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The Riverine Landscape of Formative and Archaic Susiana (SW Iran); A Suggestion Based on Recent Geoarchaeological Evidence

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Abstract

The settlement evolution of the Early Neolithic period is considered a milestone in the human cultural history. While the archaeological implications of this period are discussed extensively, the landscape of Early Neolithic Iran has remained underrepresented, mostly due to lack of geoarchaeological investigations. The early periods Formative and Archaic Susiana, attested in several sites in the Susiana plain in southwestern Iran, are of utmost importance as they bear witness to the first implications of standardization of material culture and intra-regional organization. This paper summarizes our current understanding of these periods as well as their landscape in the seventh and sixth millennia BCE. Then, it proposes a preliminary reconstruction of the landscape in this period based on recent geoarchaeological investigations by the author, applying a combination of different methods such as remote sensing, GIS analysis, and original geoarchaeological data including sediment cores, soil profiles, as well as laboratory analyses including sedimentological and chemical analyses (and lithological description in the field) and OSL dating. The results widen our perspective regarding the region's hydrology. The Early Neolithic landscape of Susiana seems to have been different from the current one, primarily due to the tangible changes in watercourses and the noticeable differences in the surface soil and vegetation. The results further confirm that heavy sedimentation of later periods covers most of the surface of this buried landscape including now buried watercourses and small wetlands.

Keywords: Iran, Susiana, Neolithic, Geoarchaeology, Riverine landscape, Early Holocene.

Article Type: Research Article

Introduction

In the semi-arid ancient Near East, the available water sources have continuously shaped the prehistoric settlement patterns at least since the Early Neolithic period (Darabi 2012; Wilkinson 2003; 2012). The human-environment interaction in the riverine landscape of southwestern Iran shall be studied by means of geoarchaeological investigation.

The Neolithic period seems heterogenous in its patterns of settlement and land-use between the Iranian highlands and the southwestern lowlands of Susiana (Hole 2004; Alizadeh 2008; Darabi 2012; Matthews and Fazeli Nashli 2013; Alizadeh 2021). Examples of Neolithic water management in highland Iran have been discussed elsewhere (Manuel *et al*. 2018), but Susiana has not been studied respectively. This paper aims to fill this gap by focusing on the Early Neolithic Susiana.

The Susiana plain is one of the archaeologically most investigated regions in Iran (Adams 1962; Johnson 1973; Hole 1987; Wilkinson 2003), having been surveyed repeatedly since the nineteenth century (Moghaddam, 2012: 519). This region has played a significant role in our current knowledge regarding the emergence of prehistoric societies. It is considered a central area of cultural evolution due to its favourable geographical setting and abundant resources (Hole, 2011: 6). The riverine landscape of Susiana (Figure 1) corresponds with the environs of ancient Susa (modern Shush) to the

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north of Khuzestan Province, southwestern Iran (Ehlers 1975; Fisher 1968). It consists of extensive sedimentary basins of Holocene age shaped by major watercourses with traces of abrupt shifts and avulsions (Veenenbos 1958; Wilkinson, 2012: 4-8).

Although the material culture of this region has been studied for nearly two centuries, its palaeo-landscape is poorly understood and remains a matter of much debate, especially regarding its fluvial regime and the Persian Gulf's head (Lees and Falcon 1952; Kirkby 1977; Kouchoukos 1998; Lambeck 1996; Gasche 2005; Heyvaert and Baeteman 2007; Heyvaert *et al*. 2010; Wilkinson 2012). While the Late Holocene landscape evolution of the region has been studied in the recent past (Alizadeh *et al*. 2004; Gasche 2005; Heyvaert and Baeteman 2007; Heyvaert *et al*. 2010), the Early and Mid-Holocene were left out. Furthermore, the Early Neolithic phases of Susiana have never been studied in the context of their probable riverine landscape due to lack of geodata and negligence of the early surveys for attending to this matter[1] . The Susiana plain, along with the neighbouring Deh Luran, has been relevant for comprehending the Neolithic evolution of Iranian highlands in a series of archaeological investigations (Hole 1987; Bernbeck 1992; Alizadeh 2003; Wilkinson 2003; Darabi 2004; Alizadeh 2008; Darabi 2011; Darabi 2012; Matthews & Fazeli Nashli 2013). Furthermore, its patterns of cultural evolution differ from its prominent neighbouring region, Greater Fras, in southern Iran (see Alizadeh 2021 for a review of Neolithic Fars and its difference to the Susiana lowlands). Therefore, its landscape evolution shall be studied in detail to complement the rich archaeological data.

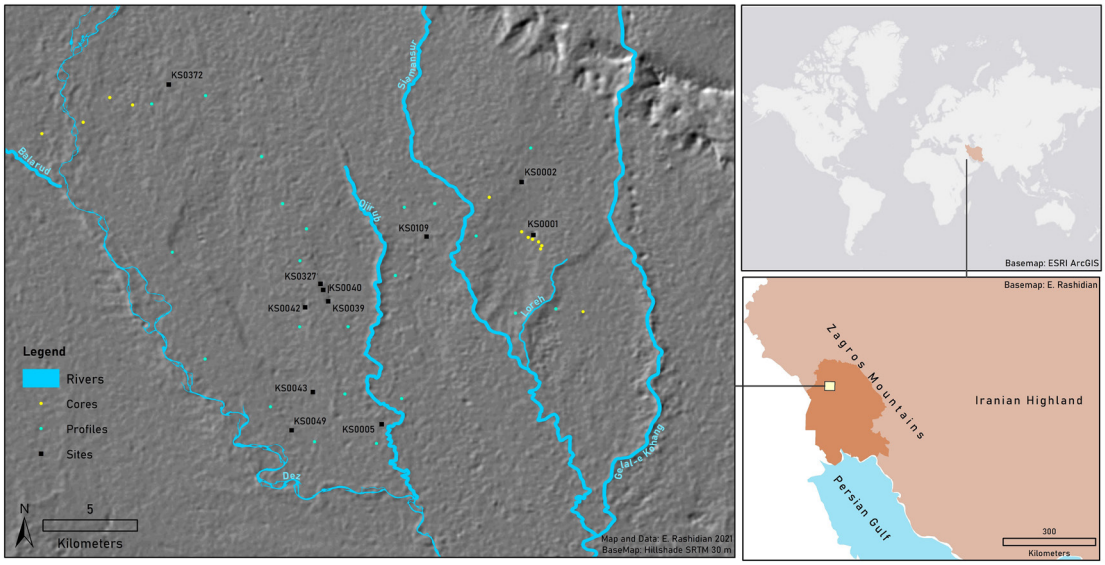


Figure. 1: *Map of Susiana in southwestern Asia and the known Early Neolithic sites (illustrated by the author)*

The Formative and Archaic Susiana periods correlate with Jarmo and Hassuna in north and Early Ubaid (so-called Ubaid 0) phase in south Mesopotamia (see Wilkinson and Rayne 2010: 118-119 for examples of water-settlement relations in the Neolithic Mesopotamia; Table 1 and Figure 2 for chronology of the sites). A certain continued cultural interaction and exchange can be assumed between them (Akkermans 2020), regardless of the nature of this interaction. During this period, Mesopotamia witnessed an evolution from the first known sedentary occupations with rain-fed agriculture to a more regional settlement pattern with pastoral societies (Akkermans, 2020: 29). Earlier assumptions regarding the causality between a large-scale sedentary lifestyle and the establishment of agriculture as the primary food production source have recently been corrected (see for example Flohr *et al*. 2016). Rather intensive exploitation of wild resources has been attested in the entire Ancient Near East (Akkermans, 2020: 41-42), which raises the question of (unintentional) landscape change and human impact on the initial landscape.

[1]Fortunately, a few excavators have integrated archaeobotanical and zooarchaeological studies in their fieldwork of primary sites, which yield invaluable information on the palaeo-landscape of Susiana in these phases for future use. Excavations of Chogha Mish and Chogha Bonut are great examples.

This question highlights the utmost importance of landscape studies in comprehending Neolithic societies. This is the case for both Mesopotamia and Susiana. The correlation among different aspects of land-use such as animal husbandry and irrigated agriculture, including ploughing and shifting parcels, can trigger a landscape change and lead to a series of adaptions to the current landscape. Some examples are given in this paper while emphasizing the sporadic nature of the evidence, which only allows indirect indications at this point.

This paper aims to present our understanding of the early settlement patterns of Susiana in the seventh and sixth millennia BCE and further to suggest a view of its riverine landscape at that time [1]. The author considers the archaeological data in the context of its palaeo-landscape to comprehend the cultural dynamics of Early Neolithic Iran, especially focusing on the water element. The presented landscape reconstruction – albeit a preliminary one – will complement our archaeological evidence of the Early Neolithic in southwestern Iran and act as a framework for further studies. The reconstruction itself must be handled as a first window into this timespan with hopes of more extensive interdisciplinary studies to follow.

Methods and Materials

Our understanding of the landscape of Formative and Archaic Susiana is vague and disperse. Specific studies to investigate the landscape of the Early Neolithic's archaeological setting in Iran are missing, although first attempts have been made in recent years (see Matthews and Fazeli Nashli 2013 for a few examples).

For the current study, two steps have been taken: evaluating available geodata and producing new geodata. For the first step, two sources of valuable data were considered: (1) geomorphological studies, including soil surveys of the last century; and (2) data on soil sequences, flora, and fauna from archaeological reports, including surveys and excavations. The tedious process of digging up geodata from such sources yields previously neglected or unknown geodata of probably lost soil and sediment horizons in this naturally dynamic and anthropogenic intensive landscape. Therefore, such data is invaluable and decisive. This step has been taken to provide a framework for the original data

Table. 1: *The Neolithic to Chalcolithic chronological sequence of Susiana (simplified by the author)*

Timespan BCE	Phase	Period	Deh Luran	Mesopotamia
seventhmillennium	Aceramic Susiana	Bonut A	Bus Mordeh	?
	Formative Susiana	Initial Village Period	Ali Kosh	Jarmo
sixth millennium	Archaic Susiana 0		Mohammad Jafar	
	Archaic Susiana 1		Surkh	Hassuna
	Archaic Susiana 2		Chogha Sefid	
fifth millennium	Archaic Susiana 3			Ubaid 0
	Early Susiana	Later Village Period	Sabz	Ubaid 1
	Early Middle Susiana		Khazineh	Ubaid 2
fourth millennium	Late-Middle Susiana		Mehmeh / Bayat	Ubaid 3
	Late Susiana 1		Farrukhabad	
	Late Susiana 2		Zargarab	Ubaid 4

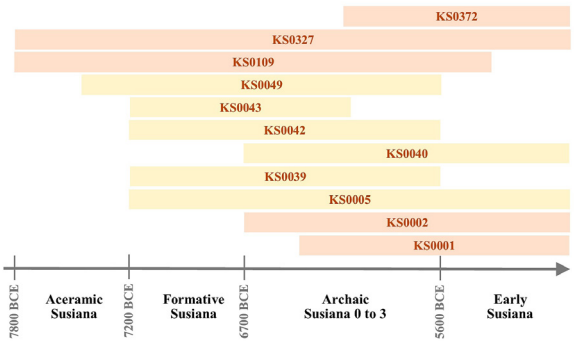


Figure. 2: *A schematic and simplistic view on the general occupational phases of mentioned sites in the relevant periods, darker sites have published material culture, and lighter sites are based on sporadic indications, dashed is the high possibility of occupation based on secondary evidence (illustrated by the author)*

[1] This is indeed an ambitious aim. As one anonymous reviewer rightly mentioned, "[t]here are few landscapes in the world that have been as severely altered over 10 millennia by agriculture, grazing, irrigation, settlements, and land leveling, as Susiana".

of the mentioned fieldwork. The second step was to produce new geodata considering the questions that arose from the first step's framework.

During a geoarchaeological survey by the author (in two seasons: spring and winter 2014), several soil profiles were documented in this region (see Figure 1 for locations). They show a drastic change in sedimentation in some areas and an incision of the riverbeds on different occasions. In the next section, the study area will be presented in terms of geology and environmental data. Thereafter, a summary of the material culture of the two successive phases, Formative and Archaic Susiana, is presented. In this section, primary archaeological sites (Figure 1; Figure 2) will be treated, including Chogha Bonut (KS[1] 0109)[2] , Chogha Mish (KS0001)[3] , Boneh Fazili (KS0002)[4] , Boneh Rahimeh 4 (KS0040, BR IV)[5] , and Tepe Tulai (KS0372)[6] .

