands, where could be occupied for several months of a year. Besides these types, ceramic was rarely used by mobile agropastoralists and people mostly used objects made from metal, animal skin, wood, or glass (Cribb 1991).

This dissertation focuses on a landscape in the Garmiyan District of Diyala Governorate in Iraqi Kurdistan and Qasr-e Shirin County of western Kermanshah Province of Iran. It is comprised of diverse microenvironments, including the Sirwan (Diyala) and Alwand River valleys, foothills of the Zagros Mountains, steppes and plateaus that have created different potentials for settlement and land use activities throughout history. The alluvial plains are the most agriculturally productive areas that are revealing the majority of the ancient settlement remains. These karstic plains were well-watered with stream-fed springs and with average annual precipitation of 200-300 mm, contain agricultural fields and dense orchards in their floodplains (Kottek et al. 2006). With an increase in elevation and precipitation in northern parts of the study area, a different environmental zone presents potentials for rainfed cultivation and pastoralism. These microenvironments, as well as the
climatic condition of the study area, are explained in more details in Chapter 2. With an interdisciplinary approach, this dissertation applies archaeological landscape survey integrated with remote sensing techniques, as well as ethnoarchaeological and environmental records to examine the human-environmental interactions with regard to the role of both intensification and mobility. In addition, I will test the potentials of remote sensing techniques for documenting the ancient features and reconstructing the past landscape.

1.2. Outline of the Dissertation

Following this introduction, Chapter 2 describes the details of the microenvironments across the study area, as well as geographic, climatic, and topographic conditions. Further, it describes the past climatic condition of the region. The study area is environmentally transitional, located between the lowlands of Mesopotamia and highlands of the Zagros Mountains. This geographic location has created a particular condition where it historically has been suitable for a mix of agriculture and pastoralism. With regards to cultivation, the area is located at the edge of irrigated and rainfed zones. A synthesis of paleoenvironmental records from the nearby lakes in western Iran and southeastern Turkey, present an optimum climatic condition in the region that coincided the second phase of the Sasanian period.

Chapter 3 describes different strategies that populations could apply in their interactions with the environmental characteristics across the study area, in particular with regard to the environmental variability and uncertainty. Whether populations responded to the variability by transforming the landscape through intensification, or whether they chose mobility as an adaptive strategy, and how these two different responses could define
settlement patterns and land use practices are discussed in this chapter. Agricultural intensification, its incentives, consequences, different capital inputs, as well as two main models of centralized and decentralized intensification based on correlations with the socio-political organization are discussed here. In addition, mobility, misconceptions and wrong theoretical perspectives towards this strategy, methodological approaches, interactions between mobile and sedentary populations, as well as agropastoralism in the study area are further explained.

Chapter 4 describes the methodological approaches to record the archaeological landscape through remote sensing techniques and systematic landscape survey. It presents the acquisition and analysis of historical and modern high-resolution satellite imagery that significantly helped documentation of the landscape. Survey methodology and its intensity, methods to collect and analyze surface materials, as well as presenting the results of archaeological remote sensing are explained. Although this area contains rich archaeological and historical remains, it has not been the subject of systematic surveys in past. Therefore, this research is the first attempt to record the Sasanian landscape and create a base for further investigations. In particular, this chapter illustrates a range of sites and features previously undocumented and characteristics of settlements, off-site features such as irrigation systems, and agricultural terraces. While the focus of this dissertation is on the Sasanian evidence, surveys have documented a longer-term occupation of the landscape. The last part of the chapter is devoted to the analysis and presentation of the ceramic remains that are used to establish the chronological sequences of the sites.

Chapter 5 reviews the ethnoarchaeological datasets on mobility and agropastoralism in the broader Zagros Mountains region and across the study area. A synthesis of the recent
historical data on local landscape activities, cultivation and herding practices, territories, as well as archaeological interpretations of settlement patterns and material remains demonstrate the benefits and limitations of using these records for understanding the past landscape. They also help to make sense of the archaeological records. Local landscape organization of mobile groups and their interactions with sedentary population are reviewed. The ethnoarchaeological records indicate a mixed settlement and land use activities and close interactions between sedentary and non-sedentary populations. It criticizes the past archaeological models that view mobility as a distinct lifeway and subsistence strategy from the sedentary agriculturalists. Other parts of the chapter are devoted to discussions of the application of geospatial techniques in reconstructing the past landscape. In particular, it examines the land cover and hydrological models of the study area to better understand the spatial relationship between various land cover types, environmental characteristics, and archaeological features. This analysis relies on multispectral Landsat satellite images and digital elevation models that illustrate the natural and anthropogenic features of the area.

Chapter 6 concludes this research by arguing that intensification, expansion of sedentary settlement system, as well as the construction of landesque capitals inputs such as irrigation systems were only parts of the strategies that past populations employed across the study area. Across an environmentally transitional area, mobility, as an adaptive strategy, has been a historically important lifeway. Archaeological landscape surveys, remote sensing and geospatial analysis, ethnoarchaeological data, as well as environmental records present enormous potentials to provide a complex understanding and reconstruction of the past landscape formation and transformations. The results have significance for
understanding the complex relationship between past populations and environmental characteristic.
Chapter Two: Archaeological and Environmental Settings

2.1. The Study Area

The study area is located in the Garmiyan District of the Diyala Governorate of the Iraqi Kurdistan and western Kermanshah Province of Iran. As a semi-arid region, it is comprised of the following microenvironmental zones: alluvial plains of the Sirwan and Alwand Rivers; river floodplains; plateaus and steppes; and foothills of the Zagros Mountains (Figure. 2.1). Based on geomorphological divisions, the northern part of the study area is located in the upper foothills and lower Zagros Mountains region, while the southern part of the study area is in the lower foothills and upper Mesopotamian plains. Climatic and environmental characteristics of the study area are defined by both temporal and spatial variations. These variations are important factors in studying patterns of settlement, land cover, and land use throughout its history.

The Sirwan River is the third largest tributary of the Tigris River, besides the Greater and Lesser Zab. It originates in the Zagros Mountains of the Kurdistan Province of Iran, shapes the border between Iran and Iraq for over 30 kilometers, flows in the Kurdistan region of Iraq, and finally joins the Tigris River south of Baghdad. Sirwan (in Kurdish) falls within the foothills in beds of conglomerate, gravel, and sandstone. It is called Diyala (in Arabic) in its lower reaches where it flows in the primarily Arab-populated regions of Iraq. Alwand (Hulwan in Arabic) is one of the main tributaries of the Sirwan River and flows in the western Kermanshah Province of Iran. After running through the Qasr-e Shirin town, the river turns south and enters Iraqi Kurdistan and runs in the region for 40 kilometers. It runs through Khanaqin town, and finally joins Sirwan near the town of Jalawla. Sirwan has played important roles in the development and water conditions of both Qasr-e Shirin and
Kahnaqin throughout history. Besides Alwand, the Sirwan River basin also comprises smaller tributaries that originate in the Zagros region of Iran, enter Iraqi Kurdistan, and run in the north of the study area before joining Sirwan in its upper reaches. Two notable ones are the Abbasan and Quraito Rivers. Both Sirwan and Alwand are agents of water supply, transportation, and environmental changes such as erosion. Both rivers cut the land deeply, which makes irrigation challenging without the aid of water management systems. They create narrow floodplains where lands get flooded in the spring and early summer months.

In recent decades, multiple dams were opened along the course of the Sirwan and Alwand, which has shifted the cultural and environmental aspects of the landscape. Most notably, the Darbandikhan Dam was opened in the 1960s on the upper reaches of the Sirwan, and Hamrin Dam was opened in the 1980s in the lower reaches of the river. In addition, the Alwand Dam in Khanaqin, and more recent dams constructed on the Iranian side, including Daryan Dam, are some of the most important water management projects in the region. Currently, the peak of the rivers flow is in April and the lowest seasonal flow occurs in July (Hamza 2012). In general, climatic changes, including precipitation decrease, water deficiency in the region, and the transboundary course of the rivers where they originate in Iran and flow into Iraq have all created a complicated water management system for both countries, sometimes causing water disputes and water crises in the region.

The lowlands of the rivers are comprised of alluvial plains which are the main agriculturally productive zone and are characterized by agricultural fields as well as orchards and vegetable gardens on their floodplains. These alluvial plains have been well-watered by both spring-fed streams, as well as groundwater sources (Figure. 2.2). After passing through the foothills of the Zagros Mountains and its hilly lands, and near the town
of Kalar, Sirwan slows down and creates a braided channel. In this area, a sharp change in the fold geometry of the river creates elongated alluvial plains. With an average elevation of 200 meters above sea level, these plains have been an agriculturally productive zone and a suitable area for settlement in the past and present. Generally, average elevation ranges between 200-300 meters above sea level in the towns of Kalar and Qasr-e Shirin, respectively (Figure. 2.3). On these plains, average annual rainfall ranges between 200-300 mm and temperatures reach 40 ° C in July and drop as low as 10 ° C in January (Kottek et al. 2006). Typically, the average annual precipitation of 200-250 mm is recognized as the minimum amount required for rainfed cultivation. While this amount might vary in different regions depending on evapotranspiration, water management techniques, and socioeconomic conditions, this average amount is widely accepted as the limit for identifying irrigated or rainfed practices (Held 2015). Therefore, based on the modern climatic condition, cultivation and continuous production in most parts of this area require irrigation. Besides surface water resources, groundwater resources have played a fundamental role in agricultural production and development of the region. In particular, the lowland plains have been fed by perennial sources of spring water. However, over recent decades, political instabilities, drought, and excessive well-pumping have dramatically decreased groundwater tables (Lightfoot 2009).

To the north, and with an increase in elevation and precipitation towards the northeast and east of the study region, there is a different microenvironmental zone (Figure. 2.4). Average elevation reaches 500 m and precipitation increases to an average of 600 mm per annum (see figure. 2.2). With a cooler Mediterranean climate, the average temperature is 30 ° C in July and 6° C in January (Kottek et al. 2006). This is a hilly landscape with
parallel hill ridges that are mainly formed by coarse gravel, pebbles, sand, silts, and clay which are eroded from the mountains. Deposition of these materials by geological processes in upland valleys have formed this foothills zone. In this zone, besides smaller patches of flat land, nearby tributaries of the Sirwan River that can use stream water for irrigation, rainfed cultivation, and herding practices have been primary forms of subsistence strategy (Figure. 2.5).

The zone at each side of the international border is comprised of plateaus, hilly lands, and steppes. Larger streams that flow in this region were probably the only areas suitable for cultivation in ancient times. The westernmost side of the study area in the right bank of the Sirwan river is the most arid zone with low annual rainfall and characterized by undulating plains, a series of seasonal wadis, and very little and unstable access to surface water resources (Stevanovic and Markovic 2004).

2.2. Present and Past Environmental Conditions

Today, the study area is a semi-arid region that is moving fast toward more arid conditions. Due to orographic effects, rainfall decreases from north to south and the main rainfall occurs between October and November. The change in the topography and climatic conditions, as well as the geographic location of the study area which is located between the Mediterranean climatic regime in the north and the arid climate in the south, indicates the environmentally transitional nature of the area. This fact creates a dynamic and often fluctuating condition that impacts production systems and the general land occupation and land use practices. Geomorphologically, the soil of the study region has a moderate sedimentation rate and composes less salinity compared to the soil condition in the southern Mesopotamian alluvial plains. This condition makes the study area moderately fertile for
agricultural practices. Soils are comprised of Bakhtiari silts, clays, and gravel overlying Fars and sandstones, and, in some places, interstratified by materials brought by rivers or stream channels (Buringh 1960). Wheat and barley are the main economic resources and the most important winter crops of the area that are planted in fall and are harvested in late spring or early summer. In the past, planting winter crops used to alternate with a fallow year. In addition, the main summer crops include dates, rice, cotton, corn, as well as vegetables and fruits which are perennially planted along the rivers floodplains where they could be irrigated by river water. In general, orchards, vegetable gardens, and smaller patches of summer crops, especially around Qasr-e Shirin and Khanaqin towns, have been irrigated by the river channels. In recent years, while the primary natural irrigation source has been surface water, the role of the groundwater sources in irrigation has drastically decreased (Frenken 2009). Currently, cultivation in the lower plains depends on irrigation and water is mainly supplied by surface sources and partially by groundwater sources.

Riverine zones are often densely cultivated with orchards and vegetables. Whereas in the past, perennial streams and karstic springs played significant roles in irrigating these plains, in more recent times, political instability, excessive mechanized well pumping, and a dramatic decrease in precipitation have led to a change in land use patterns. The upper reaches of the Sirwan and Alwand are hilly landscapes that are less suitable for irrigated agriculture. Here, grasses are the most flourishing vegetation for parts of the year (Figure. 2.6).

Understanding past climate conditions is particularly important for a better interpretation of land use models, archaeological features, and historical records. In addition, understanding interactions between past societies and the climate can help to better realize
the increasing environmental changes of modern time. Measuring ancient climatic conditions is possible by recording proxy indicators such as pollen records, lake levels, ice cores, tree rings, carbon or oxygen isotopes, or volcanic ash (Matthews 2008). Specifically, multi-proxy records have been more useful in archaeological studies. Recent years witnessed an increased focus on reconstructing the past climate and understanding potential links between environmental and social changes in the past. For instance, the 4.2 ka event has been one of the most debated topics in Near Eastern paleoclimatic studies. This hypothesis claims that a rapid increase in aridity at approximately 2200 BC was one of the main factors in the collapse of the Bronze Age societies in Upper Mesopotamia (Weiss et al. 1993). Although there is still no agreement among Near Eastern scholars about this event, this aridification has also been discussed in regards to other regions of the world, including the Indus Valley (Staubwasser et al. 2003), North America (Booth et al. 2005), and Africa (Gasse 2000). While some research efforts have speculated connections between past environmental degradations or abrupt climatic shifts and collapse of societies, less attention has been given to how environmental changes or diversity could cause different land use decisions and coping strategies.

The impact of different environmental characteristics or environmental changes, such as the presence of an optimum climatic conditions, on the Sasanian Empire’s development, expansion, or collapse, has not been fully understood. Additionally, what is even less known is the different patterns of settlement and land use strategies based on diverse environmental conditions. With research in climate change rapidly expanding, paleoclimatic data is becoming more available and enabling us to better analyze the interactions between nature and culture in the past. It has been widely accepted that since the late Holocene
(2250-0 yrs BP), aridity has increased and the current climate regime was established; however, small-scale fluctuations such as a drought or a period of optimum climatic conditions could have influenced settlement patterns and land use decisions across heterogeneous environments in particular. To provide a picture of the study area’s climatic condition during late antiquity, I use a synthesis of the proxy records from Lake Van (southeastern Turkey), Lake Mirabad, and Lake Zeribar (western Iran) which exhibit the same hydroclimatic conditions as the study area. Staple isotopic records from Lake Van provide data on the atmospheric moisture of the last 13,700 years and, due to their high temporal resolution, also allow for the detection of short-lived fluctuations and periods of stability (Roberts et al. 2008). Records indicate that a moist interval coincided with the Sasanian period and was preceded by drier conditions which lasted up to 1700 cal yr BP (250 CE). This interval was then followed by another drier period known as the Medieval Climate Anomaly (MCA) between 1050 - 650 cal yr BP (900 - 1300 CE) (Finne et al. 2011). Oxygen-isotope records from Lake Mirabad and Lake Zeribar show a precipitation increase during the Sasanian time, a mild drought in 1500 cal yr BP (450 CE), and stable conditions during the latter part of the Sasanian period (500-600 CE) (Stevens et al. 2006). This climatic stability, coinciding with the late Sasanian period, is also observed in Lake Van records (Lemcke and Sturm 1997; Wick, Lemcke, and Sturm 2003). This pattern is also confirmed by vegetation reconstructions and analysis of ocean dynamics in the Gulf of Oman (Miller et al. 2016). Data show warm, dry conditions and a desert formation phase between 910-1145 CE. In general, the MCA witnessed the warmest conditions in the region prior to the 20th century (Lamb 2013). According to this data, the onset of the dry phase
occurred sometime after the political disintegration of the Sasanian dynasty (Miller et al. 2016).

The synthesis of records indicates a moist interval as well as climatic stability in the region that coincided the Sasanian period—in particular, the second phase of the dynasty. It is also important to note that these are local-scale climatic reconstructions which rely on proxy records from the nearby study region. Further research across the vast areas of the empire and from multiple environmental zones can result in a more comprehensive understanding of the climate during this period. In addition to the climate data and in order to reconstruct past land use patterns, including settlement strategies, cultivation, pastoralism, or mixed subsistence, it is also important to study the local environmental characteristics of the area. These will be further discussed in Chapters 4 and 5.

2.3. Zone of Uncertainty Paradigm

The archaeological landscape emphasized in this research is located between the two zones of alluvial lowlands in southern Mesopotamia and Khuzistan, and the highlands of the Zagros Mountains. The alluvial plains of the southern zone have an arid climate with an average annual precipitation of less than 200 mm that makes irrigation necessary for successful cultivation. These intensely irrigated plains have been recognized as one of the most important economic and political zones across the Sasanian empire. The monumental constructions, cities, and different elements of urban patronage recorded in the south have been known as landscape signatures of the empire. These plains have also been the focus of investigations into the effects of human activities—in particular, intensive irrigated agriculture on environmental changes or degradations. Studies have indicated that while the primary goal of irrigation expansion was to minimize production risks and consequently to
increase crop yield, its environmental effects, including salinization or siltation, severely impacted longer-term productivity (e.g., Jacobsen and Bradford 1982). In general, long-term effects of these constructions, possible overexploitation of land and resources, and fall of intensive land use and irrigation system into an unsustainable one have been debated as possible catalysts for the empire’s political collapse (e.g., Adams 1981; Christensen 1993; Alizadeh et al. 2004). To the north, the Zagros Mountain Range has been of significant importance in studies of paleoenvironmental, as well as sociopolitical and economic histories. It introduced some of the earliest evidence of agriculture and processes of plants and animal domestication (Braidwood et al. 1960). These highlands are under the influence of the Mediterranean climate and historically, due to topography and availability of natural resources, have been less suitable for cultivation unless in areas along the main river tributaries. With an increase in elevation and precipitation, it presents a different ecological zone where irrigation is not necessary and rainfed cultivation is an a stable and reliable possibility.

The study area is located between these southern alluvial plains and the Zagros highlands and along the “zone of uncertainty” belt, which falls neither under the category of lowlands nor of highlands. It is characterized by a complex and dynamic agroecological and economic system where variability in the environment, particularly in precipitation and resource distribution, creates both risks and opportunities in land use and production (Sanlaville 2000; Wilkison 2000a; Wilkison et al. 2014). Located above the intensely irrigated agricultural plains where flat and fertile lands are suitable for sedentary settlement and cultivation, and below the mountainous highlands, this semi-arid zone of uncertainty is characterized by a highly variable and erratic rainfall that ranges between 300 and 200/180
mm annually. Except for the last century when climatic changes have increased clear trends towards more arid conditions, this zone’s fluctuating rainfall makes the rainfed cultivation a possible, yet a risk-prone practice that could cause production failure one out of every few years. Based on these fluctuations and variabilities, this zone can also be viewed as a zone of connections between different lifeways and subsistence strategies.

Definition of the term “risk” differs among disciplines such as archaeology, ecological anthropology, economy, and agricultural sciences. In general, risk is defined as an unpredictable variation in the outcome of behavior. In archaeological and ethnoarchaeological studies of risk, attention is paid to the subsistence economies and subsistence risk, especially in mixed production systems such as agropastoralism. In other words, the chance of loss in food production and subsistence failure is known as risk. In this regard, it relates to the concept of “uncertainty.” However, the major difference between risk and uncertainty is that uncertainty can be overcome by acquiring information, such as knowledge about the environment (Halstead and O’Shea 1989; Goland 1993; Mace 1993). Many anthropological studies in different parts of the world have studied the condition of loss or shortfall of production. Cross-cultural comparative studies illustrate diverse ways that risk has been mitigated. For instance, one of the most important strategies that populations have applied is diversification. Diversifying types or varieties of crops and herds; spatial diversification through mobility, such as changing the location of cultivation fields or pasture zones in dry years; diversification of subsistence activities, such as a combined economy of agricultural production, pastoralism, and exchange, are some of the most recognized forms of diversification to minimize variation, risk, and uncertainty (Garnsey and Morris 1989). Risk creates a zone of marginal cultivation because prior to the
modern mechanized agriculture and water supply systems, only specific areas could be cultivated or could support sustainable cultivation. It is also one of the main elements of a transitional zone where the transition is not only an environmental expression but an economic and political one as well. Overall, the location of the study area in a zone of uncertainty could have important impacts on patterns of settlement, land use, and populations’ buffering mechanisms such as adaptation or response to the uncertainties which are further discussed in Chapter 3.

2.4. Archaeological Research Background

Historically, the area has been influenced by both its geopolitical location and environmental condition. The Great Khorasan road passed through the study area, in particular through the towns of Khanaqin and Qasr-e Shirin. This major route that connected important centers at different historical times, including Baghdad to Jibal, Ecbatana, Ray, and Khurasan, has made the study area strategically important (Ibn Khordadbeh 1889; Mustawfi Qazvini 1919). According to Islamic geographical sources, the study area was one of the sub-districts of Shad Firuz (the Sasanian term) or Hulwan (the Islamic period term). Hulwan has generally been identified with the modern city of Sarpol-e Zohab in Iranian Kurdistan (Muqaddasi and Collins 1994; Le Strange 1905). Early observation records from this region come from reports of Islamic period geographers and historians of the 9th and 10th centuries and later by European travelers of the 19th and 20th centuries (Figure. 2.7). For instance, Ibn Khordadbeh in his Al-Masalik W’al- Mamalik (“Book of Roads and Kingdoms”) and Mustawfi Qazvini in his Nuzhat al-Qulub (“Pleasure of the Hearths”) describe general characteristics of the region, including towns, natural resources, and the role of trade route connectivity in the development of the region. In more recent times, the
area was a zone of contention between the Ottoman state and contemporary Iranian dynasties—in particular, the Safavids and Qajars. During the Safavid and Ottoman empires, the area was part of the Zohab district that was stretching from Sarpol-e Zahab to the course of the Sirwan River. This district was described as rich in agricultural production and well-watered by streams and qanat systems (Rawlinson 1839). Throughout its history and even until the last century, the area was primarily ruled by local Kurdish tribes (Van Bruinessen 1992: 132-195).

