A Note on the Gargar Irrigation System

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Sasanian's imperial policy aimed to construct new towns, massive irrigation infrastructures, and land modification by depopulating rural areas in order to carry out massive agriculture projects particularly in Khuzestan. Shushtar with its ancient relics presents a unique chance to investigate some of these development activities, mainly in terms of irrigation. Several chief irrigation organs have been identified inside and to south of Shushtar to shift parts of the Karun River water to the Gargar and control its flow in order to create a complex transformed landscape where it is known as the Mianab plain today.

The Gargar Channel and its expansion over the plain have not yet been systematically investigated. One of the main issues is whether the Gargar was opened as an artificial channel during Sasanian period or it was a natural stream, the flow and capability of which was utilized by ancient people for irrigation purposes. Two major obstacles to address this issue include lack of sufficient historical accounts about this ancient irrigation system, and landscape elucidation, i.e. separating changes created by human and those formed naturally through field examinations.

Evidence presented and briefly discussed in this article would hypothesize that this watercourse was originally a man made channel that was later on changed its course and formed a naturally cut river. That is why two terms are presented here: the Gargar "Channel" and the Gargar "River". It is also proposed that an avulsion had occurred at the point where Band-e Mahibazan is located and changed the course of the Gargar Channel forever.

Keywords: *Shushtar, Mianab Plain, Gargar River, Gargar Channel, Sasanian Irrigation System*

Introduction

The following discussion will sketch a general view on the Gargar irrigation system and its extension over the plains south of Shushtar. It also proposes an avulsion[1], which occurred at the point where Band-e Mahibazan is located and changed the course of the *Gargar Channel* forever. Whereas the further questions should be considered in greater details elsewhere, I hope this very brief observation provide new thoughts for those who wish to scrutinize the archaeological problems of the Sasanian period in the region.

Among Sasanian urban centers located in the Upper Khuzestan plain such as Ivan-e Karkheh, Jundishapur and Susa, Shushtar's ancient relicts provide a clearer picture of the Sasanian's imperial policy aimed to construct new towns, massive irrigation infrastructures, and land modification by depopulating rural areas in order to carry out massive agriculture projects (Adams 1981:215, Christensen 1993:107; Wilkinson 2003:92). From north to the south, the chief irrigation organs in this unique region can be outlined as follows. *Band-e Mizan*, a dike, was built merely to shift part of the Karun River water to the newly opened channel of *Gargar*. With a short distance from this point to the southwest of *Band-e Mizan*, the *Darioun* irrigation system and its complex subterranean canals and networks were uniquely created by perforating the sandstone rocks below the ancient Salasel Castle (this unique complex was heavily destroyed recently by Khuzestan Water and Power Authority-hereafter KWPA). A few hundred meters to the west of this complex, the multi functional infrastructure of *Shadorvan* weir was precisely built to increase the water level to drain in the *Darioun* and *Gargar* and stabilize the water flow. This weir was also utilized as a gigantic bridge. To the south, Waterfalls of Shushtar and their mysterious labyrinths and mills, the *Gargar River/ Channel* and *Band-e Mahibazan* are located, whose complex functions are poorly understood so far. *Band-e Khak* functioned as a complimentary bypass organ for *Darioun* system's overflow and a local mill (fig. 1). The huge earthen channels at the southern sector of the ancient town of *Dastva*, whose role has not been yet precisely

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1. " An abrupt shift of a river channel infavor of a new course. This frequently, but not necessarily, entails the abandonment of an earlier channel" (Wilkinson 2003: 223).