Then original data from the author's recently conducted geoarchaeological investigation is presented. The data consists of twelve sediment cores, ranging in depth from 3 to 9 m below the current surface, produced using a mechanical vibercorer (model Cobra) in October and November 2014 (see Figure 3 for locations) according to the standard methods of coring in geoarchaeology (Goldberg and Macphail 2006; Rapp and Hill 2006). The position of cores has been carefully planned to include a range of current landscapes such as river terraces, alluvial plains, agricultural areas, and environs of archaeological sites. During the stratified sampling survey[7] , eight cores were drilled and analysed in the environs of KS0001, and four cores were drilled in KS0372's environs. The points are located systematically along a transect/section that covers the main geomorphological units in the vicinity of the archaeological sites. These cores are presented and briefly discussed here (see Figure 4 and Figure 5 for sedimentary logs; Table 2 and Table 3 for key data; see Rashidian, 2020: 164-175 for a detailed description and laboratory analysis results; 176-178 for the dated pottery; see supporting information for more details and figures).

The eight cores (C1 to C8) in the environs of KS0001 lie on the floodplain between two tributaries of the current Dez river. The western branch, Siamansour, joins the Gelal-e Kohang about 16 km to the south of the site. The latter reaches the Dez river about 7 km further to the south. The site of KS0109 lies on the western flood plain of the Siamansour. The other four cores (C9 to C12) were drilled in KS0372's environs to examine its spatial relation with the Dez river (Figure 4; Table 2). This geodata is complemented by a series of soil profiles in the area. The 23 relevant soil profiles (Figure 5; Table 3) were documented during the stratified sampling survey in the vicinity of the cores and sites[8] . Their location was chosen in part by the availability of profiles such as recent canal sections, incised field borders, and gully eroded cuts at places where no coring was possible, or coring was not successful due to the characteristics of the surface, such as landslide risk, private property, and dense vegetation cover. The soil profiles serve two purposes: (i) complementing the cores by broadening the scope of the interpretation, and (ii) presenting control samples. The soil profiles also often include a canal section, eroded, or washed away sections of archaeological mounds, and a section of stream terraces and river valleys. Their exposed environs were also photographed and used for a better and larger scale interpretation of the profile.

The samples from cores and profiles have been sieved and examined on-site using a ProScope with x15 magnification and were lithologically described and sampled for further analysis. The samples were analysed for pH, electrical conductivity (EC), particle size distribution (via laser diffraction method), organic matter, inorganic carbon content, and soil type in the laboratories of the Goethe University in Frankfurt (see detailed accounts

[1]KS is a known abbreviation of the so-called "Khuzestan Survey" by R. McAdams, published in 1962. Further surveys have used this code continuously until today.

[2]Chogha Bonut

[3]Chogha Mish

[4]Boneh Fazali

[5]Boneh Rahimeh

[6]Tappeh Tulai

[7]The stratified sampling survey (2014) consisted of 51 cores and more than 200 soil profiles, which are published elsewhere (Rashidian 2017; 2018; 2020, 2021). A limited number of these were relevant to this study and are mentioned here.

[8]The sedimentary data on cores and soil profiles is presented here in a simplified manner and focuses on the main statement of each profile for the sake of summarizing. Detailed descriptions according to standard procedure (Goldberg and Macphail, 2006: 51-52) are given in author's unpublished PhD Thesis (Goethe University Frankfurt, 2016) and a summarized version of the laboratory analysis of control samples is published in Rashidian, 2020: 164-173.

for the applied methods in Rashidian, 2020: 23-26). Sorting degree, soil formation processes, and each soil sample's genesis were then interpreted based on the particle size distribution and organic matter. Detailed results of these analyses have been published elsewhere (Rashidian 2020). Additionally, the study area's relevant geodata has been extracted from different sources, including archaeological reports, soil surveys, and available remote sensing data. The geodata has been digitalized and integrated into a geodatabase via ArcGIS (standard desktop version 1.6) for a series of spatial analyses and interpretations. These include analysis from the hydrology and topography toolkits as well as 3D-analysis for raster data. The optical analysis of buried water courses on older imagery was also part of this step (Figure 6), although the author does not believe in an identical water course from the Holocene to the recent past (mid-twentieth century). A crucial analysis was the determination of stream order based on identified fluvial packages in cores and profiles as well as the visible traces on satellite imagery (Figure 7; Figure 8). This analysis was conducted by first ascertaining the flow direction and accumulation patterns of the area based on the digital elevation model. This yielded a coarse framework, which was then correlated with each fluvial package's identified elevation (or depth from the surface) with a similar texture. The results connected the point-by-point fluvial packages and presented a series of buried watercourses as polylines divided into five different categories based on their depth and sediment thickness. This first attempt at identifying the area's initial fluvial regime shall be refined with extensive stratified sampling in the near future. In the third section, a coarse reconstruction of the landscape of Susiana in the Formative and Archaic phases (Early Neolithic period) is attempted. The reconstruction is based on original data, presented in the last section, as well as analysis of currently available remote sensing data, including but not limited to satellite imagery (declassified CORONA, LANDSAT, SRTM), soil maps[1] , and GIS-spatial analysis of Digital Elevation Model (DEM) of the region (5m resolution). Furthermore, geodata from published excavation reports and investigations of flora and fauna in this setting is considered. The suggesting reconstruction is then refined with the archaeological evidence.

Another essential GIS analysis was the assessment of the area's initial elevation (Figure 9). This was partly possible by correlating the elevations of each identified horizon based on cores and soil profiles. A simple categorization of these horizons (fluvial, non-fluvial, eroded surface) built

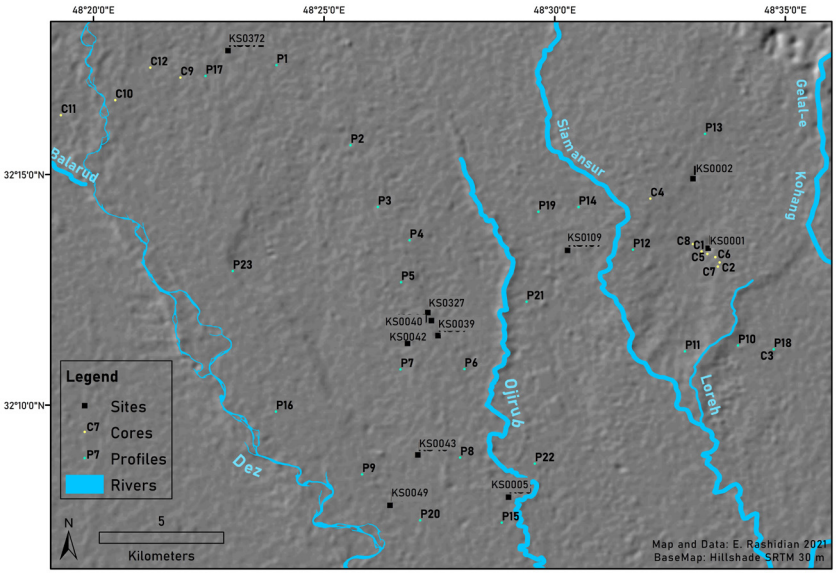


Figure. 3*: Map of the study area with the location of cores and profiles (illustrated by the author; see supporting information for details on them)*

[1]Other analyses, such as wetness index, EC, and organic carbon content, have also been conducted but are not relevant for the subject of this paper and not included in the discussion. See Rashidian 2020 for the laboratory results

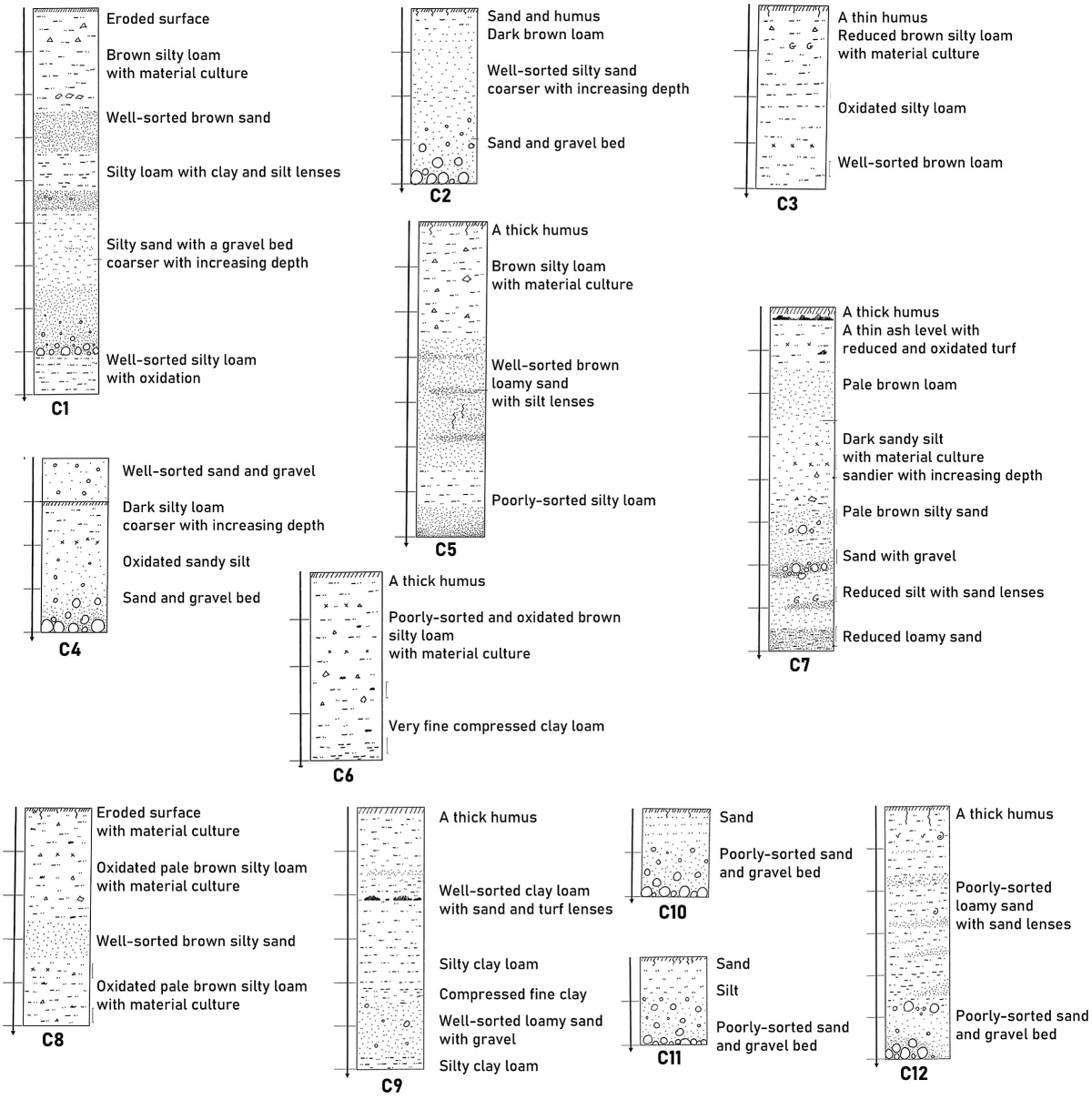


Figure. 4: *Sedimentary logs of the cores*

(illustrated by the author; see Figure 3 for locations, supporting information for details)

the framework for this correlation. These horizons were found on different elevations. Therefore, the reconstructed elevations were classified into seven groups from 47 to 96 m ASL to present the results without over-simplifying the data. For this analysis, the identified archaeological horizons extracted from published excavation reports were of great help to ascertain the environs of these sites and indirectly date the surface elevations. The contours of the area's current elevation were given to provide a visual and general comparison.

The author is aware that the available data cannot fully represent the entire landscape. The results shall be regarded as preliminary and as a suggested framework for further and detailed studies. Nevertheless, the continuously intensive land-use in the region makes it all the more necessary to study this aspect urgently. Therefore, the results are presented here for further discussion.