The study area is located in the broader archaeological region of the Zagros Mountain Range. In this Zagros region, valleys, plains, and highlands have attracted researchers to study early complexities as well as multiple social and economic systems of ancient societies. The Zagros region was home to some of the earliest scientific archaeological projects, in particular on the Paleolithic and the Neolithic periods, and has presented some of the earliest evidence of agricultural practices in the world. Some of the most recognized projects include the University of Chicago Prehistoric Project that aimed at finding evidence of the transition from hunter-gathering to early settlements, agricultural activities and domestication in the hilly flanks of the Zagros Mountains. In this project, excavations at Jarmo revealed one of the first agricultural villages. In addition, Shanidar Cave became home to paleoanthropological excavations and yielded important data about Neanderthals (Braidwood et al. 1983). In a series of publications and as part of the Iranian Prehistoric Project, Braidwood has also reported archaeological sites identified in the Kermanshah Province (Iranian Kurdistan) (Braidwood, Howe, and Reed 1961). Other early works in the region include Goff (1968), records of the Luristan and Schmidt (1940), and records of a few sites across the Kermanshah province during his aerial surveys of Iran.
Archaeological expeditions in the Mahidasht of Kermanshah Province were among the most important research projects in one of the most fertile and rich valley systems in the central Zagros. Young’s (1965) research on the ceramic chronology of western Iran, excavations in Kangavar (Azarnoush 1981; Kambakhsh Fard 1995), research on the Anubanini rock relief and Bisotun inscription, as well as their surrounding landscapes (Kleiss 1970; Mohammadifar 2005; Alibaigi et al. 2012), are some of the most important projects in the broader Zagro region nearby the study area.

Despite the archaeological attractions of the region, political instabilities in recent decades halted all projects for different periods of time. The Iran-Iraq war in the 1980s and conflicts between the Iraqi Kurds and Ba’athist regime were the most important political tensions to severely impact research and restrict archaeological work and general development schemes, including agricultural and water management plans. These circumstances caused a hiatus in research for years, in particular in the Iraqi Kurdistan, and prevented a full realization of the rich archaeology of the area. However, recent stabilities led the region to welcome multiple international archaeological projects and local institutions and heritage organizations are also developing more systematic research and records of the archaeological landscapes. In very recent years, due to the relative stability in the Kurdistan Region of Iraq and its openness to the foreign teams and because of an ongoing war in Syria which halted all archaeological surveys and excavations, many projects have made a geographic shift towards the Zagros Region (for example: Altaweel et al. 2012; Muhl 2012; Ur et al. 2013; Morandi Bonacossi and Iamoni, 2015; Casana and Glatz 2017). Therefore, the region has witnessed an increased number of national and international projects since 2009, which has been referred to as a new archaeological
renaissance (Ur 2017). Generally, the Iraqi Kurdistan was the subject of less systematic work in the past and little archaeological data that comes from the area is from sources that mapped a few sites and monuments (Directorate General of Antiquities 1976). Although this is a useful resource containing a general archaeological record, it does not include details about the sites, nor records of smaller-scale sites and off-site features. With new research endeavors and with the application of new archaeological methods and theoretical perspectives, more information is becoming available.

During the time that the region was not open to international teams, projects conducted by local scholars continued to record the rich history and archaeology of the region. Due to more stability in Iran compared to the Iraqi Kurdistan, more local projects have been conducted on the Iranian side. These local projects aimed at documenting archaeological landscapes by identifying sites and off-site features, as well as providing an assessment of the region prior to modern agricultural and irrigation expansion plans. In comparison with other regions of Iran such as Khuzistan, Kermansh Province has been the focus of less extensive archaeological surveys. Other challenges for fieldwork in the area include remains of landmines and unexploded ordinances from the conflicts in the 1980s across sections of the study area and closer to the international border, as well as escalated political instabilities in the Iraqi Kurdistan in 2014-2015 that have created risks for archaeologists.

Thus, the research presented in this dissertation is one of the first systematic attempts to document and model the late antique landscape on both sides of the border. The contemporary Iran-Iraq border has defined the study limits of most of the archaeological projects in the region. However, this boundary, same as most of the other ones in the region,
is a relatively recent establishment that hinders our understanding of the past. In light of this fact and in order to fill the research gaps, I have attempted to adopt a cross-border approach and develop a more comprehensive archaeological database.

The biggest part of our knowledge from the Sasanian period has come from art historical studies and limited excavations. Material remains including coins, metalworks, glassware, and stucco fragments that were either uncovered by excavations or obtained by museums from private collections shaped some of our earliest understanding from this period. Systematic archaeological projects that aim to study diverse landscapes and the development, expansion, and collapse of the dynasty are still limited. Within previous research, and compared to its eastern and western counterparts, archaeology has played a relatively minor role in our understanding of this period and efforts have been mostly made to understand the role of the central political system in land expansion projects. Surveys emphasized monumental structures, urban areas, and their immediate hinterlands—such as extensive imperial irrigation systems—and illustrated an apogee in land use and agricultural intensification in premodern times. Some of the most influential projects that continue to be cited for further research are the ones conducted in southwestern Iran (e.g., Adams 1965; Neely 1974; Wenke 1975-1976; Moghaddam and Miri 2003; Alizadeh et al. 2004). In addition, more recent studies in the Gorgan plain (Nokandeh et al. 2006) and Mughan steppe (Alizadeh 2014) are providing important new datasets from borderlands and frontier zones. Among the projects conducted in the Zagros Mountains region, results of the Deh Luran surveys present most similarities to the study area and can be applied as a good comparative resource. The interim reports of Deh Luran surveys indicate differences in settlement pattern with those recorded in southern plains of Mesopotamia and Khuzistan.
Studies hypothesized that Deh Luran was a relatively marginal zone, with a degree of economic and sociopolitical autonomy during the Sasanian period (Neely 2016).

In the very recent years, and with advances in the application of landscape surveys, new archaeological methods such as remote sensing and geospatial techniques, as well as improvements in anthropological theories, new research avenues are emerging that will add to our knowledge of different land use practices, and smaller communities and role of autonomy vs centralization. This will also help to reassess the past survey results and will produce a more complete picture of the time.
Figure 2.1. Map of the study area in eastern Iraq—western Iran. Image: Google Earth, 2017
Figure 2.2. View of the floodplain vegetation, including palm trees, orchards, and patches of vegetable gardens. Photograph by the author.
Figure 2.3. 15 meters ASTER Digital Elevation Model (DEM) showing elevation range across the area.
Figure 2.4. Views of the landscape in the Zagros Mountains foothills. Photographs by the author.
Figure 2.5. Springs in the foothills zone that create perennial streams. Photographs by the author.
Figure 2.6. View of the Sirwan River in its upper reaches. Photograph by the author.

Figure 2.7. View of Chahar Qapi in Qasr-e Shirin. Most parts of the remains were severely damaged during the Iran-Iraq war in the 1980s. Photograph after Bell 1914.
Chapter Three: Theories in Landscape Transformation

3.1. Human-Environment Interactions in Transitional Landscapes

Understanding human-environment interactions, anywhere from site-specific to region-wide scales, has been one of the primary goals of archaeological studies in recent decades (Kinith et al. 2014). As an important topic in archaeological landscape studies, it reveals the connection between ancient features with their surrounding landscape and clarifies the long-term social and environmental changes. The central theoretical questions of this chapter investigate the human-environment interactions across the study area during the Sasanian period. In specific, did populations respond to the diverse environmental condition by transforming the landscape or did they choose an adaptive coping mechanism? And, how different cultural responses to this variability and uncertainty defined settlement and land use patterns?

Located between the lowlands of Mesopotamia and Khuzistan, and highlands of the Zagros Mountains, the study area is environmentally transitional. South of the area are alluvial plains where an arid climate and average annual precipitation of less than 200 mm makes irrigation necessary for cultivation. Besides the expansions of political centers and urban areas, these lowlands were one of the major economic zones of the Sasanian Empire, where irrigated agriculture was a dominant land use pattern. To the north, an increase in elevation and average annual precipitation above 300 mm present a different ecological condition where rainfed cultivation has been a stable and reliable practice. Although little flat land makes cultivation restricted, other forms of land use and subsistence strategies including pastoralism and exchange systems have been suitable practices in this zone. The study area is located along the ‘zone of uncertainty’ belt (Wilkinson 2000a; Wilkinson et al.
2014), which falls neither under the category of lowlands nor highlands (see chapter 2). It is characterized by a dynamic ecosystem where variability in the environment, particularly precipitation, and in resource distribution, causes both risks and opportunities in land use and production. The area is comprised of alluvial plains, steppes, and foothills, which together create a patchwork of microenvironments. While this transitional condition is primarily defined based on geography and environment, this is, in fact, connected to sociopolitical and economic aspects of the society as well.

In discussions of the human-environment relationships, whether humans transformed the environment, or the environment played a key role in social changes have been at the center of archaeological debates and scholars have developed different models to explain this complex interaction (e.g., Butzer 1982; Coombes and Barber 2005).

One model assumes a close and direct link between the environmental characteristics and social changes. Supporters of this approach point out specific case studies such as impacts of the environment on early complexity and state formations, or climatic changes that coincided sociopolitical collapses, to explain the relationship between nature and humanity. Known as ‘environmental determinism’, this approach tends to exclusively focus on the power of particular environmental characteristics and their control over social processes and argues that cultural features have been determined by elements of natural landscapes. Among the most notable case studies that correlate climatic changes to cultural transitions—in particular to sudden collapses of sophisticated societies—are the Akkadian Empire collapse (Weiss et al. 1993), and the collapse of Classic Maya (Haug et al. 2003). This paradigm mostly dismisses the dynamic aspect of social systems, and simply correlates social changes to the environmental impacts. Therefore, this model fails to sufficiently
address how populations could adjust, adapt, or respond to natural changes (Coombes and Barber 2005; Judkins et al. 2008).

On the other side is the ‘cultural determinism’ model that simply views the natural environment as a victim of social changes and perceives humans as exclusive agents of environmental changes. Scholars of this paradigm often emphasize evidence such as erosion, deforestation, extinction, or global warming to demonstrate the strong role of cultural elements in environmental degradations. It should be noted that many recent archaeological studies point to the dominant role of human activities on landscape transformations and environmental changes over the past millennia. These studies attest human-induced environmental changes and the increasing environmental impacts of agrarian systems since the early Holocene (2250-0 BP), specifically since the rise of later territorial empires (England et al. 2008). Other case studies emphasize technological advances, such as water management systems, that helped populations to control changes caused by natural forces. In this regard, scholars use different categories of archaeological data to measure human impacts on the environment. These include faunal and paleobotanical remains, geoarchaeological evidence (such as sedimentation, erosion, and salinization), and finally, cultural imprints on landscapes such as settlement patterns and other elements of built environments. While the more recent and increasing impacts of humans on environmental changes can generally be accepted, the cultural determinism model is criticized as it neglects the impacts of the environment on human history and merely emphasizes the power of technological advances and increasing control of humans over the environment (Crumley 1994; Rosen and Rosen 2001).
Both of these models present a simplistic approach with critical drawbacks and fail to create a comprehensive picture of the interplays between the social and environmental elements. A more integrative and a non-equilibrium approach does not see the human-environment interactions as simple cause and effect. In other words, rather than viewing nature and culture as independent forces, we should consider the landscape formation and transformations as a result of intertwined and evolving interactions between human activities and natural processes (Balée 1998; Weiss 1997). In this view, the causality of changes, such as demographic shifts, agricultural intensification, environmental degradation, or sociopolitical collapses is addressed based on the interrelationship between both social and environmental factors. This two-way relationship specifies that the balance and the degree of influence of one side on the other can be fluid and change at different temporal or spatial scales. For instance, in some periods or geographic locations human-induced environmental changes might have negative impacts on populations, while in other cases those environmental changes can lead to increased land productivity. In some cases, human modifications of natural resources could cause an increase in biodiversity, but certain intensive agricultural practices have caused salinization or loss of topsoil (Balée 1994; Brookfield et al. 2002). In addition, studies of hydrological conditions indicate that water scarcity in a region could be the result of climatic changes and a decrease in precipitation, or it could be the result of sociopolitical issues such as mismanagement of water resources.

Furthermore, in order to improve our understanding of past society and its diverse interactions with the environment, we need to consider that populations can have different responses or adaptation strategies to different environmental conditions. Therefore,
understanding the full range of responses, instead of focusing on a single strategy (for instance, irrigation-based agricultural intensification in late antiquity) is necessary. Same as cultural systems, environmental systems are dynamic, and populations can choose different approaches towards environmental shifts to sustain themselves. Moreover, depending on the availability of water, fertile soil, or pasture for grazing, the microenvironments across a landscape create boundaries because they make segments of the land more suitable for some uses than for others. This variability can be conceptualized in the pattern of differences in resource accessibility, and therefore, it creates variation in land use, settlement pattern and food supply. Strategies that populations employ to respond to the variability or adapt to it are addressed in this chapter. Societies can employ a range of different mechanisms to increase production, buffer against environmental variability, or reduce risk. In this dissertation, I emphasize two major strategies that are related to the study area: intensification and mobility. As different coping strategies, these two are both cultural responses that create different approaches to landscape formation (Mace 1993; Marston 2011). How each strategy could impact patterns of settlement and land use, and how they could shape relations between sedentary and non-sedentary communities in terms of competition or cooperation are discussed below. At an empirical level, recognition of the importance of this topic helps to resolve some of the understudied points in archaeological methods and theories.

3.2. Agricultural Intensification and Social Organization

Agricultural environments form some of the fundamental elements of social complexity and contribute to our knowledge of the development and expansion of past societies. Agricultural intensification, as one of the various kinds of agricultural change, has
been at the center of discussions of land use patterns and landscape transformations (Hunt et al. 1976; Kirch 2006).

Among different cultural responses to environmental variability, agricultural intensification has been discussed as the primary land use hypothesis in the majority of the past Sasanian studies. Furthermore, irrigation—one of the forms of intensification—has been emphasized as the main mechanism to cope with certain environmental conditions such as aridity, or to increase land productivity. Irrigation and other forms of water management systems are also some of the most archaeologically visible remains that indicate land use activities. Intensification, whether in response to certain environmental conditions or to political and economic forces, as well as its consequences and its correlation to the sociopolitical structure are discussed in this chapter.

Intensification is interrelated to the discussions of both environmental conditions and sociopolitical structures. Long-term consequences of intensification can include environmental degradation or changes in resource availability and resource diversity. For instance, rising food demands of a growing population and shortened fallow periods in favor of continuous production can negatively impact soil fertility. Moreover, soil degradation and erosion can be common phenomena in intensely cultivated areas. Intensification can also have important economic and sociopolitical consequences. Production increase, distribution of surplus food, demographic changes such as population transfer, alteration of settlement pattern, such as sedentarization of nomadic groups, and introduction of new ideas for land ownership and social classes are among the most noticeable consequences of intensification (Stone, Netting, and Stone 1990).
In discussions of agricultural intensification and its relationship with sociopolitical changes, Boserup’s *Conditions of Agricultural Growth* (1965) has been one of the most influential resources. Although many aspects of her theory have been criticized (e.g., Brookfield 1972, 2001; Erickson 1993; Netting 1993; Kirch 1994; Morrison 1994), some of the core elements of her theory continue to be discussed in archaeological studies of land use, agricultural intensification, and political economy. In contrast to the Malthusian theory which assumes the availability of food determines population size and population increase results in food shortage, Boserup stresses that population is an independent variable that although it plays an important role in determining the general environment, it is not a consequence of food supply. She introduces population as the main catalyst for changes in land use patterns and agricultural developments. In other words, she suggests demographic growth as the primary cause of the production intensification. In order of intensity increase, she evaluates forest fallow, bush fallow, short fallow, annual cropping, and multi-cropping as main cultivation strategies. Further, she specifies the fallow length and the application of tools and techniques such as manuring, as indicators of agricultural intensification. Although this theory attempted to offer a full picture of the history of agricultural change and its association with social structures, multiple case studies have criticized its unilineal trajectory, causality form, and its limitation in addressing both environmental and organizational aspects in intensification process. Her typological framework has been challenged because it does not adequately investigate diverse historical and environmental dimensions. For instance, Morrison (1994), argues that in the Boserupian model, the focus on cropping frequency as an indicator of intensification is problematic and further tries to show more diversity in production strategies and complexity in land use classification. In
addition, Boserup’s idea of the population as the driving force for intensification has been the most contested aspect of her theory. While demography can be a variable for intensification, there are also non-demographic, sociopolitical variables that were not addressed in her model. These include socially motivated production for attaining a higher status or prestige, and politically motivated production, for instance under internal or external political pressures to intensify tax revenue and control over larger areas of land (Brookfield 1972; 1984). Morrison (1994) goes further and points out that besides emphasizing incentives and consequences of intensification, scholars should address intensification as a process that is formed by people’s practices across a specific space.

Since Boserup, archaeologists have been seeking a multicomponent approach towards explaining land use changes and agricultural intensification. Among the studies of intensification, Brookfield's (1972, 2001) agricultural intensification definition has become one of the most widely applied theories that most archaeologists have employed (e.g., Miller 2006). Intensification is defined as obtaining higher outputs by means of increasing capital inputs. Innovation, defined as using new skills and finding new and better ways of production, as well as adaptation, and improved management are important elements in the discussion of intensification. In this definition, there is a reference to a constant variable that can be space, labor, or technology.

Capital inputs of intensification are divided into two main categories of landesque and working capitals. The term landesque capital which was originally introduced by Brookfield (1984), was later adapted by scholars in various disciplines, in particular by archaeologists and ecologists (Kirch 1994; Fisher 2009). Landesque capitals include built elements such as irrigation systems, terraces, walls, dams, and field systems that can
substantially alter the landscape. Micro-level inputs, such as soil management strategies are also among the investments with lasting imprints on landscapes. This alteration can be aimed at increasing land productivity and yields, removing constraints such as environmental variability, or reducing the risks of product failure. Once landesque capital inputs are constructed, they endure for long periods of time and can be either utilized by future populations or become abandoned. These inputs are often constructed to improve long-term productivity and oftentimes leave permanent and visible signatures on lands that are more likely to be identified in archaeological investigations. As a consequence, these built elements have been recognized as one of the most useful archaeological remains that can demonstrate past land use (Brookfield 2001). Other important aspects of recognizing landesque capitals include understanding the organizational strategies of past people as well as their broader social and political conditions across space and time. While on one hand, landscape imprints can represent decades or centuries of land management strategies, on the other hand, evidence of their low maintenance or abandonment can reflect environmental or societal issues.

Working capital inputs consist of both material and non-material elements, including human labor force, agricultural tools, buildings, and livestock, that are often more difficult to recognize using archaeological methods (Brookfield 2001:183). However, understanding these capital inputs helps to better explain the intensification as a process. In particular, the amount and organization of labor forces can represent aspects of social organization. For instance, during the Sasanian period and across its vast territories, population transfer or forced deportation was an important social and political phenomenon. Populations were transferred from their original homes in eastern sections of the Roman Empire (for example
from Antioch) to the alluvial plains of southern Mesopotamia and Khuzistan to be used in agricultural projects (Morony 2004). Some other transferred groups were placed in newly founded urban areas. In general, scholars have argued different reasons for the Sasanian invasions of the Roman Empire, and among all, obtaining additional labor force for agricultural intensification plans and construction of landesque capital inputs, expansion of occupation and power over larger areas of land, or solving border conflicts are among the most important proposed reasons (Christensen 1993; Daryaee 2008). The topic of population transfer, either in forced or in peaceful ways, and its close interactions with social and political structures of the time can be extended as a separate research project. However, in addition to the population transfer from one place to the other, the topic of sedentarization of mobile groups, in a politically forceful way has been the subject of much less attention in past studies. This topic of mobility and sedentism is directly related to the pattern of settlement and land use across the study area, it is discussed in more details below.

Depending on the path of the intensification process and its incentives, different indicators for measuring intensification in past land use can be explored. For instance, Brookfield (2001) has used fallow length and working hours as measures of intensification. Area of land under irrigation (Leaf 1987), paleobotanical remains (Nesbitt 1996), and regional settlement data, along with historical records and pollen and charcoal analysis (Morrison et al. 1996), have been used by archaeologists to measure intensification. Some of them, for instance, the shorten fallow length, are more problematic to be proven by archaeological remains. In this dissertation, I use spatial manifestation of intensification
across the landscape, including artifacts, settlement distribution, and evidence of agricultural activities such as irrigation systems and terraces to assess intensification.

Most land use activities, either in the form of cultivation, or pastoralism, occur in areas beyond the dense archaeological settlements. Exclusive reliance on data derived from surveys of settlements in larger urban areas or excavation records creates a limited and distorted perspective of past societies. Hence, it is necessary to investigate areas beyond the permanent settlements and recognize the interactions between diverse groups. Therefore, the development of archaeological landscape surveys in many parts of the world has significantly benefited the studies of land use change and intensification. Field surveys combined with remote sensing-based analysis, allow identification of smaller features that otherwise could not be detected in the field.

Intensification occurs for different reasons, but it often occurs within a specific social and political context with certain motivations to increase production, land exploitation, and change the settlement pattern. Some of the most important incentives of intensification include meeting the demands of a growing state for food supply, expansion of control over larger lands, increase tax revenue, or to alleviate risks of product failure. Scholars indicate that the economy of most of the pre-industrial territorial states, including the Sasanian empire, was heavily based on agriculture and such states often expanded and controlled production based on both economic and political perspectives (e.g., Adams 1965; Wenke 1975-1976). Intensification is also discussed as a strategy to reduce risks in subsistence practices. Among different scholarly disciplines, there are different definitions of ‘risk’. Although the notion of risk can also be related to socially or politically risky environments such as frontiers or border areas, in this dissertation, the risk is defined based
on the relations between the environmental variability or uncertainty with land use patterns, subsistence strategies, and production failure. When there is high environmental variability, in particular in precipitation, archaeological and ethnographic records show multiple conscious choices in coping strategies that include intensification, diversification of strategies, mobility, storage of resources, or exchange (McIntosh et al. 2000; Halstead and O’Shea 2004). While there is a variety of coping mechanisms, studies indicate that in different times or spaces, populations have responded to the similar condition of variability or uncertainty with different strategies. In addition, even within the groups sharing the same landscape simultaneously, different strategies could have been employed (Rosen 2007: 147; Wossink 2009). Intensification has been closely connected to the rise and expansion of territorial empires in the Near East, including the Sasanian dynasty. These empires often intensified land use and production for economic, political, and strategic ends.

Although much attention has been paid to understanding incentives of intensification and recording its capital investments, equally important are the various social and environmental consequences of intensification at local or regional scales. The issue of consequences has also remained as one of the main research topics for understanding both present and past societies. Intensification increases production and specialization and therefore triggers economic development. It also helps the expansion of political power. Additionally, this process can intentionally or unintentionally lead to negative changes for population and their settlement pattern, such as constraining social relationships, organizational strategies, or causing forced sedentarization of nomads. Moreover, intensification can impact longer-term sustainability by, for instance, causing land salinization, siltation, deforestation, erosion, and loss of biodiversity (Jacobsen 1982;
Christensen 1993; Alizadeh et al. 2004). More archaeological surveys and excavations, together with paleoenvironmental analysis are attempting to reconstruct the environmental consequences of agricultural systems and fall of integrated systems into unsustainable ones.