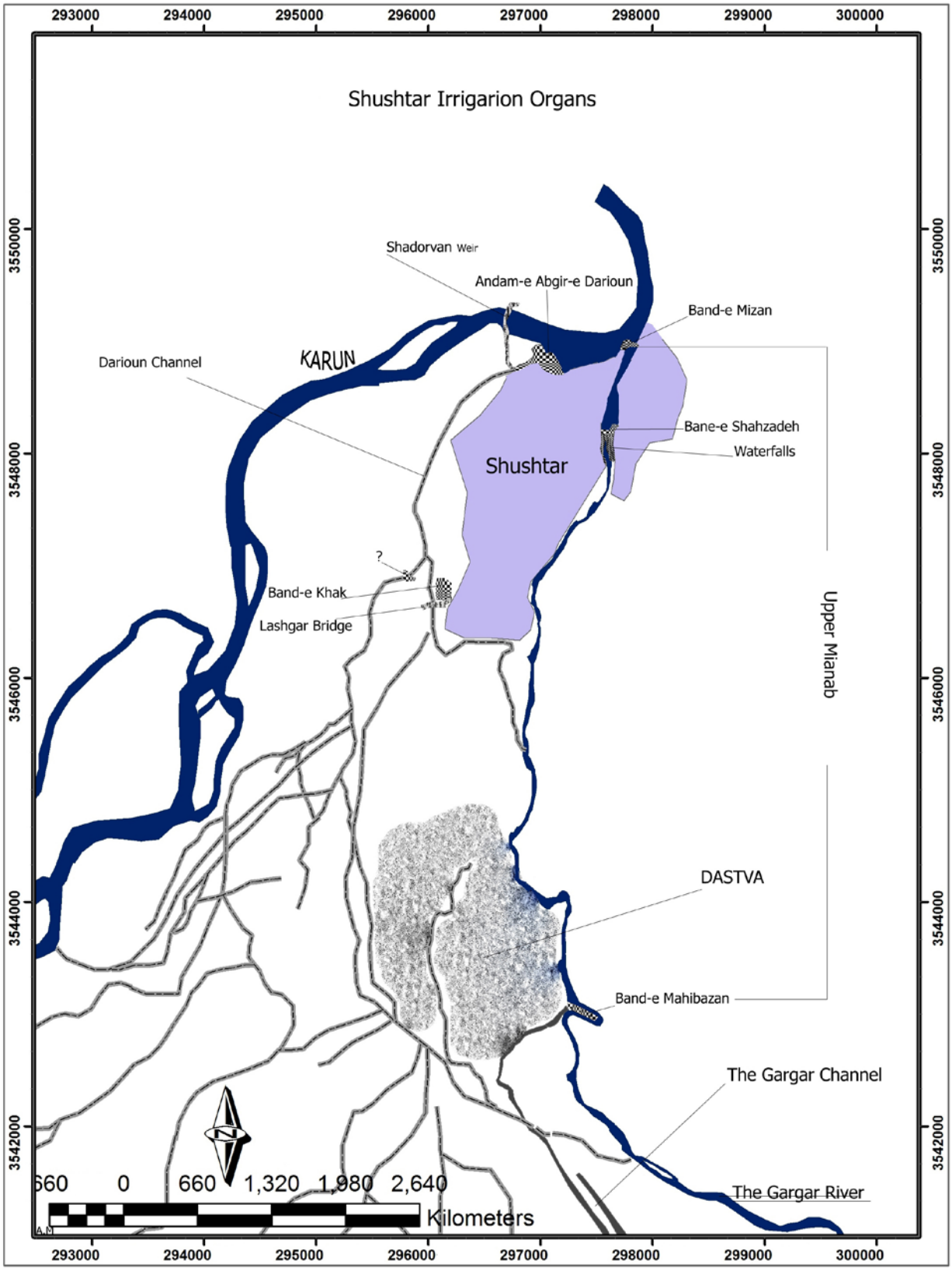


Fig.1: *Map showing the Shushtar Irrigation elements in the upper Mianab Plain.*

understood, and several other organs belonged to this irrigation system are extended across the landscape from immediate Zagros slopes to the flat lands on the northeast of Ahwaz (about 60 km long).

It can be briefly said that the Mianab plain was a unique region in *Iranshahr*, where huge investments have been allocated to create a complex transformed landscape. A late 7th century Syrian chronicle that covers the late Sasanian and Early Islamic period described Shushtar as follows:

"*This Shushtar is very extensive and strong, because of the mighty rivers and canals that surrounded it on every side like moats. One of these was called Ardashiragan, after Ardashir who dug it; another, which crossed it, was called Shamiram, after the queen; and another, Darayagan, after Darius. The largest of all of them was a mighty torrent, which flowed down from the northern mountains*". (Robinson 2004: 14, 17 from *Khuzistan Chronicle* 35:20/29:30-37:14/31:2).