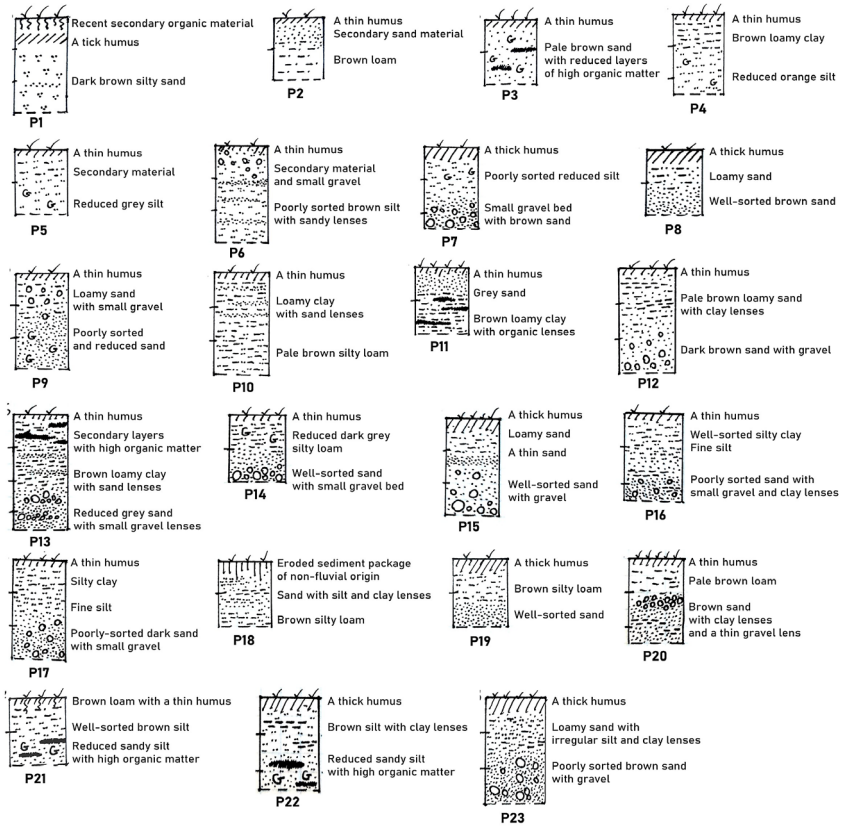


Figure .5: *Sedimentary logs of the soil profiles (illustrated by the author; see Figure 3 for locations)*

Table. 2: *Key data on cores*

(see Figure 3 for locations and Figure 4 for sedimentary logs; see supporting information for the description of the cores and sediment packages)

Code	Elevation m ASL	Depth m	Interpretation
C1	74	9	The fluvial package of a permanent river, gradually becoming seasonal and drying out, covered by secondary sedimented cultural debris of KS1.
C2	67	4	A similar fluvial package to the one documented in C1.
C3	63	4	No fluvial sediments, eroded horizon.
C4	67	3	Three fluvial horizons, a recent canal fill, and packages of a seasonally dry stream, and an older but anthropogenically disturbed riverbed.
C5	68	7	Sedentary sedimentation of cultural debris, covering a fluvial package with seasonal and regular character, a much older cultural horizon.
C6	67	4	Non fluvial eroded sediments with material culture of Early Susiana
C7	66	8	The fluvial package of a still water turning into a permanent river (identical to the one attested in C1 and C2) and then gradually becoming seasonal and drying out, covered by secondary and recent non-fluvial sediments.
C8	69	5	Two cultural horizons – from the fourth and second millennium BCE - belonging to an outpost of KS1, separated by a dynamic fluvial package (flood?).
C9	78	6	Two flood events (relatively dated to sixth and second millennium BCE) in between the fourth millennium BCE eroded horizon – known from Dar Kahzineh and Sharafabd environs.
C10	86	2	The dynamic fluvial regime of the braided Dez river – east bank
C11	80	2	The dynamic fluvial regime of the braided Dez river – west bank
C12	86	6	A permanent water flow (early Dez or one of its branches) gradually becoming seasonal and turbulent, and then drying out.

Table. 3: *Key data on the mentioned soil profiles (see Figure 3 for locations, Figure 5 for sedimentary logs; see supporting information for details)*

Code	Elevation m ASL	Depth m	Interpretation
P1	93	3	Older flood plain of Dez, not visible on CORONA imagery 1972
P2	85	2	Similar fluvial package to C2 and P5, older flood plain of Dez, date unknown
P3	80	2	Buried flood plain of older Dez visible on CORONA imagery 1968
P4	76	2.5	Recent flood plain of a new channel
P5	73	2	Similar package to P1 and P2, unknown channel of older Dez not visible on older imagery, date unknown
P6	65	3	Fluvial sediments of both Ojirub and Siamansour
P7	69	2.5	Much older flood plain of Ojirub, traceable also on CORONA imagery 1972
P8	57	2	Fluvial package similar to P15, suggesting an older flood plain of Ojirub, at least from third millennium BCE based on Chogha Pahn location
P9	59	3	Fluvial package similar to p16 indicating and older flood plain of Dez
P10	73	3	Older flood plain of Loreh, date unknown
P11	68	2	Evidence of a small flood from Loreh(?), date unknown
P12	69	3	Evidence of the buried watercourse also attested in the cores, dated to the Early Holocene
P13	86	3.5	Older channel joining Siamansour with indications of seasonality and flooding, date unknown
P14	77	2	Evidence of buried watercourse of older Ojirub, traces of this meander are visible on CORONA imagery 1968
P15	51	3	Older meander of Ojirub joining Dez, also attested on CORONA imagery 1972, date unknown (less than 300 yrs based on historical accounts on the junction)
P16	64	2.5	Older branch to Dez with indications of fluvial regime change and dry periods
P17	93	3	Fluvial package similar to P16 without the dry periods, evidence of gradually drying of an older Dez branch, at least from fourth mill. BCE based on Adams 1962
P18	69	2	Evidence of an older branch to Loreh gradually drying and eroding its environs
P19	77	2	Older branch to Siamansour, also traceable on CORONA imagery 1972, date unknown
P20	57	2.5	Older branch to Dez with a short waterflow span and sudden drying, unknown date
P21	77	2	Older branch of Ojirub with indications of slow water flow and gradual drying
P22	55	2.5	Fluvial package similar to P21, evidence of buried watercourse joining Dez S of Ojirub
P23	73	3	Evidence of a buried watercourse joining Balarud (older Dez channel), also attested in C12

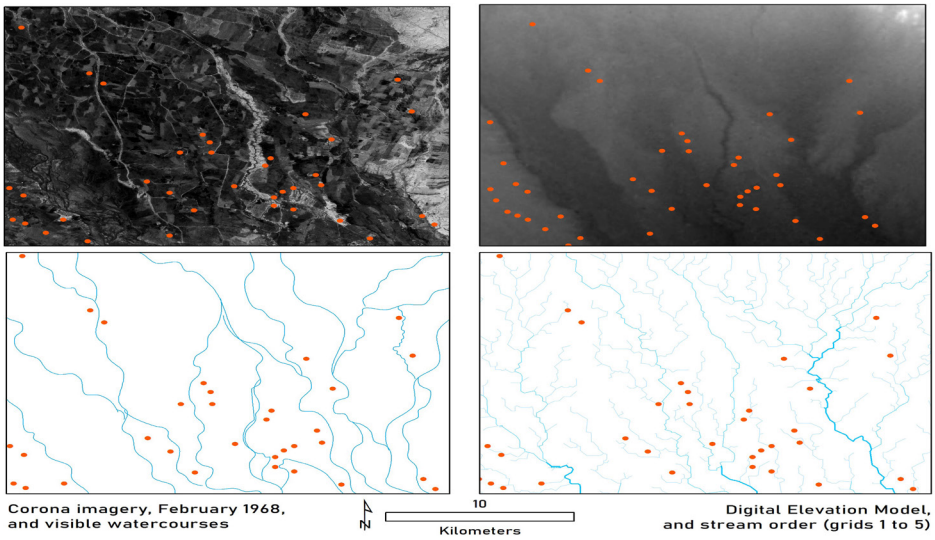


Figure. 6: *A comparative view of older and active watercourses, based on visible traces on older imagery (left column) and results of GIS analysis (right column), in accordance with prehistoric sites identified by Adams 1962 (red dots) (illustrated by the author)*

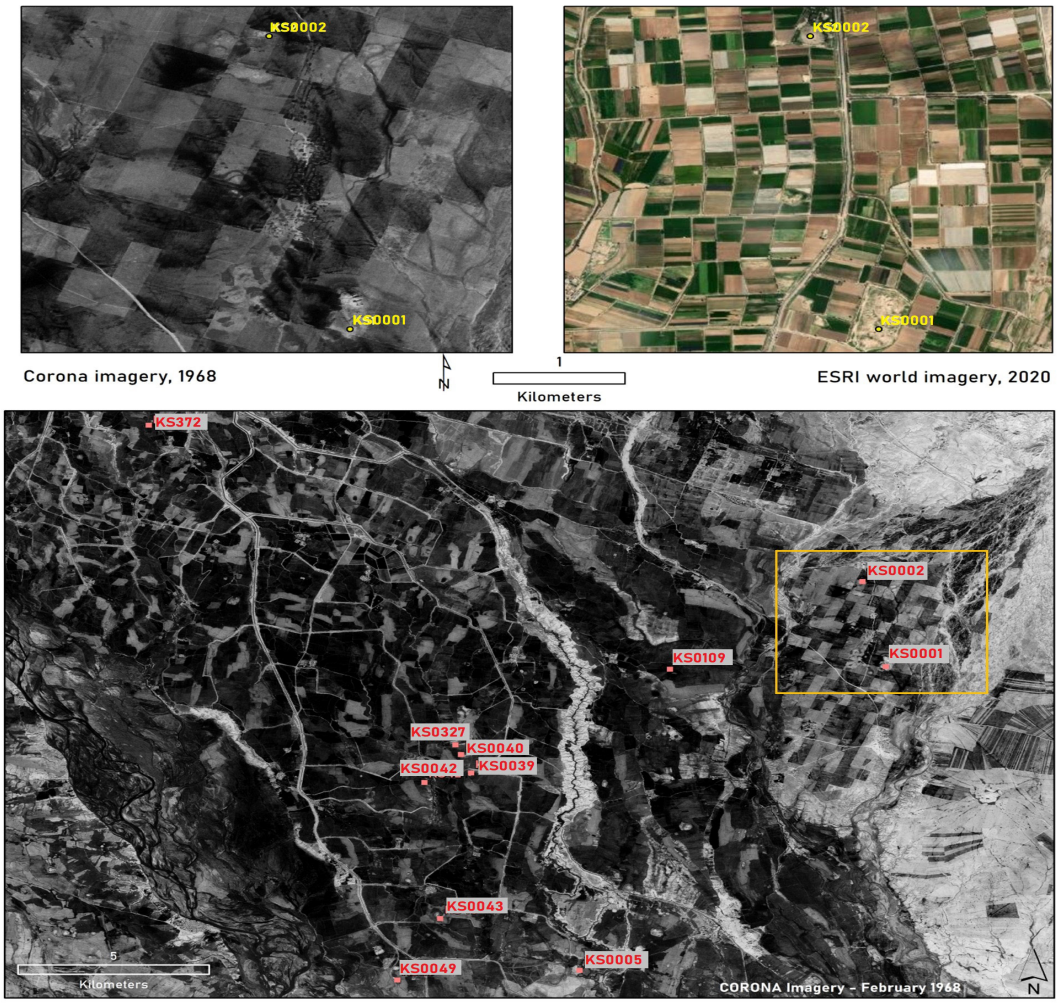


Figure. 7: *The location of Formative and Archaic Susiana sites on the CORONA imagery 1968; the insect shows details of a buried watercourse between KS0001 and KS0002 visible on Corona (upper left) and currently buried (upper right) (modified by the author)*

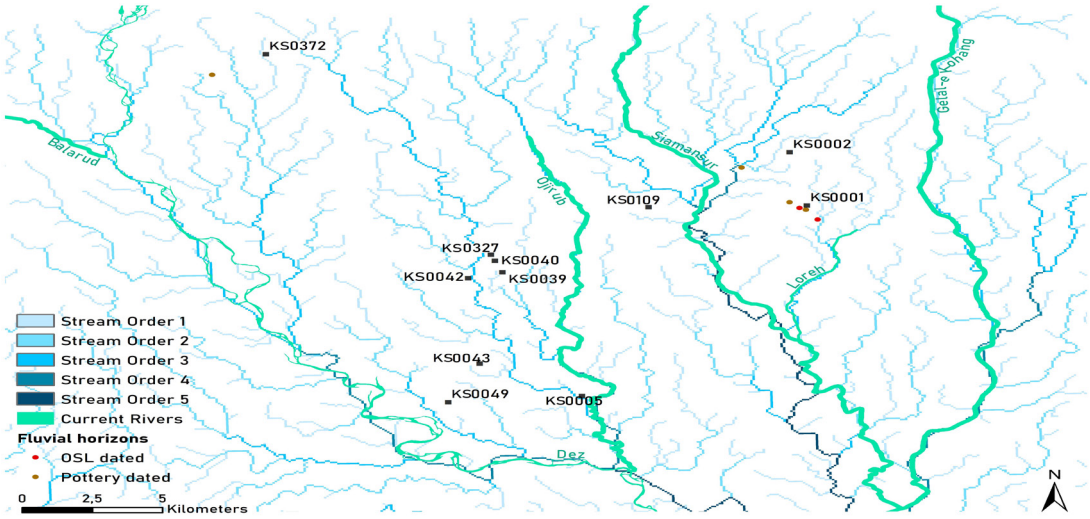


Figure. 8: *Results of the spatial analysis, showing possible watercourses in the study area based on the general topology of the surface (illustrated by the author)*