3.2.1. Narratives of Intensification: Centralized or Decentralized

Archaeological perspectives on the correlation between land use practices and sociopolitical organization have often been divided into two main categories of centralized, or top-down, and decentralized, or bottom-up narratives. With respect to the theoretical literature, both of these models are discussed below and nature of the Sasanian occupation in the study area and its relation to the broader social organization of the time will be further examined.

The political centralization model views transformations—including creation and maintenance of the agricultural landscape—in relation to the presence of a central political authority. This perspective suggests that the expansion of land occupation for widespread agricultural production is initiated and sustained under the centralized control of an authority. Wittfogel’s *Oriental Despotism* (1957) was one of the first theories established along the general line of political centralization model. By discussing the relationship between irrigated landscapes and political hierarchies, he argues that large-scale irrigation systems and intensive agricultural practices were required to sustain a high population. Consequently, the establishment and management of these complex agro-hydraulic systems led to political complexities, social hierarchies, and further fostered the centralization of despotic states. Also, the collapse of the complex agro-hydraulic systems is a result of a collapse in the state power. There is no doubt that large-scale, complex and state-sponsored agricultural systems have played important roles in long-term landscape changes, however,
various evaluations of this theory argue its unilineal and simplistic approach with inadequacies in addressing regional diversities (e.g., Hunt et al. 1976; Adams 1981; Erickson 1993; Marcus and Stanish 2006; Harrower 2008). For instance, case studies in southern Mesopotamia indicate that complex irrigation systems were constructed by the central state in order to increase land productivity and obtain surplus (Adams 2006). In addition, this political centralization model has been criticized because of its emphasis on the top of the political hierarchy, while underestimating the decision-making power of local groups. Furthermore, the presence of non-sedentary or no-agriculturalist populations, and their potential interactions with other population forms such as sedentary agriculturalists, have usually been neglected in studies with a centralized perspective. Additionally, one of the other limitations of the current literature on the top-down intensification scheme in late antique Near East is the lack of identification of different social classes and communities that created a whole complex society. Furthermore, the role of these various classes in land use decisions and social organization is another important factor for discussion. A good example is the role of newly emerged or empowered classes during the Sasanian period, particularly in the second phase of its expansions. In the highly class-based society under the rule of Sasanians, class of Dehghans played a strong role in the landholding system of centralized agricultural plans. Dehghan was a class of local gentry and landed magnates. As a result of late Sasanian land reforms, particularly since the time of Khosrow I (531-79 CE), this class developed a more powerful social and political status and became local governors in charge of agricultural activities, taxation, and land management in their own districts of rural areas across multiple parts of the empire (Tafazzoli 2000). In general, there were undoubtedly several classes in the society, as well as different tiers among the elites,
however, many of them, especially the communities and classes outside of the core area of southern Mesopotamia and Khuzistan are still poorly known to us. Most of our knowledge comes from the Islamic sources that explained the Sasanian society (e.g., Balādhurī 2013). Sources indicate that Manuchehr was the first king who established the estate of Dehghan, appointed them in villages and towns and “said to Dehghans: I expect from you the prosperity of each village, and he ordered the peasants to obey Dehghans, so that the world may become prosperous” (Tafazzoli 2000: 41). After the defeat of the Iranian army by the Muslim Arabs, some of the local gentry, including Dehghans, could maintain their political and social roles, often by paying the poll-tax (Jizya), therefore remained as landowners in charge of cultivation and tax collection in their own districts. In addition to their political and social roles, this class had an important cultural role and because of their knowledge on the history and culture of Persia, they were recognized as patrons of the Persian culture, serving several politicians in Islamic periods (Baihaqī 1902:299). While rejecting Wittfogel’s theory, many archaeologists have maintained the top-down intensification model and this perspective has remained the most established narrative and the primary hypothesis of land use expansion and agricultural activities of the Sasanians (Wenke 1975-1976; Adams 1981; Wilkinson 2003).

On the other side of the intensification narrative, the decentralized, or bottom-up approach studies land use changes as internally organized and as a result of the decision making of local groups. This approach discusses the formation and administration of complex agricultural systems outside of any control of a centralized state (e.g., Doolittle 1984; Erickson 2000, 2006; Marcus and Stanish 2006). This approach emphasizes the role of local communities and their degree of autonomy in economic and political aspects. For
instance, studies in Lake Titicaca Basin documented an intensive agricultural system that was formed over centuries and was not confined to different episodes of state formation in the region (Erickson 1993). Also, other studies indicate the presence of irrigation systems that were constructed without the presence of a centralized state (Hunt et al. 2005). Another study that supports the bottom-up approach refers to the evidence of the use of adaptive or local strategies to survive the political collapses and discuss continuity and stability of agricultural practices after the disintegration of central states (Leach 1999). In other words, the decentralized approach argues that agricultural landscapes can remain stable even when political systems become unstable. In addition, the bottom-up perspective argues that agriculture is always organized at a household level and is organized by farming households, regardless of the broader social and political institutions (Morehart and Eisenberg 2010). One of the main critiques of the decentralized approach points to its limitations in discussing the intention of agricultural intensification and land use expansion. Capital investments, including large-scale constructions, often require a large labor force with a degree of state or elite involvement. Benefits of intensification and production increase, as well as the expansion of control over broader territories often motivate central authorities to conduct multiple land use projects. Therefore, the bottom-up perspective tends to downplay the motivation and role of the institutions in land use at local or regional scales.

3.2.2. Summary

Recognizing the absolute presence or absence of a centralized state in the organization of an ancient landscape can generally be a challenging task for archaeologists. It is important to note that states can have a shifting presence, as well as different forms of
management across space and time. A central government can be present and play active roles, in particular in coordinating activities, even if the population maintain their own autonomy in some social and economic aspects. In addition, intensification is only one form of land use practice and one form among different cultural responses to environmental conditions. Past studies indicate that irrigated agriculture was a primary signature of the Sasanian land use and demonstrate that increase in settlement density and agricultural intensification reached the highest possible level prior to the beginning of the modern mechanized techniques. These studies emphasize the effects of political economy and point that while obtaining higher revenue through production increase and tax system was the main source of the state development, intensifying agricultural production was part of the broader economic intensification scheme. Although intensification, in particular, the centralized political plan has remained the main hypothesis of land use strategies in the Sasanian studies, there are other models that should be considered in our studies. In this dissertation, archaeological remains and results of remote sensing analysis (discussed in the following chapters), are proxies for assessing agricultural intensification and other land use forms. I will also test whether remote sensing techniques for recording archaeological remains and reconstructing the past landscape can be useful for addressing the dissertation questions. I study changes in settlement patterns and land use as seen through site density increase or artifact scatters; efficiency of land management, such as improvement in water supply systems; and an increase in the quantity of landesque capitals, such as irrigation systems, terraces, and fields. As archaeological evidence of intensification. Because these variables are aimed at enhancing production or removing constraints, they provide distinct evidence that can be detected archaeologically.
Alluvial lowlands of southern Mesopotamia and Khuzistan are documented as intensely irrigated plains and as the most important economic and political zones of the empire. These plains have long been the focus of archaeological investigations on land use systems and social and political structures. The monumental constructions, cities, and other landscape elements that are interpreted as evidence of urban patronage in the south have become the signatures of the imperial land use and suggest a centralized political intensification. Moreover, the long-lasting effects of intensification and overexploitation of land and resources, as well as the disintegration of intensive irrigation systems due to their unsustainability have been the focus of past debates (Neely 1974; Wenke 1975-1976; Christensen 1993; Wilkinson 2003; Adams 2006). Although this condition has been recorded for particular parts of the empire, settlement and land use systems, as well as strategies in coping with microenvironments, could be varied across different ecological conditions. This hypothesis challenges us to think beyond the agricultural intensification and examine different coping strategies that could be applied as a response to environmental variability.

3.3. Mobility and Agropastoralism

The issue of how past societies responded to different environmental conditions or changes and whether they could adapt to or be resilient has been discussed over recent years. Land use practices, in particular, mechanisms to buffer against risk and variation, can take different forms and mobility is one of them that is less recognized in archaeological records (Halstead and O’Shea 1989; McIntosh et al. 2000). Mobility, as an adaptive strategy, allows the use of spatial and temporal variability of resources, such as water, pasture, and fertile soil, and takes advantage of heterogeneities of the environment.
(Wendrich and Barnard 2008). Populations have used mobility as a strategy where variabilities in microenvironmental zones cause locations to be seasonally accessible. In this section, I attempt to shed light on the complexity of land use practices across a heterogeneous landscape and address the importance of studying mobility in archaeology. While the Sasanian land use has conventionally been introduced by irrigated-based agricultural intensification, mobility is often recognized as less visible in archaeological records and gets neglected in many studies. However, seasonal movement in a non-sedentary lifeway has been historically one of the adaptive strategies to environmental diversity. The underlying principle of mobility is using the potential of shifting land use practices and maximize the use of dispersed resources across the landscape.

There have been a few misconceptions about mobility and mobile groups in past societies. For instance, while mobile lifeway has been practiced in different forms throughout history, the traces of mobile groups in the archaeological records are often solely described as ephemeral campsites. Also, populations practicing mobility have been viewed either as hostile in their connections with the neighboring settled people, or necessarily as distinct groups from the settled ones (Finkelestine and Perevolotsky 1990). This view has widely been criticized as it does not present the actual interrelations and close economic and social interactions between the sedentary and nomadic people in many regions in the world (Khazanov 1994). The distribution of sites occupied by mobile groups in close proximity to the settled ones is the evidence indicating their close interactions. The relationship between the settled agriculturalists and mobile pastoralists has been addressed based on different models. In older models, scholars mostly viewed these groups as fundamentally distinct and with a hostile connection and based on a constant competition to gain resources. In more
recent and developed models, scholars go beyond the dichotomy and see the integrated connection between the two groups (Banning 1986). Moreover, anthropological theories have significantly improved from viewing mobility and its different forms based on the theory of social evolution and progress measurements to a more realistic approach. In the past, the emphasis was placed upon cultures based on agricultural practices and mobility was viewed as an undesirable lifeway and subsistence strategy in the evolutionary sequences. Nomadism was considered below the sedentism and marginal to civilization. Also, the hierarchies among nomadic groups and their important social and political powers, in particular in their interactions with sedentary populations or central states were unrecognized until recently (Potts 2014: 431-443). Historical cases show that how bigger and more powerful confederation of tribes in Iran were once led by powerful chiefs (Khans), while these group could even found dynasties or challenge the central governments during multiple historical periods (Tapper 2002: 30). In addition to these problematic theoretical perspectives in the past, and because of the nature of fieldwork, many scholars studied mobility according to a generalized dichotomy that divided the two lifeways as fundamentally different and distinct. They created a fundamental distinction between the sedentary and nomadic populations and between the agricultural and pastoral practices. Most fieldworks were conducted in urban areas and studied architectural remains. Even surveys in peripheral, marginal, or areas beyond the political and economic core zones were recording the ancient features based on a perception of sedentary populations engaged in the construction of an intensely irrigated agricultural landscape. Occasionally, if any other form of lifeway and land use was acknowledged, the perceptions were generalized and restricted. For example, mobile groups were identified as populations who lived in tents and raised
livestock. Progress in anthropological theories and ongoing advances in archaeological methods in recent decades are improving field projects to better identify and document different forms of settlement and land use. More studies are focussing on addressing interactions between fully sedentary with non-sedentary groups, their movement, material culture, as well as settlement types (For example Kazanov 1991; Rosen 2002). In this regard, landscape archaeology has been playing an influential role in identifying varying remains to better understand mobility. Specifically, methods to reconstruct the past land use, settlement pattern, resource availability, and environmental conditions are beneficial. Additionally, ethnoarchaeological and ethnographic studies are helpful to address mobility across an ancient landscape.

In studying mobility, it is important to recognize the wide variety of its forms based on different spatial and temporal scales. This lifeway can range from highly mobile groups where the entire population moves, to a mostly settled form where only a small portion of the population moves seasonally. The environmental condition where the mobile populations live, subsistence strategies, and social structures might also different among groups and require consideration. In this regard, different types of mobility in cultures based on factors of motivation, the pattern of mobility, and the relation between sedentary and mobile groups are defined (Wendrich and Barnard 2008: 5-10). The motivation for movement can include environmental factors such as climatic variability, or cultural factors including political pressures. The pattern of mobility specifies seasons of movement and length of movement. The relations between mobile and settled people can vary from distinct groups to the ones living by each other.
In this dissertation, in order to characterize mobility, its pattern, motivation, settlement system, subsistence strategy, and interactions between different groups across the study area, I use the general term of *agropastoralism*. This term includes both *semi-nomadic pastoralism* in which part of the population is settled or the entire population is settled for part of the year and *semi-sedentary pastoralism* in which agriculture is the predominant land use pattern although mobility in the form of short-term seasonal migrations also occurs (Potts 2014). Both archaeological and more recent ethnographic records indicate that in Iran, pastoralism has always been integrated with agriculture and mobile and settled systems have been in complex interactions with each other.

3.3.1. Mobile-Sedentary Interactions

Both agriculture-based sedentism and mobile agropastoralism are recognized as strategies in response to or to adapt to changes in environmental or cultural circumstances. For instance, while agricultural intensification can result in production increase, mobility allows populations to take advantage of dispersed environmental resources. But, these two strategies are not necessarily distinct and they should not be viewed as mutually exclusive. In fact, they can function together in an integrative way across the landscape. Comparative case studies show that two forms of settlements patterns could exist simultaneously in the same landscape. These settlements can range from sites of sedentary agriculturalists with built structures to seasonal herding dwellings, or fixed summer and winter villages of agropastoralists (Haiman 1995).

While one particular mechanism might not be continuously practiced across a landscape, it is possible to record changes in strategies over time and to observe cycles in which a dominant pattern of settlement and land use could shift from one form to the other.
For instance, even in the cases of state-initiated sedentarization of mobile agropastoralists, evidence shows that the area could be inhabited partly by settled agriculturalists and partly by mobile agropastoralists who decided to maintain their more traditional lifeway (Haiman 1995). Moreover, lifeway and subsistence might change from sedentary type to mobile or vise versa at different historical times, for instance, results of archaeological surveys and excavations in the Central Zagros show that from the Early Neolithic to the Middle Chalcolithic period, number and size of the sedentary settlements increased significantly, along with evidence of an increase in irrigation during the Middle Chalcolithic. This event was then followed by a dramatic decline of settlements and an increase in the number of temporary campsites. This evidence has been particularly observed in faunal remains that show diversified animal husbandry at permanent settlements, whereas material records from temporary campsites show seasonal animal husbandry (Abdi 2003). In a more recent historical example, nomads of Iran under the first Pahlavi regime (1925-1941) were forced to sedentarize, while after the abdication of Reza Shah, there was a return to pastoral nomadism in many areas across the country. In addition to the cycles of change in land use and settlement system, multiple strategies could integrate and function together or become complementary across the same landscape. The choice between the two lifeways depends on both environmental and cultural contexts. But it is important to note that when we investigate multiple land use strategies, the choice between the two, or an integration of multiple practices, was not a random choice by populations. On the contrary, these have been choices based on the particular cultural or environmental circumstances of the time. There have been times when mobile groups became sedentary, either due to forces of central states or because of the presence of a more favorable climatic condition. In many cases, if
they were forced to sedentarize, they reverted to their traditional lifeway at their first opportunity. Also at times of unfavorable environmental conditions, populations were choosing pastoralism over cultivation (Cribb 1991: 60). Political and economic reasons, in particular, the hostile relations between the nomads and the central states were also among the primary reason for the populations to choose mobility (Chang 2008). As evidenced in research on historical groups across the study area, up to the 20th century, local Kurdish tribes which ranged from semi-nomadic herdsmen to feudal peasants had a powerful presence ruling the region and migrating between the lowlands and highlands (Barth 1953: 11-18). Among them, the Jaf confederation of tribes, Kalhors, and Sanjabis are the most recognized who had their qishlaq (winter camping area) around Qasr-e Shirin and Khanaqin and their yaylaq (summer camping area) in the highlands of the Zagros Mountains (Hamdhaidari 1998). Even though there have been strong links between the nomadic groups and control of the major trade routes, their power, autonomy, and border crossing movements were usually not tolerated by the central governments. In specific, over the last century, the closing of the international border and compulsory sedentarization of nomadic tribes of Iran have led to the loss of their coherence and today in this study area, the majority of the population is sedentarized (Afshar 1987). Generally, studies of cycles of change from one lifeway to the other should be analyzed along with a careful understanding of the local environmental conditions, as well as the sociopolitical an economic circumstances of the time (Wossink 2009:148). Ethnographic sources of mobile groups in pre-industrial times in western Iran indicate that when advantages of sedentarism outweighed its disadvantages because of factors such as favorable environmental conditions, populations decided to settle in villages or towns for longer periods of time (Hole 1978).
Generally, in studying the expansion of agricultural settlements in marginal areas two main events can be hypothesised: one, imperial policies that forced the sedentarization because of an economic intensification scheme or increasing border protection, and two, a more peaceful and gradual sedentarization of mobile populations into settled areas because of a more favorable climatic condition. Therefore, the process of change was either initiated by central states or by the nomads themselves.

3.3.2. Mobility Indicated in Archaeological Records

Historical resources can provide information about non-sedentary groups, however, the major issue is that there are not too many records mentioning the mobile lifeways and even if they exist, they are usually written by sedentary people and were produced in urban centers. Moreover, ethnoarchaeological and ethnographic records can be sources of information. In general, historical narratives have often emphasized sedentary lifeways, subsistence, and other elements of urban and centers. In this research, while I do not simply assume a similarity between the present and past conditions, understanding traditional and recent historical lifeways through these records can significantly help interpretation of archaeological data (Hole 1978). Also, as Watson (1979) suggests, analogies should be used in areas where continuity in nomadism and pastoralism has occurred. In this regard, and after careful consideration of impacts of modern societies on nomadic lifeway, the tribal populations of the Zagros Mountains region are the most useful models for analogies because they have presented highly intertwined and mixed activities between the sedentary and non-sedentary groups. Two distinct patterns of the movement of these mobile groups include vertical and horizontal in particular. Nomads of the Zagros region practice vertical mobility where highlands are used as summer pasture and lowland plains as a summer
residence. This interaction occurs more often among the tribes who perform ‘enclosed
nomadism’, where during their vertical seasonal migrations, tribes pass landscapes of settled
villages and this pattern creates close social and political bonds between the groups
(Rowton 1974). In addition, in use of the historical cases to reconstruct the past landscape,
the changes to the lifeway of nomads in the region should also be considered. While
nomadism and agropastoralism in their different forms are still alive in the region, climatic
changes, governmental policies, closure of international boundaries, and technological
advances have all caused constraints for these populations and severely impacted this
lifeway.

In archaeological methods, identifying settlements and features related to a nomadic
lifeway is often a challenging task and requires careful and detailed field surveys. The
sampling strategy, coverage of the area under survey, and criteria for defining a site as a
sedentary or nomadic have been debated as some of the most important issues in the studies
(e.g., Bar-Yosef and Goren 1980). Although the developments in new archaeological
methods have improved this issue, yet some of the archaeological projects neglect to
document these important elements and often emphasize excavation of larger sites or
surveys of more noticeable large-scale features and urban areas.

In most of the archaeological field surveys, sites attributed to the non-sedentary
populations are small in size contain low-density surface material remains (Rosen 1992:75).
In archaeological sites, ceramics are one of the most durable remains that can be used to
understand different aspects of occupations, including sedentary or nomadic nature of the
landscape. Ethnoarchaeological studies show nomads often rely on objects made of metal,
wood, animal skins, or glass. However, they used ceramics as well, but in smaller amounts
compared to the sedentary populations. In general, two types of ceramic vessels are identified as evidence of mobile agropastoralism. One, small and portable ceramics that could easily be transported between the campsites or the summer and winter places, and two, large vessels such as cooking or storage jars that were used and remained at settlements, especially when nomads were staying in their seasonal location for months at a time. Besides these types, ceramic was rarely used by populations practicing mobility (Cribb 1999: 79). Contrary to sites occupied by settled populations, nomadic sites contain no or very low architectural remains. These settlements can be categorized into different forms. The model related to agropastoralism in the study area could be in the form of fixed winter settlements in the lowland villages close to tents, where in summers, one portion of these groups could migrate to the highlands with their herds and tents, or could migrate to their fixed winter houses in the highlands (Tapper 2002). Overall, the dwelling of these populations was in the form of fixed winter and summer houses in small villages, nearby other groups who were living in tents. While tent has been recognized as a characteristic dwelling for mobile populations, many of the nomads of western Iran live in village houses for parts of the year and migrate to summer camping zones where they can either use tents or settle in built houses. It is very likely that populations having different dwellings such as mud houses, stone-built structures, or tents were living near each other. In these close interactions between the two populations and their settlement locations, mobile groups, especially those who practice both cultivation and pastoralism, often use the infrastructures built by sedentary populations. Recent historical nomadic populations have also used the remains of irrigation canals, fields, terrace systems, and agricultural processing constructions such as mills that were built by ancient sedentary populations.
3.4. Summary

This chapter serves the main theoretical framework that helps to model human-environmental relations during the Sasanian period in an area beyond the political and economic cores zones of the empire. This will further help the interpretation of archaeological data, ethnographic and environmental records, as well as remote sensing-based analysis. In this chapter, I addressed how populations could cope with environmental uncertainty, what mechanisms or cultural responses could be applied to buffer against variability in environment and risk in subsistence, and what different forms of interactions between populations and their surrounding microenvironments could be practiced.

Populations could employ a range of multiple strategies, and here I emphasized the main concepts of agricultural intensification and mobility. While in the complex interactions between the human and the environment both of these strategies are important cultural responses to variability, risk, production increase, or buffer against production failure, they take different approaches to land use and landscape transformation. To understand the structure of this landscape, its variabilities with regard to land use and different coping strategies should be considered. Traditional land use models exploring the late antiquity have mostly discussed irrigation expansion and agricultural intensification. While this has become the primary hypothesis of land use and focus of the studies on the rise and expansion of the Sasanian Empire, I argue that strategies in coping with microenvironments could be varied. Therefore, Mobility, as another form of response and as an adaptive strategy is investigated in this study. Contrary to the intensification that aims at product increase, mobility uses dispersal of resources based on different time and space.
The research focuses on the dynamic and changing interactions between the sedentary agriculturalists, agropastoralists practicing some form of mobility, and the central state. In discussing interactions between these groups, multiple archaeological, ethnographic, and historical case studies have shown the cycles of change in land use and settlement systems over time. While the dominant land use pattern could shift from one form to the other due to cultural or environmental changes, I also discuss that multiple strategies could be practiced in an integrative way.