The Gargar Channel and the Gargar River

The *Gargar Channel* (fig. 1, also known as *Ardashiragan*, *Masruqan* or *Do Dangeh*) and its expansion over the plain have not yet been systematically investigated. To some extents, the main question is whether the *Gargar* was opened as an artificial channel during early Sasanian period or it was a natural stream, which ancient people utilized its flow and capability for irrigation purposes.

This complicated dilemma about the origin of the *Gargar* is rooted firstly in lack of sufficient historical accounts about this ancient irrigation system. In fact, those historical accounts that we expect to shed most light on this historical matter were written by the Early Islamic historians and geographers (such as Tabari 1989; Maqdisi 1967; Tha'alibi 1968; Yaqut 1956; Istakhri 1976), a few hundred years after massive irrigation systems such as those of Shushtar were founded by the Sasanians and/or perhaps when they were in decline or even deserted by any reason. Thus, the surviving historical accounts are confusing rather than presenting clues for understanding the Sasanian construction history and particularly the irrigation systems that they created so intelligently.

Secondly, in his fundamental contribution to the archaeological landscapes of the Near East, Wilkinson (2003) has confronted the major difficulty related to the landscape elucidation, i.e. separating those changes created by human and those formed by the climatic diversity through field examinations. Such a controversial task has been the focus of archaeological surveys since the beginning of the last century. In the case of the Mianab plain, this problem is particularly relevant:, human modification of the natural landscape and its side effects can be considered as one of the major obstacles to illustrate the actual irrigation landscape. Additional human alteration of the landscape by new development projects (mostly by KWPA) is posing further difficulties to understand the ancient irrigation system.

Evidence presented and briefly discussed in this article would show that this watercourse was originally a man-made channel that later on changed its course and formed a naturally cut river. That is why we face two terms here: the *Gargar* "Channel" and the *Gargar* "River". Identifying the features that differentiates these two from each other seems to be the clue to understand the actual circumstances in which the Shushtar irrigation model was formed and extended like general model in the Near East (fig. 2).

To add to the above-mentioned obstacle caused by human, there is some considerable evidence that need to be addressed here. The modern landscape of the region (Mianab Plain and the Eastern Plain of the Gargar River) is the result of several geomorphologic episodes, which more likely started since fundamental irrigation projects were first generated. In other words, the Sasanians initiated major landscape transformations in the region. Consequently, further natural and political coincidences caused changes in water and sediment supply and then resulted in a change in fan style towards greater erosion or deposition in the plains to the east of the Karun River. Namely, a dry period in the late Sasanian era (Ca. A.D. 500 to A.D. 650) (Butzer 1975; Wenke 1976) and fall of the Sasanian empire in 641 A.D., whose immediate result could be