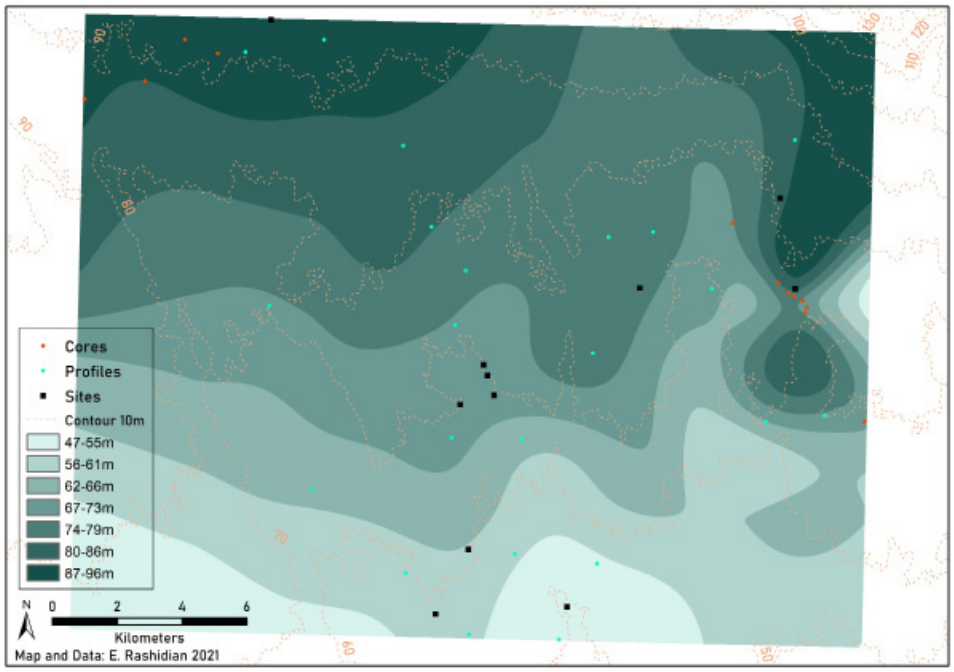


Figure. 9: *Current topography of the area (contour lines 10 m), and the suggested elevation based on data from sample and control points (illustrated by the author)*

The Study Area

The Geological and Geomorphological Setting

The Susiana region lies at the foothills of the faulted Zagros range (Falcon 1974) and borders the lowlands of south Khuzestan and Mesopotamia (Veenenbos 1958: 26 ff.; Ehlers 1975; Fisher 1968). It has been argued that the Susiana plains are a continuation of the Mesopotamian lowland, in geological terms (Lees und Falcon 1952; Dewan and Famouri 1964; Wilkinson 2012). However, the geomorphological setting of the Susiana plain varies completely from the one in the neighbouring Mesopotamia, as Susiana is highly influenced by the Zagros foothills and the high sediment freight of its main rivers.

The Susiana plains are confined by the Zagros foothills in the northeast, the sand dunes in the southwest, and intersected by the tributaries of the Dez river feeding the riverine landscape with sediments (Kirkby ,1977: 251-253, 266). This special constellation provides a unique geomorphological setting comparing to the neighbouring plains and areas. The surface of Susiana consists of recent alluvium – caused by the major alluvial fan of Dez, continuously eroding the Zagros foothills – mostly dating to the mid-Holocene – and higher located anticlines of Pleistocene age in a northwest-southeast axis parallel to the Zagros range (Veenenbos 1958). The surface sediments vary from coarse in the north to fine in the south (Dewan and Famouri 1964: 25; Rashidian 2020). The slope follows the Zagros pediments and drops from 150 m ASL at the foothills to 50 m at the Dez river terrace in a distance of about 25 km.

The Environmental Setting

Palaeo-environmental data is available on this timespan, albeit coarse and large-scale. Several geo-factors affect the palaeoenvironment of this region. The most crucial one might be the evolution of the palaeo-coastlines of the Persian Gulf during this time. This is the subject of much debate and no consent to this point (Lambeck 1996; Gasche 2005; Heyvaert *et al*. 2010; Lees & Falcon 1952; Kirkby 1977; Purser 1973; Uchupi 1999; Sanlaville 2002). The region's hydraulic setting in the later periods has been given special attention in the last decades (Ehlers 1975; Hansman 1970; Heyvaert & Baeteman 2007; Verkinderen 2015). However, it is speculative for the Early and Mid-Holocene.

In reconstructing a landscape, three items are of utmost importance: the elevation (relief), the hydrology, and the vegetation (land cover). Recent studies have confirmed that the climate is the most crucial determinant of a landscape's vegetation

(Djamali *et al*. 2012). Therefore, one must take the Palaeo-climate into account. The area known to hold Formative to Archaic Susiana settlements belongs to the Mediterranean xeric-continental (Mexc) bioclimate classification in the Irano-Turanian climate zone. The annual mean temperature is about 23° and varies between 5° and 46° in annual average. The annual mean precipitation is about 404 mm. The dry season varies between four and twelve months (one dry year), the rainy season does not match the growing season, and the temperature is always above zero (Djamali *et al*. 2011: 95-99).

The Early Holocene (roughly 10kyr to 6kyr BP) is marked by the abrupt end of the extremely cold and dry Late Glacial period, globally. Based on pollen data from the Zeribar lake (northwest of Susiana), the Early Holocene climate was warmer and moister than before, yet relatively dry compared to later periods. A substantial increase in temperature and a relative increase in moisture mark the transition of glacial to Holocene climate (Jones *et al*. 2019). In summary, the Early Holocene had warmer summers and colder winters than today (Stevens *et al.* 2001: 750-753; Stevens *et al*. 2006). This is the case in both Susiana and Mesopotamia albeit with slight differences in moisture and vegetation cover (Akkermans 2020). During this time, two climatic events of 9.2kyr and 8.2kyr BP are evident globally, imposing abrupt cooling and aridification of climate for about two centuries (Jones *et al*. 2019). However, detailed examination of archaeological data has found no evidence of large-scale migration or cultural collapse in these periods (Akkermans 2020: 33; Flohr *et al*. 2016). There are indications of local adaption to this climatic change in terms of communal storage and diversification of resources. On the other hand, there is much evidence for continuity of settlements during this event (Jones *et al.* 2019). It seems that the Neolithic population of this area had already established its food production and housing processes and was not disturbed by these abrupt climatic conditions.

The absence of forest vegetation in the Pleistocene and Early Holocene periods in southwestern Iran has also been confirmed by pollen analysis from the Dasht-e Arzhan wetland (Hoseini *et al*. 2016). Based on this record, Pistachio and oak have started to spread in the Zagros foothills in the Mid-Holocene. Interestingly, the first phase of the oak vegetation cover correlates with the 8.2 kyr event in this region. It seems that the region's precipitation regime has stabilized in the sixth millennium BCE and continued until today with major changes (Hoseini *et al*. 2016: 94-95). It has been suggested that the oak vegetation cover in the Zagros region in the Mid-Holocene and the parallel spread of nut trees were influenced by anthropogenic manipulation (Jones *et al*. 2019). The dominant vegetation of south and southwestern Zagros foothills seems to be shrubs and grass in the periods prior to the Mid-Holocene (Davoudi *et al*. 2014; Hoseini *et al*. 2016; Jones *et al.* 2019). Several types of the Cousinia plant have been documented in the pollen data of the Parishan and Arzhan lakes in the south Zagros and confirm a typical vegetation cover of arid climate.

The timeline of annual precipitation characterized the most crucial change in terms of vegetation. Pollen data indicates no (or exceedingly rare) spring rains in the Early Holocene, a situation which led to a more extended dry season and affected the vegetation immensely. This situation changed in the Mid-Holocene (from 6kyr BP) with an increase in effective moisture. Spring rains became common, shortening the dry season and enabling a whole range of flora to establish in the Irano-Turanian climate zone (Stevens *et al*. 2001: 754). A gradual increase in precipitation in the mid-sixth millennium BCE has been documented in the environs of the Mirabad and Zaribar lakes with a traceable impact on vegetation (Stevens *et al*. 2006: 498). This was followed by a severe dry period of at least half a millennium in the mid-fifth millennium BCE (Stevens *et al*. 2006). Pollen data from lakes Arzhan and Parishan confirms this correlation for the south Zagros (Davoudi *et al*. 2014; Hoseini *et al*. 2016). This suggestion is further confirmed by data from the Lake Mirabad in Southwestern Iran, indicating that the Zagros and its neighbouring lowlands, including the Susiana plains, received less precipitation than the East Mediterranean area due to a more northerly monsoon stream in the Early Holocene. This led to a dryer climate in this specific area in the Early Holocene and a substantially moister Mid-Holocene than the Mediterranean neighbouring area (Griffiths *et al*. 2001; Stevens *et al*. 2006).

Such a change affects the vegetation of the area crucially. As the Mediterranean area saw an advance of forests in the Early Holocene, this was impossible due to the longer dry season in the west to southwestern Iran. The absence of forests encouraged special flora to advance in the Early Holocene, including scrubs, grass, and resistant

trees such as pistachio and oak. Furthermore, this land-cover might have eased surface erosion and landslides due to run-off and stream floods in the wet season, as it is currently the case in some regions of the Susian plains[1] . By the Mid-Holocene, the forest could finally advance in the Zagros and its hinterland due to a gradual increase in moisture, in the form of spring rain, and higher precipitation from the westerly Mediterranean stream in the absence of the monsoon stream (Griffiths *et al*. 2001: 762-763; Stevens *et al*. 2006: 500). The evolution of the palaeo-environment in Mesopotamia was slightly different from Susiana in terms of moisture and vegetation cover (Akkermans 2020; Jones *et al*. 2019), with implications for land-use possibilities. A detailed comparison is not possible based on current available data. However, it is safe to assume that Susiana was more suitable for grazing in the Early Holocene in the absence of intensive tree cover in the highland Zagros and north Mesopotamia.

The Archaeological Setting

The Neolithic period of Iran (~ 8500 to 5500 BCE) seems to represent a dynamic of sedentary settlements and seasonal mobility in and around the Zagros mountains with an extensive network of early exchange towards the Mediterranean, Iranian highland, Indian peninsula, Taurus mountains, and north Mesopotamian lowlands (Hole 2011; Matthews and Fazeli Nashli 2013). The earliest indications of domestication of flora and fauna are known from the Zagros mountains in the eighth millennium BCE as a consequence of sedentary life (Hole 1987; Hole 2004; Helwing, 2012: 503). Some have argued that the Neolithization of the central Zagros area and Susiana lowlands were interconnected and directly related to the Younger Dryas period (Darabi 2012). Indeed, the material cultures of Deh Luran and Susiana in the Early Neolithic are strikingly similar (Hole 1987; Neely & Wright 1994; Hole 2004). A simplified chronology of the mentioned sequences [2] is presented here (Table 1). Recent archaeological data suggests a continuous occupation of Susiana and neighbouring Zagros from the Epi-Palaeolithic[3] to the Early Neolithic periods (Helwing, 2012, 504), while there are indications of a hiatus in the settlements of the central Zagros (Darabi, 2012: 107). The pre-pottery Neolithic (PPN) is attested in seemingly separated and sporadic settlements in areas with the possibility of rainfed agriculture (Hole 2004), particularly in northern Khuzestan at the pediments of the Zagros mountains in the Behbahan plain (Moghaddam *et al.* 2014; Darabi *et al.* 2021). By the time pottery is widespread in the Neolithic Susiana (~6500 BCE), the first indications of hierarchical societies' emergence become evident in the material culture and settlement patterns (Hole ,2011: 5-6; Darabi 2012: 289).