The study area has a dynamic ecosystem, with an often fluctuating climatic condition, and is comprised of a patchwork of microenvironments. While this condition could create uncertainties for the economy, it can also be a zone of connection between different lifeways by allowing a mixed strategy of agriculture and pastoralism. To what extent these two lifeways and subsistence strategies, and the general sedentary versus mobility patterns were practiced and whether the area experienced an integrated strategy will be investigated by the examination of archaeological, environmental, and ethnographic records, in conjunction with remote sensing analysis in the following chapters.
Chapter Four: Reconstructing the Past Landscape

4.1. Past Land Use Analyses

Land use analysis is concerned with the dynamics of natural and anthropogenic landscape elements and investigates the ways people used their surrounding resources. It is also an important topic that clarifies the human dimension of environmental issues (Widell et al. 2013). In addition, discussions of land use and settlement choices are intertwined with discussions of sociopolitical and economic subjects. For instance, sedentary settlement pattern and subsistence strategy could be imposed by sociopolitical decisions. Furthermore, modeling different forms of land use and land cover across a study area clarifies diverse livelihoods and human-environmental interactions. For instance, nomadism and various forms of mobility are closely connected to the availability of pasturelands and water resources, all of which can be illustrated by land use models (Wossink 2009; Wilkinson et al. 2014).

Understanding past land use can draw on a range of different datasets, including archaeological remains, remote sensing analysis, and ethnoarchaeological and ethnographic records. In this chapter, I use geospatial analyses based on multispectral satellite imagery and ethnoarchaeological records to model the Sasanian landscape of the study area. This chapter also examines the potentials of multispectral satellite datasets in analyzing historical land cover and land use patterns and results will be further used for interpretation of archaeological field survey data. In the next chapter, I will present the archaeological remains that were identified and recorded by remote sensing techniques and field surveys.

Archaeological remains play a pivotal role in exploring multiple types of land use activities through a long-term perspective and demonstrate adaptive strategies and resilience.
of populations. In particular, evidence of activities, beyond the limits of sedentary settlements recorded through field surveys or remote sensing techniques, aid in the reconstruction of past landscapes. Among the off-site features, the most prominent are irrigation systems, dams, terraces, field boundaries, agricultural processing materials, remains of pastoralism or nomadic lifeway, and ancient roads. For instance, hollow ways— one of the landscape signatures in northern Mesopotamia, in particular during the Early Bronze Age— are used as proxy indicators for understanding land use beyond nucleated settlements and reveal approximate areas under cultivation. These large-scale linear features radiate from settlements and represent the movement of people and animals passing from agricultural lands to reach a pasture zone. Analogies from both Near Eastern and European landscapes reveal how these ancient remains are comparable to the traditional routes that linked settlements to their pastoral resources (Wilkinson et al. 1994; Ur 2003).

Contrary to ethnographic records, most of the available historical and ancient texts associated with the Sasanian studies do not discuss the details of land use practices or landholding patterns. Moreover, they usually relate to the political core areas and administrative centers, while rarely explaining the agriculture-based villages, towns located along the major trade routes, border areas, or highlands. Also, textual records typically do not specify whether peripheral or marginal lands were privately-owned, held by local communities, or managed by state-sponsored plans. However, ethnoarchaeological details on agropastoral and nomadic communities form an important basis for analogies and for interpretation of archaeological data. Knowledge of the traditional land use practices in a specific region, when linked with archaeological evidence such as settlements and off-site features, can create models to contextualize the structure of a landscape and its trajectories.
The narratives about historical land use and subsistence strategies are useful for approaching past phenomena and can serve as a reference for interpreting archaeological evidence. They can inform us about local landscapes and land use activities, as well as relationships between sedentary agriculturalists and mobile agropastoralists. Also, ethnoarchaeological records provide valuable knowledge on historical practices and the broader social structures (Hole 1978; Cribb 1991).

In Sasanian archaeology, landscape elements beyond the cities, monumental structures, or state-sponsored territorial expansion schemes remained neglected until very recently. Past studies were generally more interested in monumental features and art history, while field survey and remote sensing methods were not yet developed to investigate diverse environments. While the focus remained on the evidence of sedentary agriculturalists and their role in the broader landscape formation and sociopolitical structure, negligence in discussing agropastoral, semi-nomadic, or nomadic communities rendered studies incomplete. In addition, systematic archaeological research spread unevenly across the vast territories of the empire. Emerging new perspectives and methods and conducting more surveys are improving the situation and giving insights into the heterogeneities of the landscapes. These insights also provide a fundamental understanding of the development of the state and its societal diversity. Land use and land cover can vary widely from intensive irrigated agriculture to terracing and extensification of cultivation in the foothills, pastoralism, and nomadism, or a mixed farming and herding strategy. Among all different natural land cover types and anthropogenic land use strategies, cultivation is perhaps the easiest to identify using archaeological methods. Some direct evidence that aids this identification includes irrigation systems, terraces, and field boundaries. In this chapter,
I use geospatial analyses to identify other forms of land use, including non-irrigated or non-cultivated zones. Land use and hydrological models are employed to quantify the spatial patterning of the landscape elements. This process not only gives insights into the dynamics of land use and land cover but also aids the identification of relations between the landscape structure and the broader socio-environmental systems. I apply geospatial analysis combined with ethnoarchaeological records, and results will further be interpreted in conjunction with existing field survey data.

4.2. Multispectral Satellite Imagery and Land Use Modeling

Visual and spectral interpretation of satellite images has been extensively applied in archaeological investigations in recent years and has contributed to the research by demonstrating potentials for identifying different land use practices. Specifically, changes in vegetation growth or soil color observed via aerial or satellite imagery have long been employed to detect archaeological features (Wilson 1982). Analysis of panchromatic and multispectral satellite imagery provides archaeologists with a spatial perspective of different land use and a virtual survey of the landscapes. By providing coverage of areas over multiple months and years, these images can show long-term changes across an area. Multispectral bands of satellite images can be combined in multiple ways to illustrate different aspects of a landscape. For instance, Comer (2013) used Landsat imagery to identify arable soils and further argued the adaptation of agriculture by nomadic populations around Petra, Jordan. These phenomena identified by multispectral satellite imagery analysis presented a settlement shift from nomadism to a sedentary lifeway.

One of the most common manipulations that have been broadly used for environmental and archaeological studies is vegetation indices analysis. Based on spectral
properties, models of vegetation indices examine phenological changes as well as spatial
and temporal vegetation distribution. By maximizing sensitivity to vegetation parameters
and minimizing variations such as soil background or atmospheric effects, vegetation
indices can identify the amount of biomass, leaf area, vegetation health, or greenery across a
land (Purevdorj et al. 1998; Ozdogan et al. 2010). Among the vegetation indices,
Normalized Difference Vegetation Index (NDVI) is the most widely applied and a standard
algorithm that has been used for multiple research purposes, including to measure crop
growth, predict crop failure, and estimate green vegetation. NDVI is calculated by the
formula (NDVI= (NIR-R) / (NIR+R)). While vegetated areas can include both cultivated
and non-cultivated lands, the spectral signatures of near-infrared (NIR) and visible red (R)
bands characterize the greenery variation by exhibiting values ranging from +1.0 to -1.0. In
the NDVI results, negative values or the values near zero indicate non-vegetated surfaces,
moderate values ~ 0.2-0.4 represent pastureland or grassland, and higher positive values
ranging between ~ 0.6-0.8 represent dense vegetation. In other words, if the reflectance
difference between infrared and visible red is little, it represents sparse or unhealthy
vegetation. In contrast, if the reflectance difference between infrared and visible red is high,
it represents healthy and dense vegetation (Tucker et al. 1991).

NDVI can be generated from different satellite sensors. One of the most important
differences among datasets is their spatial resolution. Generally, the highest resolution
imagery is suitable for more detailed local-scale mapping and for identifying the smallest
features, while the moderate resolution images can be used for regional-scale mapping and
for revealing the relationship between the environment and archaeological features. The
most important programs to use for creating NDVI maps are Landsat, Advanced Very High-
Resolution Radiometer (AVHRR), and Moderate Resolution Imaging Spectroradiometer (MODIS). While higher frequencies of AVHRR and MODIS produce higher temporal resolution data, their low spatial resolution (approximately 1 km for AVHRR and the maximum resolution of 250 m for MODIS) creates coarser results. Therefore, these programs are more suitable sources for regional-scale mapping than a detailed landscape observation. On the other hand, the Landsat satellite sensor offers a 30 m spatial resolution that provides a more precise local-scale mapping (Tucker et al. 2005; Atzberger 2013).

Besides the importance of spatial resolution, the timing of images and the number of acquired images are factors that impact mapping results and interpretations. Landsat was one of the first remote sensing programs to offer valuable advantages to archaeological analysis. Since its launch in 1972, the Landsat program has been the longest continuously running satellite program that captures the earth surface (Fowler 1995). It has been widely accepted that since the 1970s, most landscapes across the Middle East went under intensive land transformations, including irrigation expansion, mechanized agricultural activities, and urbanization. However, this is only a broad and generalized statement that should be considered with caution. Regional variations in both environmental and cultural aspects, as well as local sociopolitical priorities and trajectories, can strongly influence land use decisions. In recent decades, the study area has suffered from forced population deportations, being an active battlefield during the Iran-Iraq war in the 1980s, and from water disputes where the transboundary courses of the Sirwan and Alwand rivers complicate water management conditions in both countries. These incidents not only significantly restricted archaeological studies but also halted most of the development projects in border
areas. Therefore, I use Landsat-based multitemporal NDVI analysis that provides historical time-series that captured the study area prior to its modern intensive transformations.

Creating NDVI maps in the past was a longer and more time-consuming process. Each individual Landsat scene was obtained from a geospatial data search engine such as the US Geological Survey (https://earthexplorer.usgs.gov/). Then NDVI could be calculated by using Image Analysis toolbar in ArcMap. However, more recently, Google Engine (GEE) has taken a step further by providing a cloud computing platform that processes satellite images for multiple purposes such as extracting the Normalized Difference Vegetation Index. In this study, individual NDVI values, as well as the averages of multiple years were extracted from the Climate Engine website at (http://climateengine.org/app) that is powered by Google Earth Engine. Web applications such as Climate Engine provide on-demand visualizations, processing, and extraction of precomputed data (Huntington et al. 2017). I used both mapping and time-series options to generate maps of maximum Landsat NDVI. Images were selected on the basis of season, rainfall pattern, and knowledge on the regional cereal production cycles. I selected images from spring (March-April) and summer (July-August) and over the period of 1985-2005. This temporal resolution allows analyzing times with different vegetation growth patterns and different water management conditions. As one single NDVI result cannot be sufficiently representative, an average of 42 images from spring and summer seasons between 1985-2005 were calculated (Figure. 4.1). The result of the Normalized Difference Vegetation Index analysis helped to assess the different land cover types and will further help to understand different land use activities across the study area. In conjunction with using historical CORONA and modern very high-resolution satellite imagery and knowledge of the landscape obtained by field visits, values and
variation of the greenery are interpreted. In particular, distinguishing pasture zones, cultivated and non-cultivated, as well as non-vegetated areas, significantly helped to realize landscape structure and human activities. Average NDVIs show substantive contrasts between the summer and spring and illustrate boundaries of different land use classes as well as variation in the greenery patterns. In the average results, areas with no or stressed vegetation reflect the lowest values. Sparse vegetation such as pasturelands reflects moderate values and dense vegetation such as cultivated fields reflects the highest values. The results also show abrupt changes in values and greenery patterns in different parts of the study area. Results show some of the highest values are found in agricultural fields which were under cultivation during the spring seasons. These fields appear with rectangular shapes that define their borders. Among these cultivated fields, some present low NDVI values that strongly suggest that they were left fallow. North of the study area, beside small patches of flat lands by the larger streams or river tributaries that could go under cultivation, the higher values mostly reflect the uncultivated and natural vegetation. These areas do not have clear borders illustrating cultivation fields (Figure. 4.2). There is a noticeable change between the cultivated fields of the Sirwan River plains and the steppe zone immediately beyond them. This steppe zone was a suitable area used as pastureland. Moreover, there is an abrupt change between the Alwand riverine zone that supported the cultivation and its surrounding lands that were suitable pasture zones. Results show areas that presented moderate or low values in spring and zero or negative values in summer. This abrupt contrast in greenery in summer seasons where lowland pastures are not available anymore and only uplands show green pasture zones indicates the lower steppes could not be used as pasture in summer (Figure. 4.3). In the next step, sample points were selected in
order to observe values over different seasons and years. The main sample point was chosen among the lower cultivated fields. Although irrigated agriculture has expanded in recent years in the lower cultivated areas of the alluvial plains, the results show a single peak value pattern where higher vegetation reflectance occurs in the spring and lower vegetation reflectance in the summer (Figure 4.4). Summer cultivation in this area requires irrigation and this low reflectance indicates lack of irrigation in an area that was predominately under rainfed practice. In addition, areas beyond the limits of cultivated lands in both lower plains and higher steppes were primarily used as pastureland, while only narrow flat patches of land along the major streams or tributaries could be used for cultivation. Based on the topography, lack of flat land for cultivation, and the climatic condition—especially its higher precipitation and lower temperatures—I propose that this zone could be uncultivated pasturelands.

This land use modeling must be linked with the precipitation records over the period of 1985-2005. The record of average annual rainfall reveals the study area has been under a semi-arid climate that is moving toward even arid conditions. It illustrates high inter-annual variability and a fluctuating pattern where theoretically, in most years, rainfall was above the minimum required for rainfed cultivation but situates the region at the edge of irrigated and rainfed zones (Figure 4.5). This fluctuating pattern of rainfall indicates a risk-prone condition that is located between the Mediterranean and the arid zones. Under this climatic condition, irrigation could be applied to supplement dry-farming to offset rainfall instability and create continuous productivity.

In summary, the NDVI rasters and associated precipitation records were used to identify different land cover and land use patterns across the study area. Results represent
differences between the present and past conditions. In recent years, expansion in irrigation systems, projects in agricultural intensification, development of urban areas, including the expansion of all the major towns in the region, and changes in the settlement pattern and subsistence strategies have transformed the natural and cultural landscape. However, geospatial analyses demonstrate that agro-pastoralism and rainfed practices have always been integral parts of this landscape.

4.3. Water Resources and Hydrological Modeling

Accessibility and management of water resources are important factors associated with both environmental and social aspects of ancient societies. Whether discussing sedentary agriculturists that depend on irrigation systems or non-sedentary populations whose seasonal movements depend on the spatial distribution of natural resources, access to water and its flow pattern shape land use decisions and settlement choices. Traditionally, Sasanian studies have paid better attention to landscapes irrigated by means of artificial networks. Canals and qanats—as capital inputs to transform the production systems—became one of the primary signatures of the Sasanian landscapes. However, as water supply systems and different water management strategies depend on regional topographic and hydrological conditions, studies have yet to investigate geomorphological characteristics and spatial distribution of water resources (Wilkinson 2003: 44-70). Modeling terrain and its drainage system by satellite-based remote sensing helps to evaluate associations between settlements or other off-site features and landscape characteristics. GIS-based hydrological modeling is applied by scholars of different fields to analyze and visualize the spatial pattern of water availability and water flow. This modeling offers multiple analytical opportunities to shed light on the distribution of archaeological features in association with
the location of stream networks and flow conditions (Harrower 2010). This analysis can also clarify settlement choices and movements of population, especially in regions where nomadism or semi-sedentary lifeways are common.

The main objective of this section is to develop a primary hydrological model of the study area using the potential of ArcGIS. In this modeling process, an ASTER-based Digital Elevation Model (DEM) is used as the main input variable. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) has been widely used as a source to generate 30 m resolution DEMs. DEM is a grid cell with elevation values that display spatial distributions of landscape elements and analyze terrain conditions. Different land use derivatives can be calculated from a DEM to represent local variabilities. DEM not only provides terrain visualizations such as slope, aspect, hillshade, and viewshed, it can also be used for more in-depth understanding such as hydrological analysis. I have applied DEM generated from ASTER satellite imagery as a base for hydrological modeling, specifically for modeling flow direction, flow accumulation and defining the main drainage basin and stream networks. The 30 m resolution of ASTER was the highest horizontal resolution available that can meet the requirements for deriving a hydrological model of the study area and further helps to evaluate the association between water resources and archaeological features. In this process, core ArcHydro— an extension of geodatabase in ArcMap—was used for water analysis with the goal of defining watershed and its boundaries. This model determines water movement based on relative changes in elevation. In the first step, since the model is supposed to illustrate flow pattern and delineate drainage in every point of a catchment, a consistent and corrected DEM is required. Because DEMs usually contain depression anomalies, “fill sinks” was run to modify and correct values and fill the grid
sinks. Then, a “flow direction” grid is derived from the DEM. This grid consists of values that show the flow pattern of water. This delineation is based on the premise that water flows downhill. Then, “flow accumulation” was calculated from the flow direction grid. This flow accumulation raster shows the drainage area and measures the cells which are upstream of another cell. It indicates that water in each cell can flow into any number of its eight neighboring cells (Oliveira et al. 2000). With a flow accumulation grid, a threshold value should be defined in order to delineate streams. Based on Maidment (2002), I chose 5000 as the threshold value. This step allows water to flow and accumulate naturally based on the DEM structure and means that cells with a flow accumulation greater than 5000 are classified as streams (Figure. 4.6).

The results also show that the study region is a karstic landscape defined by large and active water systems with the surface (and groundwater) drainage networks. This karstic nature can also be stimulated by climatic variabilities such as drought or humid phases (Stevanovic and Lurkiewicz 2004). For instance, one of the noticeable changes is evident in groundwater conditions. Due to both climatic and human-induced factors, the groundwater table has been decreasing, and this means that natural water resources such as springs are less available. Moreover, populations are more reliant on water management projects to provide an increased and assured supply of irrigation and a stabilized land use and production system (Davies 1954; Iran’s Forest, Range, and Watershed Management Organization).

The study area contained plentiful springs and a high groundwater table, especially prior to the beginning of climatic shifts, excessive well pumping, and agricultural intensification. There have also been many areas where populations relied on natural springs
and streams for their different water needs. Additionally, a drastic decrease in precipitation has greatly reduced the recharge of aquifers. Many smaller towns and villages that have historically depended on groundwater resources for living and cultivation are at risk or abandoned. Since the onset of drought in the region in 2005, people have been displaced or moved to larger urban areas (Lightfoot 2009).

Results in combination with past records show that the area offered an attractive land use opportunity through its available surface and groundwater resources as well as pasturelands. Considering the data on the ancient climatic condition discussed in chapter two and the clear trends towards aridity in recent years, both surface and groundwater resources were more plentiful in the past.

4.4. Ethnoarchaeological Records

Ethnoarchaeological or ethnographic records serve as one of the most important datasets for archaeological models and have proven to be effective for archaeologists as they draw analogies between ancient and recent historical evidence (Cribb 1991). Because landscapes are constructs of both environmental and sociopolitical systems, ethnographic records can reveal important knowledge of the land use, settlements, patterns of population movement, human-environmental relations, and social organizations of different communities. In this section, I synthesize the most important ethnographical and ethnoarchaeological records of the broader Zagros Mountains region and then I explain the specifics and models of the local landscape of the study area.

Different nomadic tribes live in diverse locations, from politically and environmentally marginal zones to areas nearby major cities (Tapper 1979b). While direct archaeological evidence presenting non-sedentary lifeways and details of their daily
practices is rare, scholars have been debating about how to use different datasets to study diverse forms of ancient lifeways. For instance, some scholars use faunal remains to investigate what animals were consumed or raised and to understand the role of pastoralism in the economy of an area (Zeder 1998). Another study refers to ancient texts that indicate weaving workshops and pastoral productions used for woolen textiles (Wright 2013).

However, one of the major challenges in using ancient records is that these texts are predominantly reports by or to the central governments and rarely contain information about smaller scale pastoralism semi-sedentary, or non-sedentary populations and their associated land use practices that are different from the sedentary agriculturalists. Additionally, ancient written records are not available for all regions or historical periods. Some scholars discuss challenges for identifying ancient remains of nomadic lifeway, in particular, their settlements and consequently use ethnographic and historical sources as analogies to better comprehend the ancient lifeways (Cribb 1991; Rosen 1987, 1992). Some other scholars use negative evidence as a solution to infer nomadism and pastoralism. For instance, Wilkinson (2003: 121) discusses ‘pastoral corridors’ as areas without permanent settlement or cultivation evidence, arguing that uncultivated steppes immediately beyond the agricultural fields and villages could have been grazing areas. Considering these ongoing debates and the fact that some land use patterns may have changed over the recent time, ethnographic records remain one of the most effective data sources to investigate past landscapes. Therefore, it is important to look at the ethnographies of the region to understand traditional and historical patterns and to develop archaeological hypotheses of settlement patterns, and land use, and subsistence strategies.
By studying ethnographic resources from the broader Zagros region of Iran and Iraq, I explain traditional land use practices as well as the interactions between different populations. Older anthropological progress theory presented a unilineal trajectory and an evolutionary scheme of cultural complexity that is now widely rejected. Based on this simplistic theory, nomads were placed between hunter-gatherers and agriculturalists; however, the perspective that believed nomads were opponents of sedentary populations or marginal elements to the civilization has now changed (Hole 1978; Potts 2014). Systematic studies by western archaeologists and anthropologists on nomads and semi-nomadic agropastoralists across the Near East began in the 1950s and the majority of those works in Iran and Iraq were carried until 1970s (e.g., Barth 1953; Hole 1978, 2004; Tapper 1979b).

In particular, in the absence of direct archaeological evidence for pastoralism and nomadism, these studies, as well as projects that were conducted in the recent years by international or local academics, can be acceptable analogies for the reconstruction of the past landscape. It is also important to apply this data with caution and recognize its limits. For instance, past projects that recorded ethnographic data in the region primarily focused on cycles of movement and nomadic routes, the internal social organization of the tribes, kinship patterns, and the relationship between the tribes and the central states in the 20th century. Therefore, scholars did not pay close attention to local landscape features associated with these groups, their local land use, decisions, or the relationship between the population and their surrounding environment. In specific, how different populations modified or adapted to their surrounding environmental characteristics were not usually addressed. Across different microenvironmental zones or environmentally transitional areas such as the case of this research, there are mutual and intertwined interactions between the
cultural and environmental elements, that make population to choose different responses or coping strategies and past archaeological and ethnographic research in the region have mostly neglected those important topics.