Our understanding of the earliest sedentary phase of Susiana, the Aceramic Susiana, is rather elusive. This period was first recognized as the earliest settlement phase at KS0109 (Kantor 1977), concentrating on the mound's eastern section (Alizadeh, 2003: 35). Fortunately, the two successive phases, Formative and Archaic Susiana, are better-known, thanks to detailed published material on excavations in northern and central Khuzestan (see Alizadeh, 1992: 55-56 for a summarized description). These phases are known from several sites in the region, including KS0109, KS0001, KS0002, KS0040, and K0S372. A recent reassessment of older survey and excavation material suggests the existence of at least eleven sites with Archaic Susiana occupation in this region (Moghaddam 2019). Archaic Susiana pottery has also been identified at three sites (G25II[4] , G26II [5], and G86II[6]) from the Gremzila survey collection, including the mentioned KS0040 (G33IV) (Alizadeh ,1992: 19).

The Challenge of Early Neolithic Site Reconnaissance in Susiana

Archaeological studies have revealed a densely populated Susiana plain in almost all phases (Adams

[1]It is impossible to compare this aspect of the land-cover impact from the Early Holocene and today because the climate has shifted from the continental model in mid-Holocene back to the initial Mediterranean model in Late Holocene. See Stevens *et al*. 2006 for this discussion.

[2]These are approximate times of the beginning of each period, which are slightly different in some phases due to different chronologies (see Alizadeh 2003, Table 3, 31; Potts 2012, Table 27.1. for detailed chronologies).

[3]The Nature of Epi-Palaeolithic occupation of Iran is not well-understood. There are indications of caves and hillslope settlements in the Zagros foothills in Susiana. Most of the other settlements on the lowland plains might be covered by at least 6 meters of recent fluvial and colluvial sediments.

[4]Tappeh Sham'un

[5]Deylam-e Sofla

[6]Chogha Cheshmeh

1962; Hole 1987; Johnson 1973; see a summary by Moghaddam 2012), as it is currently the case. However, the rate of known site numbers from each phase is not homogenous by any measure. Some of the earliest phases are much less represented in the archaeological data than the later periods. Assessing an accurate Early Neolithic site distribution has been a challenging issue ever since this period was recognized in Susiana (Hole 1987; Alizadeh 2008: 5; Moghaddam 2019).

Besides the difficult nature of the archaeological record, several factors are responsible for this misrepresentation. One is the intensive land-use of recent decades, which has shaped the plain's surface into a mosaic of irrigated lands and townships. The other reason is the large-scale landscape manipulation of Late Antiquity, especially the Sasanian period in Susiana (see Ehlers 1975 for the recent landscape; Kouchoukos 1998 for a discussion on these factors; Wenke 1967 for the Sasanian landscape). Such intensive reshaping of the landscape during the second to fifth centuries CE has even changed the plain's hydrologic regime and the fluvial sediment freight (see case studies on this matter for later periods in Alizadeh *et al*. 2004; Heyvaert & Baeteman 2007; Verkinderen 2015; Rashidian 2017). In the course of these two phases of intensive land-use, hundreds of archaeological remains and sites have been destroyed or buried.

These anthropogenic factors have triggered natural responses of the landscape in terms of sedimentation and elevation in a successive human-environment-interaction (Rashidian 2020; Wilkinson *et al*. 2012). One visible response is the drastic change in fluvial sedimentation which might have covered entire sites and remains in lowland Susiana. This phenomenon has been studied by others. There is consensus that earlier anthropogenic changes alongside with the gradual uplifting of the Zagros belt have forced the main rivers to incise their beds around the fourth to second millennium BCE (Alizadeh *et al*. 2004; Heyvaert *et al*. 2010; Lees & Falcon 1952; Kirkby 1977; Rashidian 2020; Woodbridge *et al*. 2016). The sizable volume of such sedimentation events can be witnessed indirectly in several soil profiles as well as documented in excavated sections (see Alizadeh 2003 for KS0001; Alizadeh *et al*. 2004 for an example from Dar Khazineh; Moghaddam and Miri 2003 for Mianab; Moghaddam 2007; and Rashidian 2018 for the eastern corridor).

Another factor is the methodology and quality of the available archaeological data. The archaeologists' particular interest in certain sites such as Susa and certain periods such as the Bronze and Iron Ages has led to an unbalanced site reconnaissance in the Susiana plain[1] . Furthermore, most prehistoric sites of the region are known only from surveys, or not excavated to virgin soil, as the fifth to three millennium BCE deposits covered a large area of the sites. Several prominent sites such as KSooo1 have been occupied for more than five millennia leading to an immense volume of cultural debris covering the earliest phases. Additionally, many sites might have been destroyed due to the intensive and long-lasting land-use in the region prior to their identification in the last centuries. Therefore, it is highly probable that more Formative and Archaic Susiana settlements exist than currently known. Comprehending the region's landscape in this period can provide us with a solid framework to specifically seek such sites' remains.

The Material Culture of Formative and Archaic Susiana

The primary sites with Formative and Archaic Susiana occupational horizon are presented here (see Figure 1 for locations, Figure 2 for occupational periods).

The assemblage of the Formative and Archaic phases' material culture shows remarkable similarities and indicates a striking continuity of cultural traditions of about two millennia (Kantor ,1974: 14), especially evident in the reported ceramics of the known sites (Alizadeh, 2003: 8). The material culture of these phases includes pottery (vessels and figurines), architecture and building material (bricks, mud-pisé, and stones), stone tools (chert and flint blades), and other stones. For example, obsidian from the Anatolian sources (Blackman 1984) has been found among the lithic material at KS0109 and KS0001 (Alizadeh ,2003: 91-113). The known pottery assemblage of Formative and Archaic Susiana (Alizadeh 2003: 48-66; Thompson, 1973: 54) and the Formative phase's transition to the Archaic phase (Alizadeh 2009) consists of shared motifs between the pottery of Archaic phase in Susiana and Chogha Sefid phase

[1]This relates to the Neolithic sites but not exclusive to it. As mentioned by others, the fourth millennium BCE in the Chalcolithic period is also underrepresented in the current archaeological data (see Wilkinson *et al.* 2012: 164; Helwing 2012 for a discussion).

in the neighbouring Deh Luran (Thompson, 1973: 124), indicating a cultural exchange in the earliest phases of these two regions (Neely & Wright 1994). Furthermore, the architecture of these two subsequent phases (Kantor, 1977: 21; Alizadeh ,2003: 7, 40) suggests a continuation of endogenous cultural evolution as well as the beginnings of hierarchical societies. Especially the common standards of building material are of importance, suggesting that the Formative Susiana phase was an intermediate phase between the Aceramic phase and the Archaic phase (Alizadeh, 2003: 40) and supporting further the idea of continuous cultural evolution in Neolithic Susiana. The immense number of unexcavated sites in Susiana (Adams 1962; Hole 1987; Alizadeh 1992; Potts 2012) bears the hope of finding further evidence of these early periods in the future.

Primary Sites of Formative and Archaic Susiana

Known sites with Formative and Archaic Susiana sequences (see locations in Figure 1) will be discussed here. Due to the heterogenous state of investigation of these sites, establishing a comprehensive chronological order is not possible. However, the available data on the occupational phases of the mentioned sites can be summarized (Figure 2).

KS0001 (Chogha Mish) is the largest prehistoric site in Susiana, and its extensive excavation has provided a solid framework for the chronology and cultural evolution of the Susiana phases. The first known occupational phase of KS0001 belongs to the Archaic 1 phase. The occupation levels show an economy based on domesticated and wild legume crops (Alizadeh, 2004: 167). The estimated size of occupation in the Archaic phase is about 2 ha. Cattle were introduced in the Archaic 3 phase in addition to the already known sheep and goats as domestic fauna.

As this site's occupation has continued and become more extensive, further traces of Archaic phases might be covered by heavy debris of the fifth millennium BCE[1] . Therefore, the exact occupation size of these phases is unknown at this site. As mentioned in the last section, this is a known challenge in the region. Heavy sedimentation of later periods covers most of the area's surface and hinders an accurate estimation of site size and formation process.

KS0002 (Boneh Fazali), about 2 km northwest of KS0001, has been excavated in a salvage operation in the 1970s, showing an Archaic to Middle Susiana occupation with a resettlement in Late Antiquity (Kantor, 1976: 29). Interesting finds dating to the Archaic period were made below these levels. The Archaic material culture suggests that KS0002 and KS0001 were occupied simultaneously (Kantor ,1976: 30).

KS0109 (Chogha Bonut) lies about 5 km west of KS0001 and has been excavated as a salvage project in two seasons from 1976 to 1978 (Kantor 1977) and later in 1996 (Alizadeh, 2003: 40; Alizadeh 2009). The site's importance lies in its earliest occupation levels, the Aceramic phase, and the architecture of Formative and Archaic Susiana 0 phases, which filled a gap in our understanding of these phases previously known from KS0001 (Kantor, 1977: 21). This relatively small site has yielded the earliest occupation levels in the Susiana sequence, the Aceramic Susiana, dating back to the mid-eighth millennium BCE.

KS0109 is the only excavated site so far with Aceramic levels in central Khuzestan[2] . The Formative and Archaic 0 Susiana phases are extensively excavated at the site and presented pottery from this phase, which is not documented in KS0001. The subsequent phases of Archaic 1, 2, and 3 are not documented in KS0109's excavated areas. It seems that the site was deserted for about a millennium before re-occupation in the Late Middle Susiana phase. The Archaic phase was concentrated on the mound's eastern side, which fell victim to massive destruction with a bulldozer in 1974 (Kantor 1976; Alizadeh, 2003: 33). Therefore, it is also possible that traces of later Archaic (1 to 3) phases were lost forever. KS0109 was deserted again for unknown reasons after the Late Susiana 2 phase (see Alizadeh, 2003: 22, Table 2 for KS0109 sequence). Some suggest that KS0109 may have been a seasonal occupation of people practicing a mix of farming and herding (Alizadeh, 2003, 39).

KS0327 (Boneh Rahimeh IV) is one of the four mounds known as Boneh Rahimeh (KS0040) and was included in the Gremzila survey collection

[1]No Formative Susiana remains are discovered at KS0001 until now. But the extent of unexcavated area of the site and its destruction in recent decades makes a buried formative phase likely to the author.

[2]Recent investigations indicate that Boneh Rahimeh may also contain occupational levels at this period. See Moghaddam 2019.

(Alizadeh 1992). These mounds have only been surveyed, but their finds indicate a long occupation from the PPN to at least the Late Susiana period, including the Formative and Archaic Susiana (Moghaddam, 2019: 20).

KS0372 (Tepe Tulai) lies between Ali Kosh and KS0109. It is a relatively small mound near a Sasanian canal with Early Neolithic remains of a probable campsite or seasonal settlement (Alizadeh ,2003: 7). It was studied briefly in the 1970s (Hole 1974) and re-evaluated later (Sutliff 2015). The site might have been occupied at the end of the sixth millennium BCE for a few hundred years (Hole ,1974: 229), or even earlier, about 6200-5900 BCE (Sutliff, 2015: 392). Although there is no consensus regarding the nature of the campsite, its seasonal and pastoral implications seem reasonable. The material culture, including the pottery assemblage, indicates an exchange with both neighbouring regions of Dehloran to the west and Susiana lowland to the east (Hole, 1974: 229-235; Bernbeck, 1992: 83). This was probably a campsite of dwellers of both KS0109 and Ali Kosh for a particular seasonal activity, which indicates a horizontal migration. Alternatively, it could be the winter camp for the Zagros mountains' pastoral communities, indicating a vertical migration (Bernbeck, 1992: 84-85).

A large number of faunal remains have been found in the pits, mostly from goats or sheep. Other remains include wild ghazel, pigs, and probably herding dogs (Hole, 1974: 235). Based on the excavation finds, we know that KS0372's inhabitants were families and not just herders (Sutliff, 2015: 392). Goats were probably also used to transport goods between Dehloran and Susiana (Sutliff, 2015: 395). Unfortunately, the brief excavation did not yield any Formative Susiana sequence. KS0372 has lost a considerable volume of occupational debris due to a Sasanian construction (canal) and recent levelling for agricultural purposes. Therefore, we might never know the full extent of the site and its prehistoric implications.

As mentioned in the last section, the majority of here discussed core samples cluster around two sites, KS0001 and KS0372. However, the environs of other sites have also been studied via coring and soil profiles so that general assumptions in terms of elevation anomalies, soil texture evolution, and buried watercourses can be made for the remaining sites. These geodata are not fully discussed here, as they mostly correlate with later cultural periods (fifth to second millennia BCE) and have been published elsewhere (Rashidian 2020; 2021).

Results and Discussion

Eight cores (C1 to C8) were drilled in the vicinity of KS0001 and KS0109 alongside a number of soil profiles to comprehend the landscape change of this area throughout the earliest settlement periods. Four cores (C9 to C12) were drilled in the KS0372 environs to examine its spatial relation with the Dez river. Also, several soil profiles were documented in the immediate environs of the site. Their analysis served as a control sample for interpreting the sediments of the cores in a broader context (see Figure 3 for locations). A series of sediment packages were identified, which range from both permanent and seasonal fluvial flow to eroded buried surface and secondary depositions and channel fills (see supporting information for the details). Indications of the heavy anthropogenic sediments from the last four millennia were also identified in the upper five meters of cores and profiles. However, the area east of Dez seems to be less affected by anthropogenic young sediments comparing to the west of Dez. This is to be expected if one considers the extent of canal construction and large-scale urban and hydraulic work plans in the western parts in antiquity (e.g., Dariun canal, Shushtar hydraulic works, Gargar) and the absence of such works in the eastern Dez area, where the known Early Neolithic settlements are located[1] .

Based on the presented sedimentary logs (Figure 4; Figure 5) of the cores (C1 to C12) and soil profiles (P1 to P23), an exceptional element of the Susiana palaeo-landscape comes to light. Heavy sediments of fluvial nature in the depths of 70 to 66 m ASL indicate a deep and permanent water flow of a currently disappeared natural river. This remarkable fluvial sediment package is directly documented in C1, C2, and C7 and covered by another one with irregular fluvial sediments indicating a gradual fluvial regime change from a permanent river to a seasonal one with at least two flooding events. The fluvial package in C7 covers an even older fluvial horizon with indications of very slow or still water below the river. This has essential indications for

[1]The anthropogenic sediments are present in the whole area but vary in depth and volume, increasing to the west, as is shown in some 40 other cores from the author's same sampling survey, especially in the lower Dez and western Karun areas. See Rashidian 2017; 2018; 2020; 2021 for examples.

the landscape of the Early Holocene and earlier in the Susiana Plain.

The sand package of the riverbed (Figure 4) has yielded an OSL-date of about 25ka BP (at the bottom) to 12 ka BP (in the middle) (Table 4). This result puts the palaeo-landscape of the Formative and Archaic Susiana in the environs of KS1 into perspective and answers the water source's speculations for this prehistoric settlement[1] . The existence of this fluvial package in the mentioned cores gives this buried river a depth as well as a direction. On the other hand, its complete absence in C3 (although it includes the same elevation as the others) excludes the possibility of it being a branch of Loreh, the small stream directly to the east of KS1 separating it from the Sasanian small site of Jaliyeh (Adams 1962; Wenke 1975). In the vicinity of this area other fluvial changes are documented through the cores and soil profiles (see supporting information for details). The later seasonal water flow of this buried river – attested in the upper parts of C1, C2, and C7 – can be seen in C4 accompanied by dry periods and at least three flooding events. Anthropogenic manipulation of the upper horizons since Late Antiquity is attested in a variety of canal fills.

Another crucial result is the documented fluvial packages of flooding nature covered by cultural debris in a repeated manner in the vicinity of KS1 and KS109, especially seen in C5 and C8. The lower part consists of material culture belonging to the Middle-Susiana period (Alizadeh, 2008: 20, figure. 39-44; (Delougaz *et al*. 1996: 281-287). As the heavy sediments of cultural debris in C6 show, the area was repeatedly resettled accompanying a gradual change in the fluvial regime from a permanent river to a seasonal one and gradually drying out. The pottery in the cultural debris of C8 is similar to KS1 excavated material from the fourth millennium BCE (see Delougaz *et al.* 1996: Pl. 83 B). This puts the small mound west of KS1 with its similar material culture to the main mound (Delougaz *et al*. 1996; Wenke 1976: 118, site no. 367) and a continuous settlement from the sixth to the first millennium BCE in a highly dynamic fluvial landscape. The proposed landscape change of river avulsions and drastic increase of sediment freight in the last six millennia, attested in the environs of Sharafabad and Dar Khazineh, can be confirmed also for this area. Studies of these two sites have indicated a change in the sedimentation regime of the Susiana plains due to the incision of the riverbeds at a high rate about the fourth millennium BCE (Lees and Falcon 1952; Veenenbos 1958; Dewan & Famouri 1964; Kirkby 1977; Alizadeh *et al*. 2004; see Rashidian 2020 for detailed sedimentary logs in the environs of these two sites to confirm this suggestion). The still water fluvial package of lower depths is covered by traces of a highly dynamic and turbulent water flow regarding the current Dez river, especially attested in the upper part of C9. This fluvial sediment is another clear indication of westward river migration in this region. This flood event can be dated to the sixth millennium BCE based on the depth and relative dating of the upper sediments (see Rashidian 2020; 2021 for detailed discussion on this).

Table. 4:*OSL dated samples of feldspar material*

Sample	Core	Depth in core	Date BP
GI242	C1	690 cm	~12 ka
GI243	C7	780 cm	~25 ka
GI244	C7	390 cm	~12 ka

[1]This sediment package has been reported by others in the area (Veenenbos 1958).

The current nature of the Dez river as braided and turbulent is attested in C10 and C11 from both sides of its flood plain. Their location in a protected area is an advantage as it shows the natural fluvial regime of Dez with minimal recent anthropogenic manipulation. Therefore, these sediments must be considered much more similar to the Dez river's initial nature at its braided section and cannot be found outside of this zone. The dynamic nature of Dez becomes clear in C12, documenting at least five fluvial cycles of seasonal and swirly water flow. The increased thickness of the sand packages with increased depth indicates an older permanent river gradually changing its nature into a seasonal one. Further sampling and detailed dating of each sand package documented in this study would enable a much more coherent reconstruction of the fluvial regime. Yet, in the absence of such detailed and expensive studies, this is a first step towards a comprehensive and solid landscape reconstruction of Formative and Archaic Susiana.

A suggestion for a landscape reconstruction is attempted here, considering all the presented data while emphasizing the existing data's fragmental nature. Little is known about the vegetation and

surface elevation of the Early Neolithic period in Susiana because producing required data was never prioritized in the excavations. Such questions were rather secondary in the face of the region's extensive material culture for the prehistoric periods. Nevertheless, we find sporadic but valuable pieces of data in the reports and scattered studies. Here a summary of these finds is discussed.

Palaeo-Land Surface

Older satellite imagery such as the declassified CORONA series is a valuable data source in landscape reconstruction and has been in use since their declassification in 1995, and new tools for their optimized use are developing even today (Casana 2020). The datum of these images is crucial in the study area, for the Susiana region has undergone a drastic and sudden landscape change in the 1970s due to a large-scale irrigated agriculture project funded by the FAO (FAO 1957). These CORONA images show the state of the landscape prior to these changes. Therefore, it is logical to evaluate these sources prior to any attempt at a reconstruction. However, one must handle these with utmost caution in this area. The Susiana region has been subject to large-scale urban and land-use projects, at least since the second millennium BCE. Intensive land-use has been attested in different periods, such as the Middle-Elamite (mid-second millennium BCE), the Achaemenian (mid-first millennium BCE), the Arsacid (Parthian) (mid-first millennium CE), the Sasanian (second to fifth century CE), and the Middle Ages.

The available CORONA imagery shows the state of the landscape after a series of successive landscape changes and cannot be the base for a landscape reconstruction for the sixth millennium BCE. Nevertheless, the extracted geodata from these images can give insights into the riverine landscape changes of Susiana. In the current study, declassified CORONA images were primarily used as a first step in the reconnaissance of older fluvial traces (see below, Figure 6; Figure 7), and also as a means for choosing the right spots for coring and for interpreting the now buried fluvial packages in the soil profiles (Table 4). There are indications for a river shift during the prehistoric times. For example, Adams (1962: 113) notices that prehistoric sites are arranged along "margins of shallow fossil valleys" in this area. For a study of paleo-watercourses archaeological and geomorphological datasets were used. The archaeological maps (i.e., Adams 1962: figure3) were georeferenced with the help of markers such as Susa, Gundishapur, and Chogha Mish. Then, the sites' locations were integrated into the geodatabase as vector data. The stream order of the area was calculated by analysing the flow direction, flow accumulation of DEM data. The physical location of the current watercourses was georeferenced and digitalized and integrated as polylines of vector data based on high resolution imagery available on ESRI ArcGIS. The two datasets were compared against each other to categorize the current and buried or possible watercourses in the area (Figure 6).

The palaeo-surface of Early Neolithic Susiana shows a distinctive evolution from a hilly and heterogenous landscape towards a more levelled and homogenous one in later periods. The question is, how this mutual and successive interaction might have contributed to this change. The current geodata is too coarse and the excavated area is too small for any attempt to address this question. Furthermore, environmental data on geo-factors triggering a surface change in this area are completely absent. Future studies should focus on this issue by engaging with estimations of surface in different periods and compiling them into a holistic model. Until then, the here presented suggestion remains speculative.

Palaeo-Topography

Recent studies have shown significant evidence of occupation in Palaeolithic and Epi-Palaeolithic in northern Susiana (see summary and recent finds in Bahramiyan 2019). Therefore, it is safe to assume that the region was occupied since the Late Glacial period. Meanwhile, the landscape has evolved into more stable scrub vegetation with woodlands in the Zagros foothills. A gradual and steady earth surface motion has been detected in the Dezful Embayment due to the Zagros-related anticlines in Susiana (Woodbridge *et al*. 2016). Several karstic springs might have emerged in this region due to climate change, and the anticlines' assumed uplifting. The excavation of the earliest Archaic levels in KS0001 and KS0109 showed a decisive distinction in elevation. While the Archaic 1 level has been found in KS0001 well under the plain's current surface, this phase appears almost five meters above the plain's current surface in KS0109 (Kantor, 1977: 22). Based

on the KS0109 excavation report, the Formative and Archaic phases were concentrated on the mound's eastern part. The virgin soil was reached at 72.7 m elevation while the plain's modern surface is on 73.7 m, further indicating that the sixth millennium BCE levels were higher than the current surface. Several Aceramic floors are found on 74.7 m, 74.2 m, and 74 m elevation. Remains of the Formative phase are found between 75.7 and 77.2 m, while the subsequent Archaic 0 phase lies between 77.7 m and 78 m (Alizadeh, 2003: 39, figure. 18). The ash on the virgin soil at KS0109 was dated to 7,500 to 6,600 BCE (Alizadeh, 2003: 149-150), about 80 cm higher than the plain's current surface. The different elevation levels at which virgin soil was reached in these excavations provide a layout of the probable landscape with a soft hilly and sloped surface. This is in stark contrast with the current levelled surface of the landscape in Susiana and deserves further attention and new data.

Another landscape factor is the elevation. A general look at the area shows that all the known sites with Formative and Archaic Susiana occupation lie between 50 to 95 m ASL elevation (see contour lines in Figure 9). The area's current topography is highly affected by the sediment freight of the three active watercourses, especially its drastic change by the incision of the rivers sometime between the sixth to the fourth millennium BCE. This evolution is recent as the area's surface might have been greatly influenced by the interaction between the fluvial and estuarial sediments during the Mid-Holocene era (Bogemans *et al*. 2017). Comprehending the area's original elevation is possible with ascertaining the buried surface of the seventh and sixth millennia BCE. The projected surface on each sampled point (core points, sites, and soil profiles) as well as the elevation of virgin soil from excavation reports alongside a series of elevation control points[1]provides a coarse reconstruction of Susiana's Early Neolithic surface and elevation (see the gradient area in Figure 9).

[1]The control points were created during the author's 2014 off-site survey, using a handheld Garmin GPS device (with an average accuracy within five meters, according to the Garmin support information) to record paths and points of interest (using a digital grid system every five to ten meters) alongside the rivers and terraces. These points are not shown on this map but have been used for the analysis (as boundaries in the 3D-spline algorithm) to refine the already existing DEM of the area (courtesy of Geological survey of Iran, average accuracy of 10 meters).

A comparison between the area's current topography and its projected elevation at the time of Formative and Archaic Susiana shows a significant difference. The Early Neolithic surface was probably less elevated and had a much smoother slope from the Zagros foothills towards the lowland. However, the slope was not homogeneous but rather consisted of several elevated areas surrounded by natural sinks. It is especially interesting that KS0001 and KS0002 were located on a much higher plain than their environs (see the darker area in the right part in Figure 9). This indicates an intentional occupation of higher ground, probably due to dynamic fluvial regime of the area. The lower areas in this part were probably seasonal wetlands considering the hydrology of the area attested in the reduced sediment horizons found in the cores and soil profiles (see Tiner 2017 for definitions and indications, see supporting information for an example). Absolute dating of such horizons in the future can cast light on this matter.