Archaeological studies indicate a long-term history of agropastoralism and nomadism in the area (Abdi 2003). While records indicate that semi-nomadic pastoralism may have been practiced since the seventh millennium B.C. in the Zagros region, more explicit archaeological evidence is rare until the second millennium B.C. This is the time when agro-pastoralism in Luristan has been identified and showed that both sedentary and non-sedentary populations have often had complex and highly intertwined interactions. Records show that and while the majority of the population is currently sedentary, the area has always been home to a larger number of non-sedentary communities (Tapper 2002: 12). The presence and migratory lifeway of nomads during the Sasanian period is mentioned in a few available historical texts. Above all, the late Sasanian source of The Book of 1000 Judgements discuss nomadic pastoralists and uses the term “Kurd” to reference to nomads (Potts 2014: 122-123). Nomads (ashayer-e Khuchro) are defined based on the following important elements: 1) Social organization that is called qabileh or tayefeh and defines their broader social groups that they belong to and is usually based on kinship links under a specific leader or chief; 2) Pastoralism which is one of their main subsistence strategies.; 3) Mobility, which is based on their seasonal movement and can happen at any distance from a few to hundreds of kilometers in search of better lands and natural resources. The movement pattern and time among the nomadic groups generally might differ based on multiple factors. For instance, the availability of natural environmental resources such as water and pasture, or the sociopolitical conditions that can force them to choose migration or
sedentarization have been the primary factors. Even though there have been strong links between the nomadic groups and control of the trade routes, their power, autonomy, and border crossing movements were usually not tolerated by the central governments. Specifically, over the last century, the closing of the international Iran-Iraq border and compulsory sedentarization of nomadic tribes of Iran have led to the loss of their coherence. In this study area today, the majority of the population is sedentarized (Afshar 1987).

The relationship between tribes and states has been one of the enduring questions in archaeology. The available ethnographic and ethnoarchaeological records of mobile groups in Iran are very useful for the broader region. One of the main reasons is that contrary to the long-term and most successful attempts of some the historical dynasties such as the Ottoman rulers in forced sedentarization of nomads, Iranian dynasties such as Safavids, did not have much success in their compulsory sedentarization efforts. Even in times when nomads were forced to sedentarize such as during the first Pahlavi dynasty of Iran in 1925-1941, nomads returned to their original lifeway as soon as there was a change in the political power. There have been times, including the Safavid dynasty of Iran, when tribe members or heads presented powerful political positions and were directly assisting in the creation of a central dynasty. On the other hand, in other times, states tried to impose sedentarization to control tribes’ power and autonomy and this caused a hostile connection between groups (Potts 2014). With the abdication of the ruler of Iran in the 1940s, there was a short term return to nomadism by those who were forced to sedentarize. However, very soon after that, forced sedentarization combined with other strategies such as nationalization of pasturelands while neglecting tribal territories, agricultural intensification, and long-term water management projects interrupted nomadic lifeway. Besides the political considerations, climatic changes
which have intensified over the past few years have severely impacted their search for water resources and pasture and therefore severely constrained this lifeway.

History shows that non-sedentary populations became sedentary or integrated with the dominant populations under two circumstances: when forced by authorities and at the time of favorable climatic conditions when advantages of having sedentary settlement outweighed its risks. The climatic and environmental conditions of Iran, in particular in pre-industrial times, have been known to favor pastoral nomadism and seasonal movement more than intense cultivation (Lambton 1953). Larger and better-known tribes of Bakhtiari, Qashgha’i, and Shahsavand, usually had more power to either challenge the central states or to be one of the key elements in the formation and transformation of states. Other nomadic or semi-nomadic groups such as Kurds ones are usually less known and have a local degree of autonomy.

There are vertical and horizontal movement patterns practiced by the agropastoralists of the region. A vertical traverse allows them to benefit the seasonal availability of pasture and water and causes close interactions between mobile and the neighboring sedentary people at times, particularly during their winter settlement in the lower plains. This interaction is not only in the form of shared landscape and resources, but it also creates close economic and social interactions. In the vertical migration, a closer interaction between sedentary and non-sedentary populations are established where migration routes pass through the towns and villages of sedentary territories. Additionally, mobile groups have been historically in charge of exchange systems and controlled trade routes. This exchange system was another factor that caused a close interaction between the sedentary agriculturalists and nomadic pastoralists.
Another important factor is that while discussing the agropastoral nomadism, both the pastoral and cultivation parts of that lifeway are important elements to be discussed. Therefore, the location of the summer and winter housing, time of the trade, migratory routes, access to resources, and patterns of the settlement were all impacted by the fact that populations were practicing both cultivation and pastoralism. For instance, the time of grain cultivation differs depending on the climatic and topographical conditions as well as local environmental resources. Kurdish tribes of western Iran cultivated grains in summer and used stubbles to pasture their animals. In another model, among Qashqai tribes, parts of the tribe were migrating for better resources, while others were sedentary in their villages and farmsteads. Also, grain was stored to be consumed later or to be used as fodder in the autumn and winter seasons (Amir-Moez 2002).

Since the 20th century, these populations have been undoubtedly facing more political and social pressures that disturbed their lifeways. In general, while recent ethnographic records indicate more complicated sociopolitical issues that agropastoralists have been facing, in the past, they probably experienced fewer restrictions in terms of access to water and pasture. Therefore, my analysis prompts me to conclude and agree with the general belief that we should assume more freedom and variability in their lifeways in ancient times and before the 20th century (Ur and Hammer 2009).

4.4.1. Ethnoarchaeology of Agropastoralism in the Study Area

To define models of the study area, I use the synthesis of data presented above as the basis for interpreting the archaeological landscape. Knowledge of the historical and pre-modern agropastoralism in the area helps to better understand the local landscape formation and transformations as well as the spatiality of archaeological features. The majority of the
past archaeological and historical studies on late antiquity missed the opportunity to understand aspects of landscapes concerned with local and autonomous groups, their interactions with local microenvironmental diversities, and responses or adaptations to different environmental conditions.

In this study area, I primarily discuss mobile communities who practiced both pastoralism and agriculture. Environmentally transitional nature of the study area and numerous tracks across its northern hilly lands have made it favorable for a non-sedentary lifeway who have lived by the sedentary populations throughout its history. While nomadic lifeway and migrations across the study area have gone under serious changes in recent decades, smaller mobile groups still exist and pastoral productions play a major role in the economy of the region. Until the 20th century, local Kurdish tribes, which ranged from semi-nomadic herdsmen to feudal peasants, had a powerful presence ruling the region and migrating between the lowlands and highlands (Barth 1953: 11-18). Among them, the Jaf confederation of tribes, Kalhors, and Sanjabi are the most recognized who had their qishlaq (winter camping area) around Qasr-e Shirin and Khanaqin and their yaylaq (summer camping area) in the highlands of the Zagros Mountains. Winter cultivation of wheat and barley (seifī) used to alternate with a fallow year and orchards, vegetable gardens, as well as summer crops, were irrigated by surface water resources (Hamdhaidari 1998).

Among the groups, the size of the tribes and internal social relations were determined based on their different kinships, labor needs, geographical locations, and environmental conditions (Amanolahi-Baharvand 1975). The size and number of houses or tents of tribes in western Iran vary and can range from a small community with less than 10 tents or house, to larger groups with dozens of houses (Hole 2004). In the study area, the
location and dispersal of populations in their summer and winter camping areas depended on factors such as availability of pasture and water. Based on the land use and the hydrological modeling discussed earlier in this chapter, the area has limitations in the accessibility of pasture zones, suitable cultivation fields, and water resources. For instance, only particular parts in the lower alluvial plain of the Sirwan and Alwand rivers could be used for cultivation and right beyond those agriculturally suitable zones, there were steppes and pasturelands.

Communities had a vertical migration pattern (moving between highlands in the foothills of the Zagros Mountains and lower alluvial plains), and the primary reasons for this migration were to access pasture, water, the environmental resources, and better environmental conditions (Salzman 2002). While pasture and water resources were more available in the uplands during the summer months, they were more plentiful in the lower plains and steppes in the winter season.

The shelter of these groups includes mud-brick houses, houses with stone foundations, and tents. The characteristic black tents (siah chador) woven from goat hair. Low foundation walls constructed by mud brick or stone, hearths, storage units, and leveled floors are some of the most important features used in campsites (Cribb 1991:92-96). Agropastoral populations of the study area and similar adjacent regions used to construct stone foundations for their tents, as well as constructing mud brick houses (Hole 2004). When studying the location of campsites or villages, as well as their size, orientation, and layout, it is important to consider the geographic location, climatic condition and the degree of their permanency. For instance, some camps were often used repeatedly. Or depending on the climatic condition and available resources, some camping sites could become more
sedentary and populations could choose to stay in a location for longer periods either in winter or summer seasons (Tapper 1979b). Among many groups in Iran, the presence of more favorable climatic conditions or better access to pastures and water, populations stayed longer in their summer or winter places and even became mostly sedentary (Beck 1991). Therefore, long stays at their seasonal places or repeated habitation of the same winter villages or summer campaign locations in highlands resulted in the foundation of more permanent houses and other features such as storage units, small water divergent channels, or hearths.

Another important point is that non-sedentary people were not constructing large-scale or labor-intensive structures such as irrigation canals or terrace systems, however, they lived in the same areas as those capital inputs, in particular, irrigation systems, and benefited from the investments of the sedentary agriculturalists or the ones constructed by the influence of the central states (Cribb 1991: 189). Ethnographic records of nomadic populations show that because of their seasonal movement, nomads do not carry ceramics, but use metal, glass, and vessels made of animal skin. However, larger ceramic vessels could be used and left in their winter camping areas where they settled in villages and stored food for the next year (Hole 1978; Whitcomb 1991).

With regard to the location of settlements, winter camps were located in the lower altitudes and in river valleys. This has caused a closer interaction between the sedentary agriculturalists and agropastoralists. This also could cause the mobile populations to settle down and become sedentary either by political forces of the time or by a choice and due to more favorable climatic conditions. This interaction can be explained by two different hypotheses. One, they kept a close interaction, especially in winter seasons and two, they
became sedentary and chose to practice more cultivation in the lower plains either by force of the central government or by their own choice, because of the presence of more favorable climatic conditions. At times of the year when fields were fallow or cultivated or after crop harvest, they could also be used as grazing lands. Generally, in the past and before the expansion of modern villages and intensification of modern agricultural and water management techniques, there were much more interactions and closer connections between the agricultural and pastoral systems in the area. While the foothills zone of the study region has been historically used by agropastoralists and nomads, there have been fewer interactions between the populations in that zone, as contrary to the lower plains, this zone probably did not contain a dense settlement pattern.

To examine a local landscape that includes aspects of mobility and mixed agropastoralism, ethnographic records provide comparative data on settlement composition and location, local distribution of sources such as water, fields, and pasture, as well as land division or ownership. Ethnoarchaeological records of the village-based agropastoralists in western Iran indicate different herding patterns. This includes village-based herding where sedentary villagers practice both cultivation and herding, short-distance herding by agropastoralists who migrate short distances from their villages to find pasture, and long-distance herding by agropastoralists who migrate for long distances to find resources (Watson 1979).

Furthermore, the boundary between settlements and land use practices of these groups have remained understudied in archaeology. Drawing on the ethnographical records, boundaries between temporary and permanent settlements, pastures, and fields were often unmarked and generally defined by natural features such as streams, piles of stones, ditches,
or paths (Tapper 1979a; Beck 1991). Therefore, despite the lack of explicit archaeological evidence on boundaries, the material remains that show settlement organization, structures foundation, or daily activities, can shed light on the issue of territorial boundaries.

To conclude this chapter, the synthesis of ethnographic records provides a base for better interpretation of archaeological records and understanding the local land use patterns. Data inform us that the area has always had both sedentary and non-sedentary components, and dichotomized models based on subsistence strategies or settlement types do not address complexities of the local landscape.

4.5. Summary

This chapter presented the results of land use analyses based on two datasets: multispectral satellite imagery-based geospatial analyses and ethnoarchaeological records. Land use and hydrological models were created to identify different types of land cover and land use potentials, as well as to illustrate the spatial patterns of natural and anthropogenic landscape elements. I made Normalized Difference Vegetation Index (NDVI) map of the landscape based on the Landsat sensor to present the spatial and temporal variation in vegetation distribution. NDVI values range from +1 to -1 and present different surface types, including dense cultivated zones, pastures, and non-cultivated areas. Result of the multitemporal analysis over the period of 1985-2005 helped to differentiate various land cover types and boundaries of land use classes. It illustrated main cultivated fields and pasturelands immediately beyond them, steppes, and natural vegetation cover in the higher plains. Results were further combined with precipitation records that show high variability and fluctuation in the records which situate the study area at the edge of the irrigated and rainfed zones. In other words, the precipitation used to be above the minimum required for
rainfed practices; however, its high fluctuations indicate a risk-prone condition. Under this climatic situation, irrigation was necessary to offset uncertainties and create continuous productivity. Finally, sample points were selected to monitor value changes over seasons and years and results showed that contrary to the present land use condition which consists of irrigation expansion and agricultural intensification, the area was primarily suitable for rainfed cultivation and pastoralism. In addition, a GIS-based hydrological model of the area was created in order to evaluate the association between sites and environmental characteristics. Results showed the karstic nature of the landscape with large and active surface water resources, particularly in the form of rivers and spring-fed streams. This also indicates the importance of groundwater resources.

Moreover, ethnoarchaeological records were one of the effective datasets to draw analogies between recent historical and ancient settlement systems and land-use practices. The land use and hydrological models illustrated earlier in this chapter also helped to recognize the areas suitable for cultivation, pasture zones, and water resources distribution. Previous chapters presented the environmentally transitional nature of the landscape, where could make different cultural responses to the environmental variability and uncertainty. This chapter presented the ethnoarchaeological evidence from the broader Zagros Mountains region, including the study area, which showed complex and highly intertwined interactions between sedentary and no-sedentary populations through the history of the region. Although the majority of the population is currently sedentary, the area has always been home to a large number of agropastoralists who practiced forms of mobility. Therefore, I attempted to go beyond the studies which primarily focused on cycles of movement, kinship patterns, or internal organization of tribes, and instead focused on the
local landscape features and archaeological remains associated with land use decisions, environmental condition, and interactions between different communities.

Records presented vertical movement pattern of these groups to take advantage of spatial and temporal variability in resources. This movement, which was occurring between lower alluvial plains of the Sirwan and Alwand Rivers as their winter settlement and highlands of the Zagros as their summer settlement, caused close interactions between the mobile and their neighboring sedentary populations. This close interaction was in the form of shared landscape and its natural and anthropogenic resources, including the use of capital investments such as irrigation systems, close social and economic interactions, as well as exchange system and control of the major trade route that passed the study area.

Additionally, data gives us insights into the structure and foundation of shelters in both summer and winter settlements of agropastoralists. A mix of mudbrick houses and tents with stone foundations in the summer camping areas of lower plains and a mix of stone-built houses and tents in the higher altitudes were the main observed categories.

Generally, my arguments are in favor of the assumption that ancient agropastoralists of the region, as well as the populations living in the area prior to the modernizations that began in the 20th century, had more freedom and flexibility in their movement, land use, and interactions with the fully sedentary agriculturalists. Moreover, I concluded this section by suggesting that we should not create a dichotomized model of sedentary and non-sedentary, or agriculturalist-pastoralist. Instead, focusing on their close and intertwined interactions through history will create the most accurate models to recognize the complexities of the landscape.
Figure 4.1. Average NDVI map of the study area for spring 1985-2005 (top), and summer 1985-2005 (bottom).
Figure 4.2. Comparing greenery variation in north of the study area during spring (top) and summer (bottom).
Figure 4.3. Comparing greenery variation in steppe part of the study area during spring (top) and summer (bottom).
Figure 4.4. Average NDVI during the period of 1985-2005 for a) spring months and b) summer months. c) time-series from a sample area which is located within the currently irrigated fields. Summer 1988, specified with red arrow, indicates either an anomaly or an irrigation expansion in summer.
Figure 4.5. Annual and spring rainfall pattern for the period 1985-2005. Data from Climate Engine.org: Google Cloud Computing and Visualization of Climate and Remote Sensing Data.
Figure 4.6. Natural and anthropogenic hydrological features of the study area, base: 30 m ASTER-DEM
Chapter Five: Remote Sensing and Field Survey

5.1. Remote Sensing-Based Archaeological Survey

This chapter examines the acquisition and analysis of remote sensing datasets and records of archaeological landscape surveys. Remote sensing techniques were applied to identify potential archaeological sites and off-site features. In particular, historical CORONA satellite photographs and modern very high-resolution (VHR) satellite imagery were applied to document the landscape. Results of this process created a base for ground surveys, as well as for land use modeling and past landscape reconstruction which are reported in Chapter five. Moreover, this chapter reviews the main methods of archaeological field survey with regard to field survey intensity. Then, I present results of these surveys and conclude the chapter with an analysis of surface ceramic collections that provides a chronological underpinning for the archaeological sites.

Application of remote sensing techniques has significantly enriched archaeological landscape surveys and regional analyses in recent decades. These techniques have also begun to address enduring questions on long-term human-environmental interactions, including questions about settlement distribution, natural resource availability, and various land use practices (Hritz 2014).

Remote sensing is non-intrusive and compared with the ground survey method, it enables more expedient and inexpensive landscape documentation. When reliable data sources are available, remote sensing can generate an extensive inventory of potential archaeological features across a study area and integrate them with previously surveyed sites in order to create a comprehensive database. Among multiple remote sensing technologies, aerial and spaceborne photography have played major roles in advancing
archaeological investigations. Since the beginning of the twentieth century, aerial photography was among the first datasets adopted by archaeologists to visualize features from above the ground (Kennedy 1996; Wilson 1982). Visibility of characteristics such as crop marks, soil marks, and shadows have been particularly helping archaeologists to identify landscape features (Cox 1992). During the 1950s and 1960s, application of aerial photography, along with field techniques, resulted in intensive landscape mapping across many regions in the world, including in the Near East. For instance, multiple archaeological surveys in the Susiana Plain of southwest Iran, in 1959-1978, were all using aerial photographs (e.g., Adams 1962; Hole 1987; Johnson 1973; Wenke 1975-1976). Because these photographs provide high-resolution oblique and vertical views of features, they continue to be used in the modern archaeological studies to some extent. However, with more restricted accessibility and the higher cost of these photographs, along with improvements in spatial resolution of satellite imagery, their wider geographical coverage, and easier access to different dataset archives, the majority of archaeologists are choosing to apply satellite imagery as their main source for remote sensing analysis.

Satellite remote sensing-based analysis provides vertical views of large areas of land, and its ongoing developments continue to advance our archaeological understandings of formation and transformation of landscapes.

Applicability of these images for different research questions and the choice of what dataset to use depend on multiple factors. These include availability and the cost of acquiring images, spatial resolution, temporal resolution, geographical coverage, and the capabilities and limitations of each dataset in addressing particular research questions (Masisni and Lasaponara 2006). For instance, multiple satellite sensors have presented
strong contributions in mapping landscape formation, and their different spectral coverage and combinations can provide opportunities for geospatial analysis such as land use and land cover classification. Moreover, temporal coverage of images can help to monitor changes in land use over time (Parcak 2009).

Some of the most important ancient features across the Near Eastern landscapes, including within the study area, are settlements that are often formed as artificial mounds (known as tell, tepe, or chogha), and off-site features, including irrigation systems, remains of agricultural activities, and ancient routes. The settlement-mounds are formed as a result of long-term human occupation—often several millennia— and if not occupied by modern villages or leveled by agricultural expansions, they appear as contrasting spots that make them distinguishable from their surrounding lands on satellite imagery. Besides identification of these ancient settlements, satellite imagery particularly facilitates recovery of off-site features. Most notably, depressed and linear morphology of ancient roads and irrigation canals, the regular interval of qanat shafts, agricultural field systems in highland areas, as well as historical nomadic sites have been discerned through analysis of historical and modern images (Challis and Howard 2006; Ur 2013; Wiseman and El-Baz 2007).

Although the study area contains rich archaeological and historical remains, few systematic investigations had been conducted in the past. Thus, this fact has resulted in gaps in our archaeological knowledge. In this dissertation, investigation of different parts of the study area, including the alluvial plains of the Sirwan and Alwand Rivers and foothills of the Zagros Mountains, heavily relied on the application of satellite remote sensing. Different datasets were used to identify and map archaeological features, most of which were documented for the first time. Satellite images were processed in ArcGIS 10.4.1. and
potential archaeological features were documented as points of interest. The ability to overlay images from different satellite sensors and times made the identification process more efficient. Extensive application of these images resulted in the identification of numerous potential sites that created a guiding base for conducting field surveys. Afterward, from the potential features, representative samples were ground-truthed, surface material remains were analyzed, and chronological sequences were established. Examination of parts of the survey area in the Iraqi Kurdistan was based on remote sensing analyses and verification of the features on the ground. Examination of the Iranian side of the study area relied on remote sensing analysis, accompanied by one season of field visit and consultation with available archaeological field survey reports. These reports included published and unpublished materials that contain the location of the surveyed archaeological sites and off-site features, chronological sequences based on ceramic collections and test excavations, description of environmental features, and assessments of damage to the remains (e.g., Directorate General of Antiquities 1976; Gholami 2017; Hozhabri 2013; Moradi 2012).

The combined use of historical CORONA and modern very high-resolution satellite imagery made a greatly improved the detection process and enabled the record of landscape changes over the past few decades. CORONA satellite programs captured landscapes at different seasons from 1960 to 1972 that is considered prior to massive land transformations. In addition, with a moderately high spatial resolution (between ~ 2-5 m), and wide geographical coverage, CORONA became a powerful dataset to record past landscapes, in particular in locations where aerial photographs are not easily accessible. Furthermore, over the last few years, easier access to very high-resolution satellite images with a spatial resolution of 1 meter or finer such as WorldView, IKONOS, and GeoEye have
shifted archaeological prospection. These datasets are now used extensively prior to and during archaeological fieldwork. Besides their visual analysis that aids detection processes, other approaches such as multispectral analysis are helping archaeologists to identify more features. In the following sections, I describe the potentials of these datasets in archaeological studies and their effectiveness, in the mapping of the ancient features across the study area.

5.1.1. CORONA Satellite Photographs

Since declassification in 1995, CORONA satellite photographs have played an influential role in the Near Eastern landscape archaeology by advancing the process of feature identification (Challis et al. 2002-2004; Kennedy 1998). CORONA satellite captured landscapes during a time that predates many of modern urban expansions, agricultural intensification, and political instabilities, which have resulted in the eradication of many ancient remains. Considering the current and ongoing landscape changes, such as water management plans and agricultural intensification, many of the features discussed in this dissertation are also under threat. CORONA imagery has replaced the application of aerial photographs in many research projects and particularly has benefited landscape studies for the following reasons. 1) Images pre-date many of the modern land use changes, therefore they provide a unique glimpse of the past landscapes. 2) Unprocessed images can be obtained at low or no cost from USGS (United States Geological Survey) website and through its Earth Explorer (https://earthexplorer.usgs.gov/). Because images have spatial distortions, a collection of orthorectified data can be freely viewed and downloaded as NITF file through the CORONA Atlas of the Middle East at the University of Arkansas (https://corona.cast.uark.edu/atlas). In addition, orthorectification of images for this study
was possible through methods developed at the Center for Advanced Spatial Technologies at the University of Arkansas (Casana, Cothren, and Kalayci 2013). 3) Images have a high spatial resolution of between 2-5 m, depending on different camera systems. The highest resolution cameras are KH-4B and KH7. 4) By covering large geographical areas and through multiple satellite missions, CORONA imagery makes extensive remote sensing-based surveys feasible. 5) Images were taken at different times of day as well as different seasons of the year, consequently, ground conditions such as soil moisture, vegetation cover, and shadows create differences in visibility of features. For instance, mounded sites can be discerned based on their shadows or lighter soil color compared to the surroundings, and anthropogenic soils are better revealed by the ground moistures in winter or spring seasons. Furthermore, CORONA has been particularly beneficial in investigating off-site landscape elements. Linear features such as roads and irrigation canals appear as depressed and dark lines due to moisture attraction, and in the case of canals, their lighter upcast can be visible on satellite imagery as well (Alizadeh 2014; Ur 2013). In addition, the regular interval of qanat shafts and the deposited soil around them create a unique shape that is discernable from above. Overall, CORONA imagery is proven highly effective for identifying various site morphologies in both alluvial plains and foothills.

I have used CORONA photographs from missions 1039 (February 1967), 1103 (May 1968), and 1107 (August 1969) acquired from USGS website and orthorectified images using CORONA Atlas & Referencing System developed by the Center for Advanced Spatial Technologies, at the University of Arkansas. Visual analysis of images resulted in the discovery of previously undocumented sites and off-site features in different geographical zones of the study area. It also helped to locate and analyze sites that were previously
recorded by local archaeological ground surveys. Further, conducting field surveys after an initial examination of imagery helped to test the effectiveness of these remote sensing techniques in the identification of different types of features.

Intensive examination of CORONA, as well as recent very high-resolution imagery (discussed below), was highly effective and mapped a total of 300 potential archaeological features, of which a representative sample of 150 features was ground-checked (Figure. 5.1). These include high mounded sites, low mounded sites, irrigation systems, terrace systems, and architectural remains. Overlying historical and modern satellite imagery particularly helped in better distinguishing between the modern and ancient mounded features. Among the points of interest, high-mounded tell sites were more obvious and could be identified easier, while low-mounded sites or non-site features were more difficult to recognize. Images were particularly useful in the lower alluvial plains of the Sirwan and Alwand Rivers, a zone where most of the sites were identified. An initial analysis of all the potential sites indicated that the majority of settlements in particular, for the sites containing the Sasanian occupation are modest-sized with less than 1 hectare in area. This result was cross-checked during the field survey and site visits.

Sites in the lower plains of the Sirwan River are clustered and mostly distributed in the water-rich areas, along the karst streams. In the Alwand River area, while some sites are located along the permanent water resources, others are farther from the streams and in higher elevations. The same spatial pattern of site distribution can be hypothesized for the middle parts of the Sirwn River, where surveys have not been conducted (Figure. 5.2).

Besides the settlement evidence, results of remote sensing analysis show terraces of artificial irrigation systems. These include one canal on the right bank of the Sirwan River,
one canal associated with the Qasr-e Shirin complex, and a qanat network. Sirwan canal is a large-scale construction, running for approximately 40 km to convey river water to broader areas of land (Figure. 5.3). It is constructed in one of the most arid parts of the study area to expand cultivation beyond what normally could be practiced. Along its course, two inverted siphons were built to transport water through wadi depressions. These U-shaped siphon tunnels were built at the bottom of depressed wadis and transferred water to the other side and back to the original level of the ground (Figure. 5.4). Thanks to efforts of archaeologists at the Garmian Department of Antiquities in Kurdistan Region of Iraq, a Middle Persian (Pahlavi) inscription on the wall of a siphon was recorded that dates this construction to the Sasanian period. The inscription contains a few characters only, which although they clearly are Middle Persian, it is difficult to gain a clear understanding of their meaning. Most parts of the canal course are now obscured on the modern landscape, however, CORONA imagery shows that the canal turns into a qanat system in its southern parts (Figure. 5.5). This modification was probably aimed at reducing siltation of the system and salinization of the soil. Another canal system (nahr-e Shahgodar) was constructed in association with Emarat-e Khosrow in Qasr-e Shirin town (Blizard 1918; Gholami 2017; Hozhabri 2005). Both Sirwan and Alwand Rivers flow below the level of surrounding lands, therefore, fields could only be irrigated by the construction of water management systems such as canals. Among the travelers and archaeologists who visited Qasr-e Shirin monuments, Binder (1887), stopped on his way from Baghdad to Kermanshah to particularly visit this canal system, and reports that most of the system was destroyed. However, in the early twentieth century and during the first Pahlavi dynasty (1925-1941), parts of this system were renovated in order to irrigated orchards and agricultural fields. Currently, reports indicate
that only small parts of its traces are visible on the current landscape and it is not possible to determine its original length or its beginning and end points. Overall, this canal was built to provide water to the Qasr-e Shirin complex structures and irrigate their associated gardens. The evidence of these canals presents a sophisticated knowledge of hydraulic engineering and an apogee in land use intensification during the Sasanian period.

5.1.2. Modern High-Resolution Satellite Imagery

Very high-resolution (VHR) commercial satellite imagery is another dataset that is significantly improving archaeological studies and will most probably continue to play a constructive role by opening new research avenues. By discovering, documenting, monitoring, or preserving archaeological resources, these images have triggered advances in many archaeological and cultural heritage projects. In landscape surveys, application of recent panchromatic or multispectral satellite sensors improves the detection process, enables understanding landscape changes over recent times, and provides inputs for different geospatial analyses. Most satellite sensors measure spectral reflectance of surface features in multiple bands of the electromagnetic spectrum. For instance, a false-color composite with three primary bands of red, green, and blue has been typically used as a color representation of land features, but in addition to this method, pixel values are used to measure physical properties of features (Kochoukos 2001). Moreover, sensors produce images with a different spatial resolution ranging from coarse to high, and different temporal frequencies ranging from hourly measurements to updates in multiple weeks. Generally, depending on the research questions, multispectral and hyperspectral imagery can have various advantages in archaeological studies and cultural heritage management. For instance, case studies show that multispectral ASTER (Advanced Spaceborne Thermal
Emission and Reflection Radiometer) satellite imagery effectively located archaeological features which were not easily distinguished on historical CORONA photographs (Altaweel 2005). It has also been used to develop a method to detect potential archaeological settlements based on elevation and anthropogenic soils across vast areas (Menze and Ur 2012). Moreover, by offering a stereo view, these satellite images can be used to extract digital elevation models (DEM). ASTER is one of the suitable sensors that construct a 30 m resolution DEM. Also, certain ancient remains such as circular and regularly spaced qanat shafts can be easily seen on VHR imagery, however manual extraction of these traces is a laborious and time-consuming process. Recent studies are proposing semi-automated extraction methods that can identify linear, circular, or rectangular features over wide areas (Luo et al. 2014). In another example, the creation of hydrological and land classification models helped to address the role of environmental factors in the development of irrigation agriculture (Harrower, McCorriston, and Oches 2002). Additionally, the rapidly changing modern landscapes place multiple elements of cultural heritage at great risk, and valuable information about past societies is under threat to be lost. Access to regularly updated time-sequenced satellite imagery is helping archaeologists and cultural heritage administrators to actively monitor and document a timeline of damage caused by conflicts and looting in the Near East and beyond (Casana and Panahipour 2014). Using spectral information to identify land cover types and understand the spatial relationship between archaeological features and their surroundings is another application that is used in this dissertation. In Chapter 6, I apply a Landsat-based multi-temporal vegetation index to assess land use classes and agricultural strategies.
Archaeological remains appear differently based on satellite sensors and time of imagery acquisition. Therefore, a multitemporal and multisensor investigation usually brings the best survey results. Visual analysis recognizes features based on their physical attributes including shape, size, and spatial relations. Moreover, depending on vegetation cover, soil type, and illumination, various soil, and crop marks can be detected from a vertical view. While commercial satellites provide very high-resolution datasets at high costs, these images can sometimes be obtained for research purposes at low or no cost. In this dissertation, I obtained data from DigitalGlobe’s Worldview satellite (https://www.digitalglobe.com/), and Planet Explorer (https://www.planet.com/) to visually detect and interpret the features. The most important advantage of these images was their less than a meter spatial resolution that allows a detailed landscape observation. Although historical CORONA was an indispensable data source in recording lost or obscured archaeological traces, certain features presented much better visibility on recent imagery through a qualitative and inexpensive visual inspection. In this study, one of the most important contributions of employing VHR satellite imagery was the discovery of sites in the foothills zone of the study region. Evidence includes extensive stone-built structures, terrace systems, and probably nomadic sites that all represent a change in the natural ecosystem (Figure. 5.6). While the modern imagery was highly effective in documenting these traces, establishing chronologies of these sites and agricultural fields required a ground survey. Overall, these dispersed remains in the upper reaches of the Sirwan River are located in a different, yet closely interconnected microenvironmental zone in proximity to settlements in the alluvial plains. The stone-built agricultural terraces and their associated building structures show a first-time extensive modification of this upland
microenvironment and indicate that these have been primarily constructed to expand
cultivation in a zone where was uncultivated or was little cultivated before. These could
make seasonal dry-farming cultivation possible and most likely could use runoff and spring
water sources as well. In addition, by controlling runoff water, the wall could preserve
surface soil from erosion. Rectangular structures associated with agricultural fields can be
interpreted as small and seasonally used homesteads in a predominately dry farming area,
and the fewer number of circular features were probably nomadic camps. These remains
resemble the adjacent dry farming homesteads and terraces in Deh Luran (Neely 1974), and
according to this comparative data as well as the ceramic collections uncovered from the
sites, these traces were apparently first introduced during the Sasanian period.

In addition, analysis of modern satellite imagery led to the identification of a qanat
network (Figure. 5.7.). Qanat (Persian), Karez (Kurdish), or falaj (Arabic), is a water supply
system consisting of a subterranean tunnel that typically runs over long distances to
transport water from an aquifer to the lower elevations by gravity flow (English 1968;
Beaumont 1971; Boustani 2008). Different forms of this traditional and sustainable water
management system have been built to either directly transfer groundwater to the fields or to
direct water to surface canals which then irrigate agricultural plains. The qanat tunnel is
connected to the surface by a series of shafts that are dug at regular intervals. These shafts
are the only components of a qanat system that can be observed from space. This qanat
network is located in the alluvial fans and beyond the cultivated zone, therefore, it is not
directly associated with the cluster of ancient settlements and makes challenges to establish
a precise construction date for this system. Whenever it was constructed, it indicates efforts
to expand cultivation beyond the limits of karstic spring-fed streams and created new land
use opportunities by irrigating an extended area of land. Although this network is not in use today, the remaining shafts show fragments of its course and illustrate how the area’s groundwater table was once plentiful. In general, climatic changes, increased aridity, extensive mechanized well pumping, overexploitation of groundwater resources, as well as urban expansions and political instabilities are the primary reasons for the abandonment of qanats in the region.

Finally, the potentials of applying historical and modern remote sensing data will increase if they are used in conjunction with other techniques, including field survey.

5.2. Archaeological Landscape Survey

Field surveys map sites and non-site features, analyze archaeological and environmental elements across landscapes, and collected data to establish chronological sequences for the ancient remains. As one of the primary data collection methods in the modern-day archaeology, regional surveys reveal inter-site relationships and provide regional-scale data that can be used to investigate human-environment interactions and reconstruct landscape changes over time (Banning 2002). In addition, as one of its earliest purposes, field survey still helps to create an inventory of archaeological sites and select the best candidate for further excavations. In the Near Eastern archaeological studies, an increasing number of projects have been moving beyond an exclusive reliance on excavation or record of the urban areas and monumental architecture, and place more emphasis on recording rural, agricultural, or pastoral landscapes. Some of the most significant contributions of surveys include recovering regional data that help to understand long-term trends on demographic patterns, sociopolitical organizations, and diverse land use
systems. In addition, surveys are identifying remains of non-sedentary populations that mostly remained unrecognized until very recently (Alizadeh and Ur 2007).

Over recent decades, advances in remote sensing techniques and application of geospatial technologies, Geographic Information Systems (GIS), and Global Positioning System (GPS), have transformed the ways archaeologists identify, document, and interpret past remains (Kvamme 1999; Wheatley and Gillings 2002). These approaches along with advances in anthropological theories also enable a reassessment of past studies. The detection probability in both remote sensing efforts and field surveys depend on multiple cultural and environmental factors that shape and change landscapes. Topographical characteristics of an area, vegetation cover, sedimentation, erosion, as well as urban and modern agricultural expansions, and looting are all factors affecting the visibility of ancient features. In addition, geographical location, physical characteristics of sites including their shape and size can significantly impact their visibility in the prospection process (Banning 2002: 46–47). While remote sensing-based datasets can significantly help and advance an archaeological prospection, field surveys would still be necessary to cross-check potential archaeological features, collect diagnostic surface materials, and improve our understanding of the general landscape and its environmental characteristics. Based on the study area’s geographical and geomorphological conditions, as well as research questions and approaches, field surveys can be conducted through different methods.

5.2.1. Survey Methods

One of the first considerations prior to conducting fieldwork is deciding about survey design and the way to document the target area. Field walking requires team members to distribute across the area with appropriate distance from each other and walk along the
transect lines to record features and collect the surface materials. Typically, the orientation of the transect lines and distance between them differ in projects and depends on the general survey goals. For instance, if the goal is to do a highly intensive landscape recording, members would need to walk in closer distance to each other to be able to record more details (Banning 2002: 198). Today, surveys are conducted with a Global Positioning System (GPS) that helps to record the precise location of features. When identifying an archaeological site, members typically have a limited period of time and should record as many details as possible. Therefore, most projects use a survey record form that contains check-boxes for multiple important elements. Some of the most important attributes that are recorded in forms include date of visit and name of the surveyor; location of the site based on GPS coordinates; periods of occupation; method of surface material collection; site dimensions including height, width, and area; environmental characteristics of the site surrounding including water resources and soil condition; possible site disturbances and factors that impact site visibility such as vegetation cover, modern constructions, or evidence of looting; types of survey materials such as ceramics, lithics, or human skeletal remains; and other observations such as evidence of building materials. Using a survey record form makes recording system more efficient and expedient.

Measuring site size has been used to estimate population size or to study changes in settlement patterns over time. Sites can be measured by both remote sensing techniques or during the field survey. Visibility of sites, in particular, mounded settlements on satellite imagery, allows archaeologists to make an estimated measurement of the site size. In the field, the changes in topography and surface material distribution help surveyors to define an approximate boundary of sites and measure its dimensions. While some archaeological
projects spend time on each site to collect material remains, others choose to only record and examine materials in their original locations and do not collect any materials from the surface of the sites. In any case, recording surface materials is a common method to establish relative chronologies of features and further investigates the function of the sites. In this regard, most projects only collect diagnostic surface materials. This method has been widely practiced across the Near Eastern landscapes and has resulted in establishing many successful relative dating of sites and non-sites. However, it should be noted that there are some general issues with this method. For instance, the lack of diagnostic artifacts from certain periods does not necessarily mean that a site was not occupied or used during that time, or the collection process might be impacted by conditions such as vegetation cover, sediments, or erosions and this can hinder the visibility of materials. Among other factors that surveyors record is the environmental characteristics of the site location. This information can create a base to understand the ancient environs and estimate its general characteristics before conducting any detailed environmental study. For instance, site proximity to water resources, cultivation fields, or pasturelands can provide valuable information about its function, and subsistence strategies. Another important factor that should be recorded while surveying is about site preservation. Damages made to a site or possibility of damage to a site should be precisely recorded and this information can then used to plan for preserving a site or conducting salvation studies before the whole site is lost.

In addition to sites, surveys can be particularly useful in recording off-site features. In the past, off-site surveys were limited to the areas in the immediate vicinity of major settlements or urban areas. This method could create an incomprehensive and biased map of
a study area. In particular, sites and features in diverse microenvironments, or semi-sedentary and nomadic settlements remained unrecorded. However, with advances in archaeological methods, in particular, remote sensing techniques, more extensive investigations of a landscape and all of its features are now made possible. (Banning 2002).

The decision on how intense a field survey should be and what extent of a study area should be covered create different survey approaches and results. Surveys are conducted in two general categories of intensive (sample-based) and extensive (full coverage). While both might have strengths and weaknesses, the choice of survey type depends on multiple factors including the research purpose, methods, and availability of time, budget, and personnel. Therefore, archaeological projects might choose either or combine both of the survey types. For instance, if a project goal is to record urban areas, it may dismiss smaller and less noticeable features in rural regions or evidence of other lifeways such as nomadic campsites (Redman 1982, 1987). An intensive survey strategy obtains representative samples of data by covering specific parts of the study area. In this method, surveyors spend more time and effort to map and collect data within parts of the study area while leaving other parts unsurveyed. This method is often chosen when the goal is to generalize and draw inferences in order to address broader research questions without a need to study the entirety of the parameters. In general, recording entire extent of the study area is either not practical or it requires multiple seasons of groundwork, hence sampling to some extent is inevitable and is one of the important strategies in modern archaeological projects. Sampling enables estimations about factors such as the density of sites or artifacts and population size and can also help to build predictive models. Therefore, it is crucial to choose samples with reasonable size and accuracy that can be representative enough for a
study area (Redman 1987). Sampling can be designed in different ways. The most common types of sampling are: random, stratified, and systematic. In simple random sampling, any random part of the study region can be selected for the survey. This means that elements have an equal chance of being identified. While this is a simple method, it might not be the best choice for some survey projects. There is a high possibility that large areas will remain unsurveyed, therefore, it results in neglect of some important information that can improve our archaeological knowledge of the study area. Stratified random sampling tries to minimize the limitations of simple random sampling by creating different strata and then surveying each by random sampling. Finally, systematic sampling is a non-random survey technique that creates regularly-spaced and evenly distributed sampling units throughout the study zone (Banning 2002: 114 –116).

The extensive survey technique enables defining survey boundaries and while it usually reduces the intensity, it attempts to record the entire extent of the study area with consistent accuracy. Many scholars believe that full-coverage is often impractical and sampling to some extent is inevitable. Based on the survey method, surveyors systematically walk along transects and record all features and some further decide to select parts of the area for more intensive surveys or excavation. In areas where previous survey records are very limited, an extensive strategy plays an important role in mapping and creating a general understanding of the area. In addition, studying spatial relationships, that is a key to many landscape studies, and patterning of features such as settlements, water supply systems, agricultural activities, and road networks would benefit more from an extensive survey strategy (Kowalewski 1990: 35).
In the Near Eastern archaeology, many scholars argue about the merits of the extensive method and refer to restrictions of intensive surveys (Kowalewski 1990; Sumner 1990). The extensive technique provides larger and more diverse datasets and contributes to understanding structural patterns and their evolution. Recovery of a larger number of archaeological traces and detecting features with lower frequency but high importance can broaden our interpretations and result in establishing more precise chronologies. In addition, the extensive survey enables the investigation of different microenvironments across a study area. Recognizing spatial relationships among features, social hierarchies, and creating rank-size models all require an extensive survey approach. Furthermore, by recording off-site features such as roads, water supply systems, and traces of agricultural activities, an extensive survey is able to provide sufficient data to reconstruct ancient subsistence strategies and land use patterns. Other advantages of this method include creating an inventory of sites that can be further used to select the most appropriate candidate for excavation or more intensive investigations. Despite these strengths, the success of an extensive strategy is conditioned by how many details, such as low-lying or dispersed features are identified (Wilkinson 2000b: 223). Generally, it is important to identify whether a project’s preference is to record the smallest features or to cover a wider area. Some surveys choose to use one or integrate both strategies. Depending on geographical location, morphological conditions, and archaeological periods of focus, different strategies can also be chosen for different parts of a study region.

5.2.2. Results of Archaeological Survey

After an extensive application of remote sensing tools to identify potential archaeological features, systematic archaeological surveys were conducted in 2014–2016.
Data from the Sirwan River valleys were collected by remote sensing-based surveys, collaboration with the Sirwan Regional Project, and conversations with local archaeologists and informants. Documenting sites in the Alwand River valleys is built upon remote sensing–based surveys and previous archaeological survey reports, in conjunction with one season of fieldwork. These reports which discuss the results of recent years surveys were particularly useful as baselines for further spatial analyses. In general, surveys were planned as the first ever systematic archaeological landscape documentation and created the base for future investigations and a multistage regional project. One of the main shortcomings of the Sasanian studies is about how most of past surveys have primarily focused on large tell-based records, while they missed the smaller evidence such as villages, farmsteads, non-nucleated settlements, low-lying, smaller-scale settlements, and remains of non-sedentary populations. Surveys for this study had five purposes. 1) Ground-checking sites which were previously identified by remote sensing techniques. This process not only helped to build a more precise archaeological database of the region but also checked the accuracy of remote sensing tools in archaeological surveys. 2) Collecting surface ceramics for establishing chronological sequences. 3) Documenting off-site and smaller-scale features that maybe could not be detected through remote sensing analysis. 4) Recording environmental characteristics of the study area. 5) Assessing damage to sites and recording recent and ongoing human-induced landscape changes that might place ancient sites at risk.

The survey area extended from the lower plains of the Sirwan River between the Kalar and Khanaqin towns to Alwand River plains in Qasr-e Shirin town and included the upper reaches of the Sirwan in the foothills of the Zagros Mountains (see Figure. 5.2). An extensive survey method was chosen to visit and survey both lower alluvial plains and upper
parts of the study area in the foothills. However, lower plains, containing the largest number of potential sites, were surveyed more intensively. While the field surveys attempted to make adequate coverage, certain parts of the study area remained unsurveyed due to the risks of landmines and unexploded ordinance remains from the conflicts in the 1980s and, escalated political instabilities in Iraqi Kurdistan in 2014-2015. In addition, because the initial goal of the survey was an intensive coverage of the lower plains, much of the upper reaches of the rivers remained unsurveyed. I propose that future surveys with an extensive (full-coverage) survey strategy can most likely uncover valuable information about long-term and non-sedentary occupation evidence. In general, the combined approach of intensive and extensive survey strategies enable adequate coverage of the study area, to be able to address research questions. This combined approach was also suggested by Wilkinson (2000b), in which extensive surveys are conducted to define the boundary of the survey area and obtain knowledge on different microenvironmental zones, settlements, off-site features, and varying land use practices. Later, more timely intensive surveys can aim at near-complete and higher-resolution coverage and provide better knowledge of the nature of the landscape.