In general terms, KS0372 seems to be far away from the cluster of other sites. Its location differs both in terms of access to the Deh Luran highland and surface soil. It is the highest settlement in an area with the least alluvial sedimentation. The excavated area shows a gently sloping surface with recent (probably Sasanian) layers of sand and gravel on fine-textured clay loam soil (Hole, 1974: 235). This favourable location provided feasible access to the flora and fauna of Zagros foothills, not available in the area where the other sits are located. Based on the spatial distribution of known KS-sites in this region and the visible blank region between this site and the southern ones alongside the buried Old-Ojirub watercourse (shown in Figure 9), the existence of similar settlements in this region is highly plausible.

Palaeo-Hydrology

The Susiana riverine landscape is a dynamic one. Its everchanging river channels and branching tributaries have been subject of numerous studies so far (Kirkby 1977; Kouchoukos 1998; Gasche *et al.* 2005; Heyvaert *et al*. 2010; Verkinderen 2015). While most of these studies focus on the lower Khuzestan, a few aspects of the riverine Susiana plains are included in them. Summarizing the available data on this matter, one can assume the following points regarding the study area:

The Dez river has always been joining

Karun, at least since the Late Pleistocene, based on hydrological, sedimentological, and geoarchaeological evidence (Kirkby, 1977: 276-277; Alizadeh *et al*. 2004; Rashidian 2021).

The tributaries Ojirub and Siamansour seem to have had parallel and spontaneously active beds since the Early Holocene (Veenenbos 1958; Rashidian 2020).

Other channels – now buried – seem to have existed between the current Ojirub and Dez channels, based on the distribution patterns of archaeological sites (Adams 1961; Rashidian 2021).

The Susiana plain's current hydrology shows indications of considerable anthropogenic intervention which altered its initial riverine landscape (Ehlers 1975; Wenke 1976; Kouchoukos 1998; Rashidian 2020).

One challenging aspect in our understanding of Susiana's hydrology is the immense human impact in the recent five millennia, which has shifted the watercourses and changed the nature of the rivers from braided and multi-channel to incised and fixed. Recent studies have shown that current river channels are a mosaic of initial and responsive courses due to this human factor (Heyvaert *et al.* 2010; Verknderen 2015; Woodbridge *et al.* 2016; Rashidian 2020; 2021). Geoarchaeological investigations enable a more in-depth look into this landscape and provide insights for proposing a reconstructed version of this landscape in the Early Neolithic period. The presented data has confirmed entirely different riverine dynamics in the Early and Mid-Holocene compared to the current landscape. The buried fluvial horizons attested in the presented cores could be dated to the end of the Pleistocene and the beginning of the Holocene era (see Table 4; Figure 6; Figure 8). Indirect dating of trapped material culture in these and upper horizons shows that these last watercourses were active in the Formative and Archaic Susiana periods (see supporting information for this evidence). The spatial arrangement of known archaeological sites shows that a portion of these buried watercourses might still have been active in the fourth millennium BCE (Adams 1962; Wenke 1976). Such a correlation between occupations and the possible past river channels in their immediate vicinity is also evident in Figures 7 and 8. A similar case has been shown in an area to the south of Susiana alongside the Dez river for a later period (Rashidian 2021). Spatial analysis of data including the known fluvial sediments of the region shows that all known sites with Formative and Archaic Susiana occupations lie directly at buried watercourses (and probable playa lakes) in Susiana (Figure 8).

There are three crucial possible watercourses in Formative and Archaic Susiana sites' environs, which have disappeared in the later times probably due to the intensification of land use and higher sediment freight from the rivers Karun and Dez in the last three millennia (see Rashidian 2021 for a discussion regarding the Dez-Karun confluence). These were older than the earliest occupation of the plain, based on their OSL-dating. One is a seemingly meandering watercourse flowing east of the present-day Dez near KS0372 towards KS0327 and KS0042 and passing KS0005 to reach the current Ojirub. The fluvial package is attested in P5, P6, P7, P8, P15 (see supporting information for details). Another smaller watercourse flows in the vicinity of KS0040 and KS0039 and reaches the current Ojirub just above the former one. KS0109 seems to be located near a much older watercourse (date indicated by stream order 3 in Figure 8) reaching the current Siamansour river. On the eastern side of the Ojirub, a rather impressive watercourse with at least two branches might have flown directly near KS0002 before reaching the current Siamansour. A third impressive possible watercourse appears to have been connecting the former with the current Loreh river and flowing in the direct vicinity of KS0001. The presented analysis, albeit a mere speculation on the possible watercourses and partly confirmed by the correlation of settlements and active channels, also indicates that the rivers Siamansour and Ojirub might have migrated slightly in their current channels (compare the stream order 5 with the current river in green). None of these dynamics are currently visible on the surface due to intensive land use and significant land cover changes in recent years.

These buried watercourses deserve a detailed elaboration. A crucial question is the nature of Early Neolithic Susiana's prominent watercourses, which can be addressed by combining these new geodata with available archaeological data of known sites. A first attempt to understand these buried watercourses is to identify their traces on older imagery and analyse their presumed locations according to the spatial distribution of known prehistoric sites (Figure 7). As seen here, the current surface lacks

any visible traces of them, while the older imagery contains hints at their location and the prehistoric sites in their immediate environs (Figure 6; Figure 7). Several points are of importance here: (i) as most Early Susiana sites (5500 to 5000 BCE) are not excavated, an earlier occupation of Formative and Archaic Susiana can be assumed for at least a number of them (see arguments in Moghaddam 2019). In spatial terms, these sites[1] (Thompson, 1973: 40, figure 6) are located between the Siamansour and Ojirub watercourses and follow their approximate flow. (ii) The Ojirub is prominent in its spatial relation with sites from later periods, especially the third to the first millennia BCE. Traces of older canals have been documented and roughly dated to the fourth millennium BCE (Thompson 1973; Alizadeh, 2008: 3, footnote 12).

The Ojirub's junction to the Dez river builds a vast wetland (estimated around 2,300 ha) with several generations of older meanders. The Siamansour reaches the Dez about 16 km southeast of this area and does not build any wetlands. Both are of meandering character, with the Siamansour meandering more strongly with a sinuosity index of 3.7, while the Ojirub has an index of 1.8. However, if one takes the estimated older flow of the Ojirub (shown in Figure 9), the sinuosity goes up to 2.1 and the spatial arrangement of the sites makes sense. Therefore, the author suggests that the Old-Ojirub and the Siamansour were the prominent watercourses during the Early Neolithic period. This adds to the newly found and dated buried watercourses to the southeast of KS0001 and northwest of KS0002 (Figure 6), which can be considered branches of the Old-Siamansour. Possibly, the Old-Ojirub had two upper branches, the buried one and the currently active one, similar to the Old-Siamansour with its branches near KS0002 and KS0001 (see traces of them on CORONA imagery in Figures 6 and 7).

The existence of these watercourses in the Formative and Archaic Susiana landscape affected the landscape of the Early Neolithic in many ways. The twofold nature of them is attested in the presented cores and profiles (compare different identified fluvial sediment packages in supporting information). The permanent flow is shown by the well-sorted sand silty packages with gravel, where the texture gets coarser with increasing depth (see examples in C1, C4). The seasonal flow is shown in the fluvial package with repeated sand and silt lenses, where the texture is vertically heterogeneous and horizontally homogeneous (as in C5 and C7). Furthermore, episodes of turbulent waterflow are attested in the identified sediment packages (for example in C7, C9, C12), which can be interpreted as the progress of hydraulic regime change in the area evolving from the braided palaeo river channels into incised riverbeds. Arguably, this event has taken place during the Mid-Holocene and continued into the Late Holocene (Kirkby 1977; Alizadeh *et al.* 2004; Rashidian 2020).

The gradual river shift had clear consequences for the landscape and its dwellers. At this point, one can only speculate at the extent of anthropogenic impact on this event. While the permanent and stable waterflow in the vicinity of KS0001 and KS0002 as well as KS0372 and KS0327 were gradually drying out with episodes of flooding and seasonal still water stands (as seen by the sedimentation here and in other places[2]), the settlements were growing physically, and the population seems to have increased (Hole 2004; Moghaddam 2019). This in turn led to an overexploitation of resources, especially grazing areas, and an alteration of the land-cover from the disappearing river terraces to steppe flora.

Based on this scenario, the Early Neolithic settlers were adapted to the wetter conditions of Early Holocene in Susiana and exploited the resources offered by braided river channels and numerous small wetlands in their vicinity, since Aceramic Susiana phase. Herding of goats and overgrazing the surface (among other land-use practices) altered the vegetation cover and led to a delay in overall tree vegetation in the Susiana plains. This might have contributed to a change in sediment freight of Palaeo-Dez River and its tributaries, including the Old-Ojirub and the Old-Siamansour (see Figures 6 to 9 for possible past channels). During the Formative and Archaic periods, this, and other geo-factors (such as the Mid-Holocene dry episodes and tectonic movements of the Zagros faulted belt) triggered a gradual riverbed migration and altered the hydrology of the plain towards less stable river channels and less abundant small wetlands around the settlements. As a response, some settlements were deserted for long periods (such as KS0002

[1]Sites including KS0042, KS0614, KS0004, KS0108, KS0041, KS0110, KS0109.

[2]See Rashidian 2017 for a similar case study of lost niche in the eastern corridor.

in Archaic Susiana 0 for about one millennium), and others were rearranged (such as KS0001 and KS0327, where the settlement is stretched towards the river in the Archaic horizon). Obviously, more evidence, especially detailed excavation of each site's relative horizons, is needed to examine this scenario. However, the practice of intentional settlement rearranging in response to a migrating watercourse has been discussed elsewhere, based on geoarchaeological evidence (Rashidian 2017; 2020; 2021).

The other lost water features of the Susiana palaeo-hydrolo=Early Neolithic Susiana are sparse but existent. This becomes clear by studying the water-related sediments in the presented cores and profiles (Figure 4; Figure 5). It is indeed difficult to differentiate between fluvial and pluvial sediments in the presented cores, as they both are of hydrological origin. However, a few points can indicate the existence of playa lakes in the Formative and Archaic Susiana landscape in this dataset. Pluvial sediments are (i) less well-sorted, (ii) made of more homogeneous material, and (iii) limited to a basin; while fluvial sediments have (i) a better sorting both horizontal and vertical, (ii) more heterogeneous material as they flow over a much longer distance, and (iii) lenses or packets of other particle sizes. With this in mind, one can speculate that a few seemingly fluvial sediment packages in the dataset might be pluvial. As an example, sediment packages presented in C1, C5, C7 are definitely fluvial according to this definition, while sediment packages in P4, P16, P17, P23 might be of pluvial origin.

In many soil profiles (see example in Figure 10; and supporting information for details), a wetland horizon[2] (horizons B and C) was documented, covered by a younger fluvial horizon (horizon A). In the absence of absolute dating for this horizon, correlating its depth with the documented virgin soil of the proximate sites affirms their shared surface indirectly. The unique biosphere created by such small wetlands can diversify the resources available to a settlement in terms of migrated fauna and halophile flora (see Tiner 2017 for elaborations). These are indirectly evident in the excavated material from KS0001 and KS0002 (Redding 2003; Miller Rosen 2003)[3] . Therefore, such landscape feature might have been considered favourable by the Early Neolithic settlers of Susiana. The spatial distribution of known Formative and Archaic settlements (Figure 1) might be explained by the presence of such playa lakes in their vicinity.

The gradual transgression of the Persian Gulf's head during the Early to Mid-Holocene (after its initial regression in the late Pleistocene) has affected the rate of erosion[4] and river incision in Susiana in later periods (Lambeck 1996; Lees & Falcon 1952; Sanlaville 2002). The extensive fluvial sedimentation of the Mid-Holocene has probably buried surface indications of such pluvial lakes and wetlands. Currently, a small fraction of such landscapes remains in the form of seasonal inland and playa lakes. This is especially the case in the vicinity of KS0001 and KS0002 and can be considered the remaining traces of a past landscape.

Palaeo-Land Use

The available data in this study did not directly contribute to the question of Early Neolithic land-use in Susiana. However, a targeted look at the available data in the archaeological discourse provides a series of crucial information regarding this matter. Some of these are discussed here.

Herding was a significant source of stock since the Early Neolithic period. Caprines were amongst the most captive herd animals (Moghaddam, 2012: 525). The majority of fauna remains from Archaic KS1 belong to captivated Caprines. Cattel is less presented, indicating a direct contact with the pastoral communities of north Susiana and Deh Luran, especially given that for cattle only a certain fraction of the body bones was discovered. This might indicate a hunting and primarily processing outside of the site. This changes in the Archaic Susiana 1 phase, where whole cattle in larger numbers are evident (Lev-Tov *et al*. 2017: 478-479). Most fauna finds of other sites consist of young

[1]This crucial topic is discussed by the author in a separate paper, currently under review.