In the lower plains, the topographical and hydrological conditions, as well as fertile and less saline soils, make this part of the study area more favorable for settlement and cultivation (see Chapter 2, and Buringh 1960; FRWO: Forests, Range, and Watershed Management Organization of Iran 2010). Additionally, environmental characteristics, including karst nature and abundant spring-fed streams, were influential factors in the occupation of these lower plains. As a semi-arid and environmentally transitional region, and compared to the alluvial Mesopotamian plains or higher altitudes of the Zagros
Mountains, archaeological features appeared to have survived well, and with minor salinization or sedimentation. Sites were located by a handheld GPS and diagnostic surface materials including ceramic rims, bases, glazed sherds, and decorated pieces, were collected. During the recording process, the boundaries of each site were defined based on topographic variations and distribution of surface materials. Attributes such as approximate site measurements, immediate environmental elements, accessibility to sites, periods of occupation, visibility of the site and its surface materials, as well as other observations such as evidence of building remains were recorded. Site latitude and longitude were recorded by means of a handheld GPS, and approximate site size was measured during the field observations, as well as through remote sensing analysis. Visiting and documenting sites in the field depended on ease of access and the relative visibility of sites. For instance, at the time of field visit, unharvested grain crops were covering some of the sites and their surroundings. This condition caused challenges in site access and surface collections. In addition, modern constructions, agricultural expansions, past political instabilities, and the relatively small size of the sites affected their visibility to some extent. One of the examples of human-induced factors that severely impacted the sites condition is about modern and recent historical villages in the area. Most of these villages are built upon ancient sites and this fact caused challenges for surveys (Figure. 5.8).

All the field records were then integrated into a Geographic Information Systems (GIS) geodatabase that facilitated further analyses. Results show that the most continuously occupied sites are located in the lower plains and among a total of 150 ground-checked sites in both lowlands and uplands, over 50% of sites have Sasanian evidence. This represents the largest number of sites occupied during one particular period across the study area. This
number shows that compared to its preceding Parthian and succeeding Islamic periods there was an increase in occupation during the Sasanian period. This occupation is recorded on both long-settled high mounds as well as on newly founded low-lying sites. Settlements are mostly located along the natural stream courses.\footnote{1} Sites that were recorded during the field surveys or through remote sensing techniques are modest-sized, with less than 1 hectare in area and contain a modest amount of surface materials. Moreover, apart from a few bricks and evidence of stone foundations, no architectural features were identified. Examination of these sites shows substantial differences with that found in earlier regional surveys in agricultural lowlands of the empire. Urban constructions, political or administrative centers, evidence of large building complexes, the foundation of new cities or the expansion of older ones, as well as extensive artificial and multi-functional irrigation systems were recorded on those plains and interpreted as reflecting urbanization and centrally organized agricultural intensification schemes. For instance, records from Khuzistan indicate that settlements are a minimum of 1.5 hectares in area (Wenke 1975-1976), and in the lower Diyala of southern Mesopotamia, approximately 75\% of settlements are larger than 10 hectares, a measurement considered for urban complexes (Adams 1981).

Among the sites located in the lower plains, two special purpose structures have been subject of some past research. The complex of Qasr-e Shirin is located in the Qasr-e Shirin town, on the right bank of the Alwand River (Figure. 5.9). It was known to Medieval geographers and historians (for example Al-Faghih 1885; Ibn Khordadbeh 1889) and later travelers and archaeologists (Bell 1914; de Morgan 1894). The complex includes a fortress called Ban Qale, a domed structure called Chahar Qapi, a canal system, and the main structure called Emarat-e Khosrow. Today, only a few remaining walls of Ban Qale are

\footnote{1 Hydrological condition of the area and settlement distribution along the streams are discussed in Chapter 6.}
preserved on a large mound and the structure has been interpreted as a fortress (Reuther 1964). *Chahar Qapi*, which most of its remains were severely damaged during the Iran-Iraq war in the 1980s, has been called a *Chahartaq* structure (Reuther 1964, Figures 158 and 159; Schippmann 1971). *Chahartaq* literally means “four arches” and is an architectural form consisting of a dome over four arches. Multiple remains of this architectural form have reported from Iran and beyond. For instance, in *Firuzabad* (Huff 1971), *Bishapur* (Ghrishman 1938; Sarfaraz 1987), *Takht-e Suleiman* (Naumann et al. 1965), *Qale Yazdgird* (Keall and Keall 1981), and many more places. It has been suggested that this architectural form originated in the early Sasanian period with the construction of *Firuzabad* (or *Ardeshir Khureh*) as its first reported example, however, the function of this structure has been a subject of debates over the years, while the widely recognized interpretation suggests a Zoroastrianism-related religious function to these buildings. Among the structures, *Emarat-e Khosrow* has been the subject of more studies and has been known as the main palatial structure in the area. Historical records have recognized the whole complex as of late Sasanian structures and associated them with the reign of Khosrow II (590–628 A.D.). On the Iraqi side of the border, and among the agricultural fields the abandoned Hawsh Kori village, there is a monument identical to *Emarat-e Khosrow* that is locally called *Tepe Gawr* (Figure. 5.10). Other than a brief description by de Morgan (1894: PL. LI), this structure has not been studied systematically. The structure is on a smaller scale compared to the *Emarat-e Khosrow*, however, there are significant similarities between the two: they both have the same architectural layout, recovered pieces of wall decorations, and surface ceramic collections. This comparative study suggests the late Sasanian construction date for this building.
Furthermore, it has been an important goal of this dissertation research to investigate varying microenvironments and detect possible diverse settlement patterns and land use strategies. Because of the lack of previous archaeological records in the highlands, and to provide a broader knowledge of the area, field surveys examined the features that were identified on satellite imagery (see Figure. 5.6) in the foothills of the Zagros Mountains. This resulted in the record of a different settlement and land use pattern from that of recorded in the lower plains. Remains of agricultural terraces and stone-built structures indicate that some parts of this upland zone were transformed to expand cultivation and production beyond what was practiced in previous periods and indicate an expansion of dry farming cultivation in a zone where was previously little cultivated. Visibility of these features on CORONA photographs, collection of Sasanian ceramics, and using comparative analysis with records from the regional surveys in western Iran (Hole, Flannery, and Neely 1969; Neely 1974), indicate the Sasanian construction date for these features in an area historically occupied by nomadic or agropastoral populations.

Finally, one of the goals of surveying the landscape was to cross-check the results of remote sensing surveys and evaluate their accuracy and effectiveness. Surveys justified that analyzing satellite imagery prior to surveys in a different zone of the study area were highly effective. Results showed that there was very few numbers of features incorrectly identified on satellite imagery as an archaeological site, and there were also very few features that were detected by the pedestrian survey and were not previously identified on the satellite imagery.
5.2.3. Surface Materials and Chronology

In order to establish relative chronologies for the sites, diagnostic materials were collected from the sites surfaces. In this section, I discuss some of the key methodological points about studying surface ceramics in archaeological surveys. I then discuss the Sasanian ceramics of the study area. One of the main goals of archaeological surveys is to understand the history of human occupation across a landscape. In this regard, analyzing surface materials including ceramics, building remains, or ecofacts is a suitable method to establish chronological sequences for archaeological features. Among all materials, ubiquity and variations in the form of ceramics make them as one of the most informative datasets for archaeological understanding.

In the standard survey approach of the Near Eastern archaeology, a mounded feature that is either recognized by remote sensing techniques or during the fieldwork is regarded as a potential archaeological site. Afterward, regardless of the density of remains, observing surface materials is one of the primary factors to recognize whether a mound is an archaeological site or not. Although surface remains might not be fully representative of all the periods of site occupation, they can give us a good approximation of different cultural phases and their changes over time (Banning 2002: 197-216; Wilkinson, King, and Tonghini 2001). In collecting ceramic remains, there are a few challenging points that most archaeologists and surveyors encounter.

When visiting and surveying multiple sites during one season of fieldwork, there are always chances that some material remains are missed from our observation or their visibility is hindered by different natural or cultural elements. Vegetation cover or unharvested crops, sedimentation, in particular in the alluvial plains, erosion, and colluvium
deposits are some of the most common natural elements that can impact the visibility of a site and its surface remains. Sometimes, these elements can even block the access path to a site. Different environments can cause different visibility conditions for sites. For instance, dense vegetation cover in rainforest areas, sand cover in desert regions, erosion and movement of surface materials by water, or movement of materials by animal activities in semi-arid regions are all conditions that can cause low archaeological visibility. Moreover, modern agricultural and pastoral activities, construction on ancient mounds, military activities or installations, leveling of mounded sites, plowing, looting, and dumping are among the most common cultural factors that impact the condition of an archaeological site and visibility of its surface remains (Bintliff 2000).

To solve these survey challenges and in order to inform the future surveyors of a landscape, archaeologists should fully record the environmental and cultural elements that are disturbing a site. Moreover, while multiple cultural and natural elements can impact surface visibility, they can also impact the condition of materials. In other words, surface materials have been subject to disturbances such as erosion and movement over time that made them worn, broken, or damaged (Tylor 2000: 20). One of the issues with the surface collection is concerned with the impact of previous surveys that were conducted across a study region. Multiple surveys across the same landscape and collecting materials will impact the quantity of surface remains available for future collections. Therefore, if previous surveys have been conducted, and in particular, if surveyors applied an intensive collection method, in order to avoid a biased or unrealistic study, it would be necessary to either access past material collections or the full records of survey results. Another challenge in collecting surface remains is concerned with multi-period sites, where there are
chances that remains from later historical periods present better visibility and higher quantities in comparison to the remains of earlier periods (Wossink 2009: 47). Most of the Near Eastern landscapes contain multi-period sites, therefore it is a possibility that remains of an earlier occupation are hiding beneath deposits of later ones. For instance, Wilkison and Tucker (1995), describe their survey challenges and point out that they could record fewer early occupation evidence (such as Neolithic sites), across their North Jazira survey region and this lack of visibility may be blamed on the obscuring presence of materials from later periods. In general, tell the formation process of the multi-period sites and their long-term and consistent occupation can probability cause restrictions in our understanding of the history of a landscape occupation. Another challenge in studying ceramics to establish chronological sequences of sites is the issue of transitional periods and the expertise of surveyors in associating remains to the correct cultural phases. For instance, if we record sites across a landscape with Parthian as well as late Sasanian and Islamic occupation evidence, there would be an obvious gap of the early Sasanian period in the occupation pattern. In explaining this condition, although we may recognize that the absence of evidence may, in fact, be related to the decline in or absence of occupation, but there is a possibility that the gap might have been caused due to our limited knowledge of the early Sasanian diagnostic material remains. Therefore, in similar cases, it is important to obtain sufficient knowledge of the cultural periods and their transitional phases.

One of the important decisions to be made prior to a survey is whether or not to collect all the visible surface materials. This decision will further impact the survey method, time spent on each identified site, post-survey material analysis and curation, as well as the site condition for future surveys. Collecting materials from the archaeological sites, either in
small or large quantities, create obligations for proper storage, curation, analysis, and finally
publication. In addition, the process of a full collection and further material analysis is a
highly time-consuming task that will most likely prevent the researcher from documenting a
larger survey area. Consequently, most of the modern surveys are focusing on strategies
such as a collection of diagnostic materials or collection based on sampling. For a collection
based on diagnostic materials, surveyors should have a good knowledge of the materials
from different occupational periods. What is regarded as diagnostic might vary in different
areas, but in the Near Eastern surveys, remains including rim, base, handle, or a decorated
piece that can be dated to a particular time period are recorded as diagnostic. In general,
sherds recovered from the surface of sites and during surveys are usually dated by
comparing them with sherds that are recovered from stratified excavations within or near the
study area. This comparative analysis also helps to improve chronological precision across
the study region and beyond. For a collection based on sampling strategy, depending on
research questions, goals, and methods, either a random or stratified sampling strategy can
be applied. While random sampling is more common, in stratified sampling, surveyors first
create grids on a single site and then each grid is surveyed and samples are picked up by a
random strategy (Banning 2002).

In landscape surveys, it is a common practice to interpret site types based on the
surface materials and their quantities. For instance, archeologists suggest that trace of low-
density materials on sites, and in particular on newly founded ones, indicate temporary
occupation by nomadic or mobile agropastoralists. In this respect, deciding about what
quantity of sherds would indicate low, modest or high density depends on comparative
studies with the same time period sherds recorded in the similar survey regions (Ristvet
2005; Wilkinson 2000b; Wossink 2009: 47). For instance, in Tell Leilan and during its Middle Bronze Age period, sites with a smaller number of sherds were proposed to be temporary occupations (Risvete 2005: 121-158). Overall, I agree with this common view of the surveyors in the Near East that recovering low-density materials from sites is one of the indicators suggesting a form of non-sedentary or non-permanent occupation. With all the discussions above and by studying the key issues in using ceramics for establishing relative chronological sequences of archeological sites, I will now discuss the Sasanian ceramic evidence from the study region.

During the field surveys, some natural and cultural elements impacted access to certain sites and visibility of surface materials. A dense cover of unharvested crop grains on and around a certain number of sites was the main natural element hindering the survey process and surface visibility. Due to the general topographical and geomorphological conditions of the study area, sedimentation, in particular in the lower alluvial plains was not a key issue, however, in surveying upland sites, erosion and colluvium were casing challenges for identifying surface remains. Among the human-induced factors, modern agricultural and pastoral activities, intensification in land use, and urban expansions have caused full or partial damage to archaeological mounds. In visiting each site, a full description of the natural and cultural elements surrounding the site was recorded in a survey record form. As the area has been rapidly changing by both human activities and environmental shifts, these records will benefit potential future fieldwork. The Iraqi side of the study area has recently opened to systematic archaeological studies and international teams, therefore, there were no previous survey material collections from the sites. However, limited surveys were conducted over recent years on the Iranian side of the study
area and access to the available survey reports and surface materials, as well as collections recovered from stratified excavations greatly benefited the process of studying materials and establishing site chronologies.

To understand the Sasanian occupation in the region, I studied ceramics based on their regional similarities with the materials collected by past surveys or excavations in the neighboring areas. These comparanda collections come from different projects in the Kermanshah Province, northern Khuzistan, and northern and southern Mesopotamia (for example Alibaigi et al. 2012; Azarnoush 1981; Keall and Keall 1981; Kleiss 1970; Mohammadifar and Tahmasebi 2014; Young 1965). Besides the published collections, unpublished materials at the National Museum of Iran (for instance, Mahidasht surveys by Levine 1974), and from the expedition “Flights Over Ancient Cities of Iran”, stored at the Oriental Institute of the University of Chicago (Schmidt 1940) were studied. Many of the sites across the lower plains of the study area are multi-period mounds and contain remains of millennia of occupation spanning from Neolithic to the recent historical times. As discussed earlier in this section, surveyors often face challenges in identifying remains of earlier occupation phases as they are often obscured by the remains of later periods. Consequently, many projects decide to conduct a full or test excavation to recover material remains and establish long-term occupation chronologies. In this dissertation, I am primarily focusing on the late antique remains, therefore I did not encounter challenges in identifying those surface remains. Generally, if Sasanian ceramic remains are not found on an archaeological site in the region, it would indicate lack of occupation. Also, the number of recovered sherds would suggest the settlement type. In other words, the presence of a smaller number of Sasanian sherds in the area suggests a small-scale or temporary and
seasonal occupation of the site that could be in the form of fully nomadic or semi-nomadic agropastoralism. In addition, as I will discuss below, past surveys and excavations in the broader region of northern and southern Mesopotamia, as well as western Iran have made significant improvements in establishing late antique chronological precision and distinguishing its different phases of occupation. For instance, stamped sherds are one of the most significant indicators of the late Sasanian (5th-7th centuries A.D.) occupation in the region (Simpson 1997, 2013). It is also important to note that my analysis was based on the view that cultural horizons do not necessarily or immediately change with the dynastic succession or political shifts (Whitcomb 1999), therefore in this dissertation, I do not typologically distinguish an Early Islamic ceramic typology.

During the field surveys, when each site was visited, all the sherds were picketed up for primary analysis, but only diagnostic sherds were collected. While non-diagnostic remains were left on sites, sherd density, site condition, and surface visibility were recorded in the survey record forms. Collections were made without using survey grids on sites, but for more efficiency, in particular in the case of larger settlements, each site was divided into different zones and each team member covered a zone and collected diagnostic remains. In addition to the sites, their immediate surroundings were also visited to record any possible material remains. Among multiple periods of occupation, Sasanian ceramics were well-represented, and the classification was made based on the materials, surface finish, form, and size.

All the diagnostic ceramics were studied and 43 sherds which are qualitative representations of the Sasanian occupation in the region are drawn (Figures 5.11-5.21). The ceramics are all utility ware, wheel-made and most are well-baked. Vessel sizes range from
medium to large (~14-38 cm), with medium to coarse thickness (rim thickness: ~1.5-7 cm), and tempered with a small to medium amount of grits. Sherds fabric color include buff, orange, and light brown. Some orange wares include medium to coarse white grits and have a burnt core. Most sherds are plain, but the small number of decorated pieces include stamped pieces, sherds with raised bands, impressed, grooved, and a small amount of turquoise glazed sherds. Rims of jars and plates are more common than other forms. Rims, which mostly are from large storage or utility wares, have medium to the coarse thickness and their forms include double rims (Figure 5.11), round rims (Figure 5.12), ribbed (Figure 5.13), grooved (Figure 5.14), corrugated (Figure 5.15), flat rims (Figure 5.16).

Bases are either flat or pointed (Figure 5.17). The most distinctive groups of bases are Torpedo ones which are part of Torpedo-based jars, collected from multiple sites across the study area and beyond (Figure 5.18). These bitumen-coated bases are characterized by a large cylindrical body and with a buff and sand-tempered fabric. These are parts of the large storage or transportation jars that have been widely recognized across the broader region from the late Parthian (0-224 A.D.) to the Early Islamic periods, however, these have most frequently appeared in the late Sasanian period (Seely et al. 2006). Therefore, the presence of these bases in the study area suggests the late Sasanian occupation.

Diagnostic handles are illustrated in Figure 5.19. Decorated pieces include impressed, grooved, and roped and shallow combed decorations (Figure 5.20). Stamped sherds, as one of the best indicators of the late Sasanian period in the region, are recovered from different sites across the survey region (Figure 5.21). These are pieces from large jars or other vessels, with a fabric color ranging from buff to light brown and medium to coarse sand grit inclusion. Stamps are rounded and usually with motifs encircled by a line of
pearls. Motifs of these stamped sherds consist of rams, stags, goats, horses, birds, as well as geometric designs, crosses, and plants. As Simpson suggests (2013: 109), these motifs can indicate a mix of Christian and Zoroastrian patterns. These distinctive stamped sherds have been found in sites in both north and south of the study area. From northern Mesopotamia, sherds were recorded from multiple sites including Eski Mosul area (Simpson and Watkins 1995), and Ninevah (Campbell Thompson and Mallowan 1933), and in southern Mesopotamia, they were recovered from many sites including Hamrin basin (Jacob-Rost, Wartka, and Wesarg 1983), and southern plains of Diyala (Adams 1965).

These ceramic analyses are used to date the Sasanian sites across the study area and help to examine the patterns of settlements and land use during the time. The overall analysis of all diagnostic ceramics shows similarities and connections between the study area with the broader Zagros Mountains region in western Iran, northern Mesopotamian, and southern Mesopotamia. Sites contained modest-sized ceramic density, with obvious evidence of late Sasanian occupation, as well as evidence of single-period sites with only Sasanian remains. Although upland terraces and structures contained lower-density materials, they provided compelling evidence in support of the Sasanian occupation. They illustrate an expansion in the Sasanian occupation. Overall, the modest-sized settlements with a modest density of material remains can be related to temporary settlements of agropastoralists or temporary sedentarization of mobile populations.

5.3. Summary

In this chapter, I explained the methods applied to document the ancient landscape through the application of remote sensing techniques and archaeological landscape survey.
The chapter started with a description of satellite remote sensing techniques and their applications in archaeological studies. Investigations of the study area heavily relied on remote sensing, in particular on historical and modern satellite imagery, to identify various ancient features across different microenvironmental zones. This chapter explained why certain satellite sensors were used, how satellite images were processed, and presented the results of remote sensing-based surveys. The high spatial resolution of images and their temporal resolution that covered the landscape through different seasons and years were the most important factors aiding the identification of features. In addition, geospatial analysis based on multispectral imagery—discussed in Chapter 5—was another significant utilization of these images. Results showed how remote sensing greatly advanced the process of identifying landscape elements and created an inventory of 300 potential archaeological sites and off-site features that was further used as a base for fieldwork. Mounded settlements, artificial irrigation systems, and remains of agricultural activities were the most notable features identified by remote sensing techniques. Settlements appeared as contrasting spots from their surrounding lands, irrigation canals appeared as depressed and dark linear features, and the qanat network was discerned by the regular interval of its shafts and deposited soil around them. After an extensive application of remote sensing techniques and creation of an inventory of potential features, field surveys were conducted in order to ground-check sites, collect surface materials, and establish chronological sequences.