[2]Indicated by highly reduced fine textured material consisting of waterlogged soil with high amounts of organic matter and electric conductivity (Tiner 2017).

[3]Similar conditions are assumed for the neighboring Deh Luran (Helbaek 1969).

[4]Unfortunately, no estimation of the erosion rate in the Early to Mid-Holocene has been made due to lack of extensive geodata from the region. In the absence of such holistic erosion models, we can only estimate the rate of erosion of the Susiana riverine landscape at the sample points, mentioned in this study. A general estimation or statement regarding this issue remains impossible at this time.

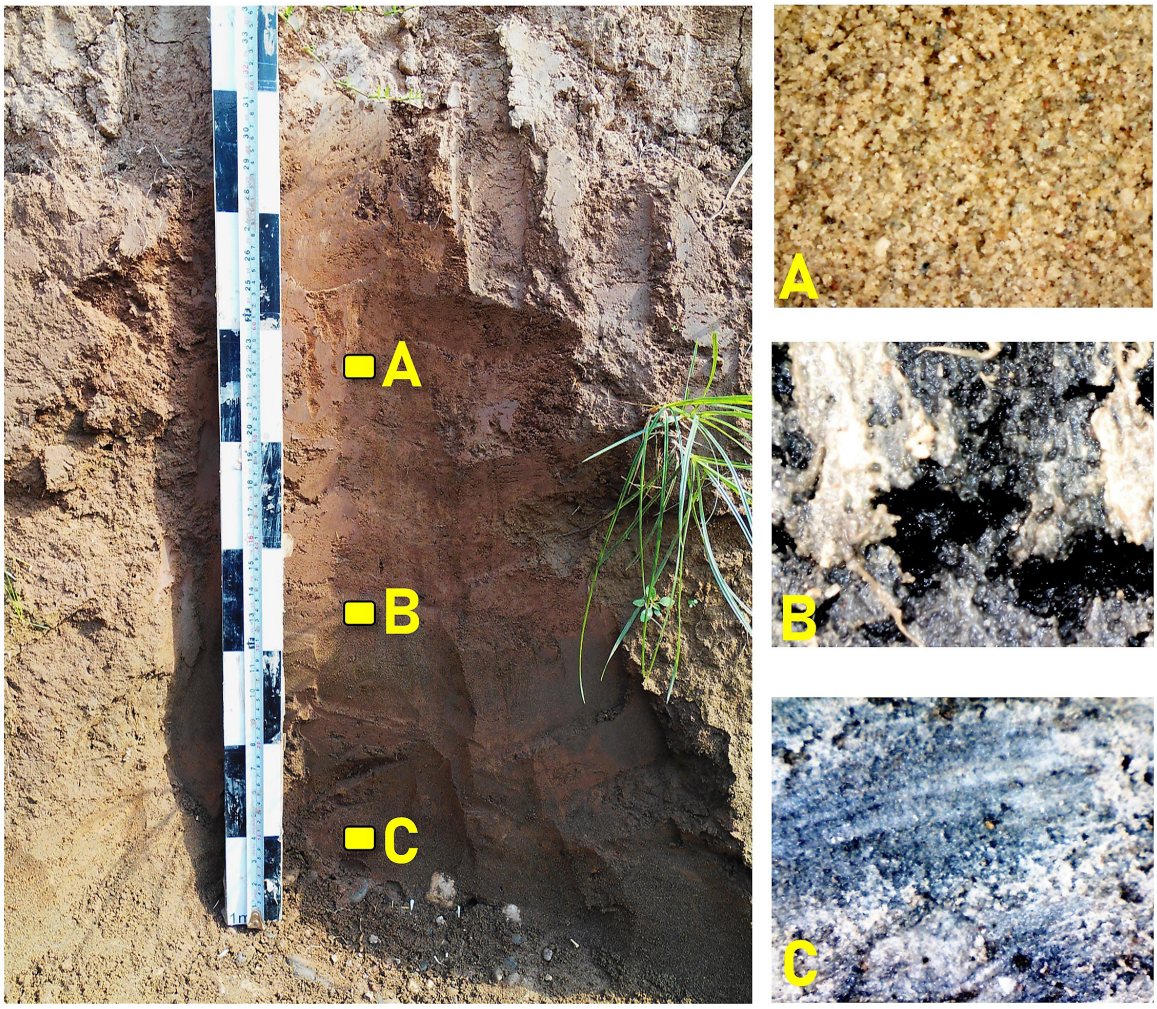


Figure .10: *Soil profile indicating buried wetlands between KS0001 and KS0002 (left), ProScope view (15x magnified) of its horizons (see supporting information for details on sediment packages) (illustrated by the author)*

goats, and older goats were probably also exploited as pack animals for transporting goods between the camps (Hole 1974; Sutliff 2015).

The Zagros region is a natural habitat for goats. A re-analysis of known finds from the Zagros Neolithic sites has brought evidence of early domestication of goat in the eight millennium BCE. In the seventh millennium, domesticated goat herding has become common practice outside of this natural habitat in the Deh Luran and Susiana regions (Zeder & Hesse 2000). The existence of domesticated dogs in KS0372 is of great importance regarding the practices of herding. Most herding evidence shows the breeding for meat in the Early Neolithic (Davis 1993; Zeder & Hesse 2000). Large herds' impact on the landscape due to their grazing and selective vegetation choice (Zeder & Hesse 2000) might have been decisive in further shaping the landscape's cover.

Palaeobotanical studies of Deh Luran and Susiana excavations indicate that barley was the favourable cereal in the Early Neolithic (Moghaddam, 2012: 526 after Helbaek 1969). Wild barley was one of the oldest cereals to be processed for food at that time. The process of barley domestication has been identified in several PPN sites in the Zagros foothills north of Deh Luran and Susiana from the Early Holocene period (Riehl *et al*. 2013). Faunal data of KS109 suggests that the area was much wetter than today, possibly even marshy, in the absence of woody vegetation (Alizadeh 2009; Miller Rosen, 2003: 127). Wild pig and cattle as well as gazelles were hunted. Herds of sheep, goats, and a small number of domestic cattle were kept on the site. Based on this evidence and the series of stratified levels of ash and material culture known from campsites of eastern Khuzestan, KS0109 was

probably occupied seasonally in winter and early spring in this period (Alizadeh, 2003: 21; Redding ,2003: 142). Evidence of seasonal wetlands in the region is scarce but significant. Based on the flora remains such as high reeds and the concentration of cultivated seeds in the muddy fossil horizons, agricultural land-use of such landscapes is probable (Miller Rosen, 2003: 131).

One blank page in this reconstruction is the original vegetation or land-cover. Sampling and pollen data analysis are necessary to build a database of Susiana's initial vegetation cover. As this is not available yet, one shall examine indirect evidence of vegetation to attempt any statements. Due to its direct impact on vegetation, the area's soil formation and evolution shall be considered. Currently, the area is covered by anthropogenic soils as a by-product of intensive irrigation. These soils are mostly clay loam with poor sorting and moderate drainage, yet not saline and not alkalic (Rashidian, 2020: 34-37; Veenenbos, 1958: 18-19). The initial vegetation might have been a high bush cover with lush grazing possibility in October to May and trees and scrubs in between. The current steppe land-cover is of anthropogenic origin in later millennia (Veenenbos, 1958: 53).

An important issue is the emergence of forests in the Zagros foothills (see last section for the evidence) from the Mid-Holocene, indicating a more open landscape in the earlier times (Hoseini *et al.* 2016). Recent reviews of published pollen data of southwestern Asia suggest that anthropogenic vegetation management such as intentional grazing of certain areas and tree selection (nut/fruit trees instead of oaks) in the vicinity of settlements have shaped the vegetation cover of the region during the Early to Mid-Holocene (Jones *et al*. 2019). Further investigation is needed to reconstruct a detailed vegetation cover for Susiana in the Early and Mid-Holocene. Based on the here suggested landscape reconstruction, one shall consider the following points in seeking further settlements from the Early Neolithic period in Susiana: (i) known sites lie in the vicinity of smaller streams and not on the river terraces; (ii) the sites' occupied area were up to 3 m higher than their surroundings, probably due to the wetland nature of the sinks and to prevent destruction due to seasonal stream floods; (iii) animal husbandry shaped the landscape's vegetation cover, which strongly varied seasonally; (iv) further sites might exist alongside the buried watercourse between KS0372 and KS0327, as well as south of KS109. The former might be easier to find, while the latter might be buried under at least 5 m of the Dez river's younger fluvial deposits.

One crucial aspect of such reconstructions is the concept of correlation, as mentioned in the Introduction. The correlation of goat-herding and barley cultivation is another example in this regard. As mentioned, both goat and barley have been domesticated in the Zagros foothills at the very beginning of the Early Neolithic period (Riehl *et al.* 2013; Zeder & Hesse 2000). It is noteworthy that grazing by large goat herds would help free arable land for barley cultivation in Susiana. Due to the small need for mutation from wild to domesticated barley, domestication was achieved in a few decades (Hillman & Davies 1990). Yet, the sizable land needed for this practice was not available prior to the emergence of goat husbandry. Models of early barley domestication suggest that the shift from old plots to virgin soil in each cultivation year was favourable to the mutations, also correlating with archaeobotanical finds (Hillman & Davies, 1990: 181). The evidence is scares and not comprehensive by all means. However, some argue that this aspect indicates a complex land-use practice (see Zeder 2016 for the concept of co-evolution), where the available land plots were shifting in use from goat herds grazing and barley cultivation each year. The cultivated land was probably expanded into the neighbouring virgin soil each year (Hillman & Davies, 1990: 199). This was only possible with the continuous enlargement of goat herds, which would graze more scrublands annually.

This practice correlates with the zoo-archaeological finds, which suggest that goats were kept longer and slaughtered at an older age in this period (see Zeder, 2016: 326 for the difference between goat and other animals regarding their domestication process). By keeping more goats and older animals, animal husbandry by-products such as textile and diary might also have expanded. Additionally, older goats were probably employed as pack animals and eased the transport of other goods and increased the interregional mobility of populations. The author argues that these two factors have correlated in manipulating the landscape in the Formative and Archaic Susiana and shifted the practices of land-use and food production in the Early Neolithic.

Concluding Remarks

This paper summarizes the current evidence and suggests a coarse and preliminary reconstruction of Formative and Archaic Susiana's palaeo-landscape based on new geoarchaeological evidence. Obviously, one cannot fully reconstruct an entire landscape with a limited number of cores and soil profiles as it is the case here. Extensive and in-depth further studies are needed to achieve this goal[1] . Therefore, this reconstruction shall be considered an outline for further studies. Hopefully, continuous data production from different disciplines such as field archaeology, geoarchaeology, zooarchaeology, and archaeobotanical studies will refine this model and provide a sharper image of the Neolithic human impact on past landscapes.

An essential point is to be made here. The study area was chosen to include all known sites with the Formative and Archaic material culture. Nevertheless, these might be a portion of the real settlement numbers, as discussed above. Probably, seventh and sixth millennia occupation levels exist in the unexcavated portions of several other known sites. Furthermore, dozens of sites with Formative and Archaic Susiana might have disappeared in recent centuries due to intensive land-use since the Sasanian era. A more accurate landscape reconstruction is always possible with successive data production in the near future. However, this loss of sites and cultural horizons cannot be compensated. Therefore, reconnaissance and deep trench excavations at the hundreds of the area's prehistoric sites are of utmost importance to provide a more realistic view of this crucial timespan's population and settlement dynamics.

Successive manipulation of the landscape and adopting to its response during a period of large-scale climate change in the Early Holocene enabled the Susiana plain's Neolithic population to acquire new land-use practices and exploit new resources. By the fifth millennium BCE, this landscape has been established (compare with Mesopotamia in Akkermans 2020), providing a wide range of possibilities for hierarchical societies' emergence, evident in Chogha Mish and later in Susa. Future archaeological investigations must consider this potential and finally integrate interdisciplinary methods into their projects to realize large-scale data production to verify and refine this hypothesis. Until then, this remains a probable but speculative story.

[1]A continuation of this fieldwork was originally planned for 2020, when the pandemic hit and made fieldwork impossible for the next two years. The author is now involved in other fieldwork for the near future, but intends to re-launch this project in 2024 for an extensive soil sampling at selected spots to address several issues arisen by the interpretation of the first phase, presented here. Among other methods, a sub-surface geo-prospection of several river incision sites and gathering datable samples for different shared horizons as well as inclusion of recent excavated materials at selected sites are planned.

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