Different methods of archaeological landscape survey and the merits and limitations of both intensive and extensive survey strategies were discussed. How to record and measure a site, how to collect and analyze surface material remains, factors impacting the visibility of sites and surface remains, as well as issues about surveying diverse
environments were explained. I argued that across this environmentally transitional landscape with a dynamic ecosystem, alluvial plains were the focus of more intensive surveys; however, a survey of other zones, including foothills, as well as analysis of satellite imagery, strongly enhanced understanding of the past settlement system and land use patterns. The presented results of field surveys are the first systematic archaeological documentation of the landscape on both sides of the international border. While an extensive survey strategy resulted in the documentation of both lower alluvial plains and foothills and helped to obtain knowledge on different microenvironmental zones, intensive surveys were exclusively focused on the lower plains with evidence of dense mounded settlements. Overall, 150 sites were ground-checked and diagnostic surface materials, including ceramic rims, bases, handles, and decorated body pieces were collected to establish chronological sequences of the sites. In the lower plains, sites with Sasanian evidence are the largest in number, modest to small in size, and contain a modest amount of surface materials. Apart from a few special-purpose sites, smaller settlements contained few brick remains and stone foundations. In addition, comparative studies suggested a late Sasanian construction date for identical monuments of Emarat-e Khosrow and Tepe Gawr. In the upper plains and foothills, remains of agricultural terraces and stone-built structures indicated expansion of cultivation, small farmsteads, and probably seasonal dwellings of agropastoralists.
Figure 5.1. Potential and surveyed sites mapped by CORONA 1107-8464563DF534, 27 May 1972.
Figure 5.2. Map showing the main unsurveyed zone located between the left bank of the Sirwan River and Iran-Iraq border.
Figure 5.3. Arrows show a Sasanian irrigation canal mapped by CORONA 1103-1041DF027, May 1968. Parts of the canal is still remained on the modern landscape.
Figure 5.4. Remains of siphons on the Sirwan irrigation canal. Photographs by the author.
Figure 5.5. Part of the Sirwan irrigation canal that turns into a qanat system, mapped by CORONA 1103-1041DF027, May 1968.
Figure 5.6. Cultivation Fields and stone-built structures at the foothills of the Zagros Mountains. 
a) general view of the remains. b) remnants with square and circular structures c) photo from 
Figure 5.7. The qanat system on the modern landscape (top) on DigitalGlobe © 2015, and qanat shafts recorded during the field visit (bottom) taken by author.
Figure 5.8. Example of an archaeological site, remains of a village abandoned over recent decades, and modern constructions and inhabitation on top. Satellite Image: DigitalGlobe © 2015.
Figure 5.9. Map showing Qasr-e Shirin complex structures, including Emarat-e Khosrow, Chahar Qapi, and Ban Qale, in addition to a later Islamic caravanserai. Satellite Image: DigitalGlobe © 2015
Figure 5.10. Tepe Gawr in Hawsh Kori area. Its surrounding encircled features are surveyed sites that contain Sasanian material remains. Satellite Image: DigitalGlobe © 2015.
Figure 5.11. a-f: Double-rims of Sasanian jars, a: includes corrugation, e and f: include raised bands. All pieces have buff fabric color.
Figure 5.12. a-f: Round rims of the Sasanian jars, b: includes raised bands, c: includes a groove, f: includes raised bands. All pieces have buff fabric color.
Figure 5.13. a-c: Rims with ribbed decoration, a: is also a flat rim, and c: is a round rim. All pieces have buff fabric color.
Figure 5.14. a-b: Grooved rim of jars. Fabric color: buff.

Figure 5.15. Corrugated rim. Fabric color: buff.
Figure 5.16. a-f: Flat-rimmed jars, c: includes raised bands decoration, all pieces have buff fabric color.
Figure 5.17. a-d: Bases of jars and plates, including flat base (a), and pointed bases (b-d). All pieces have buff fabric color.
Figure 5.18. Base of a bitumen-coated Torpedo jar with a buff fabric color.

Figure 5.19. a-d: Diagnostic handles of the Sasanian jars, c: orange fabri color with a burnt surface.
Figure 5.20. a-c: Decorated body pieces, a: is decorated with added pieces, b is impressed, and c has incised lines.
Figure 5.21. Sasanian stamped sherds. These are body pieces with buff fabric color. Motifs include encircled animals and plants.
Chapter Six: Conclusions

6.1. Discussion of the Results

This study investigated human interactions with the environment during the Sasanian period across a landscape in eastern Iraq and western Iran. The study area is comprised of a patchwork of microenvironmental zones that each presented a different condition for settlement and land use. This research attempted to move beyond the dichotomy in the discussions of the human-environmental interactions that question whether humans transformed the environmental characteristics and caused degradations, or the environment played a key role in fundamental sociopolitical changes such as historical collapses.

The central topic addressed in this dissertation is about understanding the population’s diverse responses or coping mechanisms to environmental diversity and variability. I emphasized two main categories of adaptation through mobility and transformation through agricultural intensification. Among the previous explanations of the Sasanian land use strategies, intensification has been introduced as the primary and often exclusive cultural response to environmental variability. It has been closely linked to the rise and development of the state, as well as its main production system that was associated with the expansion and sometimes, collapse of this territorial empire. This dominant narrative has revolved around the theoretical perspectives and methodological approaches which emphasized intensification in agricultural practices, production growth, unprecedented increase in sedentary settlement, and territorial expansion of the empire. Moreover, landscape transformations and built elements have been associated with the presence and management of a politically centralized system.
This perspective could not represent a complete picture of the past landscapes across different parts of the empire. In particular, studies have mostly neglected areas beyond the core political and economic zones of the empire where land use, production, and social systems could take on a variety of forms.

In this regard, mobility is one of the most important forms that has been either entirely neglected from past research or has been incorporated into the discussions through limited historical records. Mobility is an adaptive strategy that relies on the spatial and temporal variability in natural resources. Communities move between locations when variability in environmental zones makes land and water resources seasonally available.

Intensification has long been at the center of most of the discussions about agricultural change, landscape transformation, and sociopolitical change across different regions in the world. In this study, intensification was regarded as just one of several strategies in coping with environmental variability and uncertainty across the landscape during the Sasanian period. Some of the most important data that indicated intensification included expansion of irrigation systems, land use and agricultural expansion in the uplands through terrace constructions, and increase in settlement density compared to its preceding Parthian and succeeding Islamic periods. As these are some of the most archaeologically visible features, they are considered as the best resources for understanding agricultural intensification. Irrigation canals and qanats were constructed to irrigate some of the most arid parts of the area, to better use the once plentiful groundwater sources, and to create reliable water sources. These capital investments expanded the area under cultivation and created a more permanent occupation. Generally, these investments that left lasting imprints on the landscape were aimed at removing constraints such as aridity and water deficiency,
minimizing risks of product failure that could be caused by climatic condition, and subsequently increase yields. Main incentives for this intensification scheme are recognized as increasing land productivity and mitigating environmental variability, in particular, precipitation fluctuations. Additionally, this intensification probably had sociopolitical reasons such as expanding control over larger territories and developing the economic situation and increasing revenue.

In the discussions of the correlation between intensification and sociopolitical organization, both centralized and decentralized models and their limitations were explored. I argued that while evidence of top-down management across the landscape is observed, both models suffer from limitations in addressing the complexities of the study area. In specific, while the political centralization model views built elements in relation to the presence of a centralized political authority, it is inadequate for addressing local diversities in management strategies and human-environmental interactions. It mostly neglects the decision-making power of local communities, as well as the role of non-sedentary and non-agriculturalist populations. Furthermore, I argued that the centralized perspective has not explained different social classes and their land use decisions. During the Sasanian period, *Dehghan* was a class of landowners who were particularly empowered during the second part of the dynasty and were in charge of land management plans, tax collections, and agricultural activities, mostly beyond the core zones in rural districts of the empire. In spite of these criticisms, the top-down model has remained the most established narrative of land use expansion across the Sasanian Empire, as well as in many other similar entities in the world.
On the other hand, decentralized approach views changes in land use and transformations as internally organized by the role and autonomy of local communities. The main critique of this approach points to its inadequacy in addressing the intentions of agricultural intensification and land use expansion and stresses that this approach downplays motivations for construction of labor-intensive and expensive capital investments.

Based on the definition of each model, the presence of a centralized authority or top-down management in the region is observed through an increase in site density, efficiency of land management through construction of water management systems and an increase in landesque capital inputs such as agricultural terraces and fields. An increase in the number of sites and evidence of constructions such as Qasr-e Shirin complex and Tepe Gawr suggest the presence of a form of authority that attempted to expand land use and production across the study area.

In addition, I argue that in addition to economic and sociopolitical reasons, intensification occurred in response to the environmental conditions. Results of land use and environmental reconstructions illustrated that the area is located between the southern plains with an arid climate and uplands with a Mediterranean climate. This caused a dynamic and often fluctuating environment that impacted land use decisions and selection of buffering mechanisms such as intensification. Strategies in coping with different microenvironments are varied, and this challenged me to think beyond the intensification and its different models and evaluate another potential strategy that could be practiced across the area.

Mobility, as an adaptive strategy that benefits from the spatial and temporal variations in the availability of the resources, has been one of the primary settlement and
land use practices across the study area. Mobility could be practiced in different forms, from groups with high mobility, to the ones practicing semi-nomadic or semi-sedentary lifeways. Based on the different patterns of mobility, motivations, settlement systems, and subsistence strategies, I used the term agropastoralism that involves three major factors of agriculture, pastoralism, and mobility.

This dissertation criticized the perspective that makes the distinction between sedentary and non-sedentary lifeways and between the agriculture and pastoralism in land use and subsistence strategies. In particular, the assumption that mobile groups were located outside of lowland agricultural plains or were forced to more marginal and isolated areas away from the sedentary populations are criticized.

After examination of data collected from field surveys, remote sensing analyses including reconstruction of the past environment and land use, as well as careful consideration of ethnographic resources from the region, I proposed a closely integrated settlement and land use system that was based on mixed evidence of mobile agropastoralists and sedentary agriculturalists. Both intensification and mobility are discussed as coping strategies to buffer against environmental variability and uncertainty in different ways. Intensification was intended to alleviate risk in production failure by bringing stability and increase in production, and mobility was practiced as an adaptive strategy to take advantage of microenvironmental diversity and seasonal variations in resources.

The study area is located between the alluvial plains of the southern Mesopotamia and Khuzistan and highlands of the Zagros Mountains. In the southern plains, aridity and an average annual rainfall of less than 200 mm makes irrigation a requirement for production; however, in the highlands, rainfed cultivation was a more stable and reliable practice.
Therefore, the area is located at the edge of two diverse ecological categories and along a zone of uncertainty. This zone is comprised of a complex agroecological system that could cause both risk or uncertainty, and opportunity in land use. In this study, the notion of risk and uncertainty are defined based on the impacts of environmental variability and uncertainty on land use patterns and production failure. Risk is defined as a variation in the outcome of a behavior that is usually unpredictable. Therefore, the risk is referred to as a condition when there is a chance of product loss, in particular in mixed practices such as agropastoralism. The main difference between the two terms of risk and uncertainty is that certain knowledge of the land use and the environmental characteristics can help to overcome the condition of uncertainty.

Data presented in this study illustrated the highly variable and fluctuating climatic condition of the area, in particular, precipitation. Consequently, intensification and mobility were the most important mechanisms to cope with this variable condition. Expansion of irrigation helped the population to alleviate risks and increase crop production. Moreover, moving between the ecological zones was aimed at taking advantage of the spatially and seasonally available resources without a need to construct capital investments to change the landscape conditions. The environmentally transitional nature of the study area made it suitable for combined settlement patterns of sedentary and semi-sedentary, as well as a land use system consisting of agriculture and pastoralism. The integrated practice of intensification and mobility points to the fact that the area was a zone of connection between different populations with their own settlement and land use organization.

Past research almost exclusively collected and interpreted data based on the practices of sedentary agriculturalists and the role that intensification played in both environmental
and socio-political aspects of the society. In this study, I explained the reasons for this limited perspective. Earlier archaeological studies primarily focused on the excavation of large-scale sites, or surveys of monumental features, urban areas, as well as their immediate hinterlands. In particular, extensive artificial irrigation systems in arid zones, evidence of apogee of settlement, and intensified agricultural production have been at the center of the past discussions. Even when areas beyond the political or economic core zones were surveyed, settlements and other landscape features were primarily interpreted based on a sedentary lifeway perception. Some peripheral or marginal areas have been exclusively viewed as suppliers of food or labor for centers, while variability in local cultural and environmental elements was mostly neglected. More importantly, studies had a dichotomized perspective in understanding different practices. They assumed a distinction between sedentary agriculturists and mobile agropastoralists in theoretical and methodological models.

Remains of dense settlements in alluvial plains were believed to be exclusive evidence of sedentary lifeway, while populations practicing some form of mobility were believed to have settled outside of these agriculturally productive lowland zones. Some studies also have emphasized challenges in detecting the remains of mobility in landscape surveys and have only pointed to the invisibility of features, their small scale, or ephemeral campsites. Intensive surveys in the most agriculturally productive zones resulted in missing the smaller-scale features or understanding of other microenvironments such as steppes, plateaus, and hilly landscapes. As a result, non-sedentary populations, their broader role in subsistence and sociopolitical aspects, as well as their close interactions with sedentary populations have not been fully understood. This study focused on the local
landscape formation and its environmental characteristics and realized that populations have been practicing both intensification and mobility in an integrated way.

In this concluding chapter, the integrated results of the archaeological field surveys, remote sensing analyses, ethnoarchaeological records, and environmental data are presented. Methodologically, this study was an interdisciplinary effort with different datasets that were applied to better realize the anthropogenic and natural characteristics of the study area and to reconstruct the past environmental and land use conditions.

Different types of satellite imagery were applied for multiple purposes. Historical and modern very high-resolution imagery was applied to document the landscape, including settlements and off-site features. Overlying images from different times and sensor capabilities were useful to better distinguish features and recognize landscape changes over time. Moreover, multispectral satellite images were used to model the environmental characteristics and land use types across the study area. Historical CORONA and modern WordView-2 sensors were particularly beneficial as they identified numerous features previously undocumented and created an inventory as a base for the field surveys. Historical imagery has proven useful, in particular in the identification of mounded settlements in the alluvial plains. Because of their shadows and anthropogenic soils, mounded sites of the alluvial lowlands are discernable on CORONA that captured the landscape prior to its modern transformations. This imagery dataset was also beneficial in identifying depressed and linear traces of artificial irrigation systems.

Application of modern satellite sensors with a spatial resolution of 1 meter or finer and a high temporal resolution that includes daily or weekly updates to identify other features which could not be identified by historical imagery. In particular, evidence of
agricultural terraces and stone-built structures in the foothills zone of the northern parts of the study area presented much better visibility on modern imagery. Further, a field visit and surface ceramic collection dated these remains to the Sasanian period and showed the first-time extensive modification of this upland zone for expansion of production.

Field surveys resulted in cross-checking of the potential features and collection of diagnostic surface materials. Fieldwork was conducted where very little systematic research had previously been carried out. The zone of alluvial lowlands which has been under irrigated agriculture in modern time was surveyed by an intensive strategy. In this strategy, more time and effort was spent to map features within one particular zone. In addition, the zone of the foothills was also surveyed which made the survey strategy of this dissertation a combinatory intensive and extensive. The extensive strategy was conducted in order to visit a different microenvironment of the study area and test the possibility of different settlement and land use patterns. In particular, because previous survey records of the study area were either very limited or non-existent, this extensive strategy significantly helped to document and obtain a general understanding of the study area and provided a near complete database of the archaeological features across the area. Further, this inventory of data also helped the analysis to reconstruct the land use and subsistence strategies.

Surface ceramics were the primary means of dating sites. Collection of diagnostic surface materials from the sites helped to establish relative chronologies and distinguish the ones occupied during the Sasanian period. Among all the recorded sites, the results of the analysis showed that Sasanian occupation was predominant. One of the most important goals of these field surveys was to move further than what previous Sasanian studies have obtained by investigating smaller sites, different microenvironmental zones, non-nucleated
settlements and consequently evidence of non-sedentary populations. Future more intensive surveys should consider this fact in mind and look for evidence of occupation of the region by recent historical and ancient nomadic groups in different environmental zones. More importantly, surveys in steppes, plateaus, and lands immediately beyond the agricultural zone are required. In this process, high-resolution modern satellite imagery can be particularly beneficial to investigate larger areas of land and identify features related to agropastoralism and nomadism in the region.

Many of these lowland sites were typical Near Eastern multiperiod mounded settlements; however, there are a number of low-lying and single-period Sasanian sites. Settlements were measured by remote sensing and during the fieldwork. These measurements indicate small to modest-sized sites, with an average area of less than 1 hectare. Also, sites contain a modest amount of surface materials and most of them are large storage vessels. This suggests a form of temporary occupation, in particular in the case of the newly-founded settlements. Upland sites were constructed as part of the Sasanian broader economic intensification scheme in the peripheral and marginal zones. Besides evidence of agricultural expansion, evidence showed that recent historical nomadic groups also used this uplands zone and its ancient constructions. Particularly, nearby these agricultural traces and their associated rectangular stone-built structures, that indicate attempts to cultivate more lands, smaller circular structures and remains of modern materials such as porcelain pieces indicate the occupation by recent historical nomadic groups. These circular structures could be tent foundations, corrals, or fixed summer settlements of mobile groups. In this regard, ethnographic records played an important role in understanding the landscape organization. Studying ethnographic sources showed that
nomadic groups had a tendency to occupy lands nearby the ancient structures, particularly irrigation systems and agricultural fields or terraces to benefit from these landscape investments.

Collecting surface materials was challenged by visibility of materials in both lowland and upland sites. Generally, visibility of these remains can be impacted by natural or human-induced elements. In particular, among the upland terraces and structures, the colluvium deposits, vegetation cover, erosion and movement over time were the common natural elements impacting the surface visibility. In the lowlands, the expansion of urban and agricultural activities were the main reasons for leveling some sites, and surface visibility was impacted by unharvested crops and vegetation cover.

For the purpose of this dissertation, I only analyzed the diagnostic material remains. Recovering low-density materials from newly founded and single-period sites indicated some form of non-sedentary or non-permanent and seasonal occupation. Studying the diagnostic materials was possible by using regional similarities from the material reports of the neighbouring areas. Among the diagnostic materials, some of the forms, including stamped sherds and bitumen-coated torpedo jars indicated the later or the second phase of the Sasanian occupation expansion. The final results of the ceramic analysis indicate the similarities between these materials with the ones identified in the broader Zagros region of western Iran, northern Mesopotamia, as well as southern Mesopotamia. This fact indicates that besides the environmentally transitional nature of the area, it was also culturally transitional. In this regard, we should also consider the important role of the major trade route passing the study area and connecting multiple centers.
Reconstructing the past environmental condition and land use patterns was an important part of the analysis made possible by the application of multispectral satellite imagery, geospatial analysis, combined with studying ethnographic records. Specifically, while historical or ancient texts discussing the land use patterns or social organization of the study area are very limited. This process revealed the spatial relationship between the archaeological features and environmental conditions. Landsat-based multispectral vegetation analysis was applied to assess different types of land cover including non-vegetated, densely vegetated, as well as areas with moderate or low vegetation cover. The Landsat sensor was particularly selected for this analysis as it provides results with higher temporal resolution. In addition, the timing of the image was also important in the results. Landsat has been operated since the 1970s, therefore, it provided data predating most of the land modernization across the area, including development in the water supply systems, construction of several irrigation canals, and expansion of the urban areas. It also predates one of the most dramatic changes in the region that is a decrease in the groundwater table due to climatic changes and reduction in precipitation, excessive well pumping, and mechanized agricultural intensification. Therefore, Landsat provided a historical time-series, with a high spatial resolution capturing the area predating most of its modern transformations.

Results of analyzing average NDVI values over the period of 1985-2005 presented variations in the greenery pattern. In particular, monitoring changes in values over seasons and years showed that contrary to the current condition with irrigation expansion in summers, the area was predominantly under rainfed practice, except in smaller patches along the floodplains that could support irrigation of dense orchards. Moreover, areas
immediately beyond the cultivated fields were suitable as pasturelands. High inter-annual variability in the rainfall records during the same years between 1985-2005 shows significant differences between the present and past conditions. The predominant land use practice included limited cultivation, mostly based on raised practice and pastoralism benefiting the seasonal variability of the land. Backed by the ethnographic records, these practices were integral parts of the land use system in the area.

Modeling terrain and its main drainage system presented associations between archaeological features and environmental characteristics. The hydrological analysis showed the karstic nature of the landscape and distribution of natural water resources in the form of river streams and spring-fed streams. This analysis also revealed some of the most arid zones of the area where cultivation required the construction of artificial irrigation systems. This modeling also clarified settlement choices and movement patterns. The results delineated the landscape with the large and active surface as well as groundwater stream networks. Combined evidence from the hydrological model, field survey results, and ethnoarchaeological records showed significant changes to the water resource availability. Both climatic and human-induced factors have caused noticeable changes in the area. The study region, especially up to the onset of drought in the region in 2005, contained plentiful springs and higher groundwater table.

Ethnographic records revealed valuable data regarding past land use patterns and population movement. As one of their most important contributions, these records helped to correct the assumption that made a distinction between landscape occupation of sedentary and non-sedentary populations. While different types of mobility and interactions between mobile and sedentary populations have been recorded across the Near Eastern landscapes
and beyond, the area presented an integrated land and resource use by both sedentary and non-sedentary groups. In this study, instead of using this dataset for understanding cycles of movement, the internal organization of the communities, or the kinship patterns, I emphasized the importance of realizing local landscape organization, their land use decisions, how they interacted with environmental characteristics of the area and its variabilities, the place and role of mobile communities within the broader landscape, and their interactions with other groups sharing the same landscape. Results show that while the majority of the population in the study area are now sedentary, this region has always been home to a large number of agropastoral and nomadic groups traversing between the lowlands in the alluvial plains and highlands of the Zagros Mountains. Sources also indicate the cycles of mobility and sedentarization in the region and throughout its history. For instance, while at times in the past, movement and autonomy of nomads were not tolerated by central states and they were forced to sedentarize, they returned to nomadism and their original lifeway as soon as political systems changed. While there is still a population in the study region, in particular in the Iranian side, that practice mobility, recent climatic changes, political tensions, nationalization of pasturelands and changes in the modern lifeways such as reliance on technology have interrupted this lifeway and forced many to sedentarize.

Economic intensification scheme of the government helped the agricultural intensification in the region during the Sasanian, however, mobility was still persistent and populations practiced it through agropastoralism. They continued their vertical migration, were in charge of the trade route exchange system in the area and maintained their close economic and social interactions with the other groups. Considering the political and social pressures since the 20th century, I emphasize that these populations had fewer restrictions in
their movement and their access to resources in premodern times. Results show the area consisted of both sedentary and non-sedentary components and suggest moving beyond the dichotomized models to better understand the complexities of the landscapes.

6.2. Future Prospects and Broader Impacts of the Research

This dissertation addressed some of the most important issues in archaeological and anthropological methods and theoretical perspectives that have restricted identification and further research on complexities of settlements and land use practices, as well as different landscape elements connected to both practices of intensification and mobility. Through a critical lens, this research pointed to the importance of surveying diverse microenvironments, in particular in studying historical periods, as well as application of new methods, including remote sensing and geospatial analyses, to better reconstruct the past environmental and land use conditions. It attempted to challenge the way we perceive the past landscapes in terms of different modes of land use and shared landscape. More intensive surveys are needed to record steppes and plateaus on both sides of the border, as well as the foothills of the Zagros Mountains. Other than the Sasaanin elements of the landscape, I suggest more research on its preceding and succeeding periods in order to investigate how the patterns of agricultural intensification and mobile agropastoralism have possibly changed through time.

The data analyzed and presented in this research are part of the first steps toward more research in the future. In addition, this research can contribute to a better understanding of one of the challenges in archaeology, the history of human-environment interactions. These discussions can benefit the longer-term views of change and this knowledge can provide insights into the issues that we face today.
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