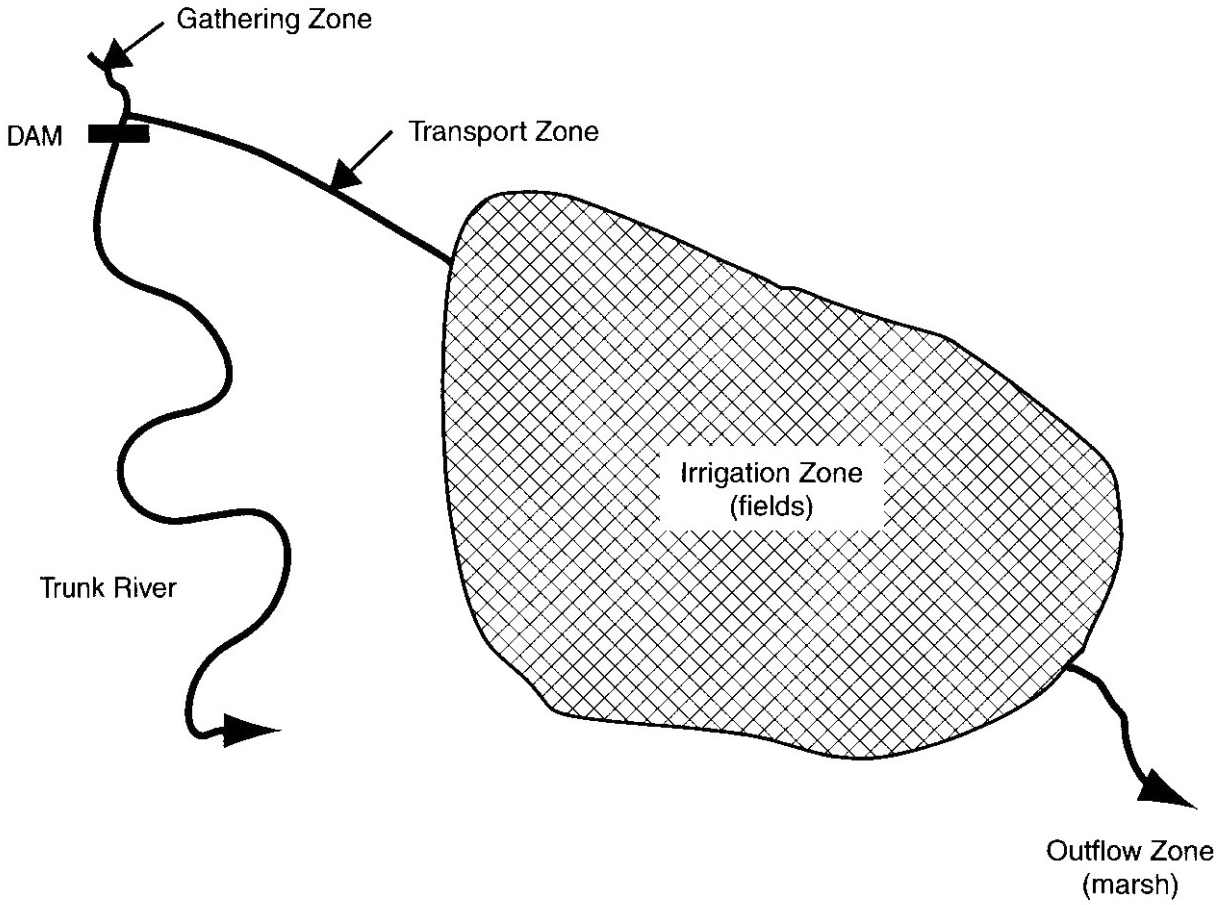


Fig. 2: *Elements of Irrigation systems in alluvial lowland such as southern Mesopotamia (After: Wilkinson 2003 p.49. fig. 4.2a).*

the suspension of any maintenance and management attempts in the highly invested and manmade irrigation systems. Then during the next phase, the collapse phase, some of the main infrastructures collapsed including the Darioun Entrance site or *Andam-e Abgir-e Darioun* (Moghaddam 2002) and probably Band-e Mahibazan.

In fact, a long period of environmental and taphonomic processes in the landscape started since the changes in the landforms accelerated after the collapse phase; in the alluvial plains, to some extent, this can lead to an anomaly in the course of major streams that would cause them either to shift their course or to entrench their bed deeper. A channel avulsion simply can cutoff the alluvium, which were previously accumulated by regular lighter sediments like silt and clay. Consequently, the new channeling activities force dynamically a fresh base level for a new local drainage system to be made. In the first place, this causes the earlier plain to be removed by erosion. The best example of this process can be found in the area around the Gargar extension (Lees and Falcon 1952).

Now we shall return to the main issue of considering the features that differentiated the *Gargar Channel* from the Gargar River: firstly where and in which circumstances this critical *avulsion* could have taken place and secondly whether the evidence of the Gargar channel can be drawn in the plains to the south.

The geomorphologic contrast between the northern and southern segments of the Mianab Plain and the situation in which this differentiation can dictate different drainage models for the Gargar stream can be measured. Upper Mianab with a higher elevation point (fig. 1) mostly lies on solid sandstone bedrocks, mudstones and heavily impacted gravels

like conglomerates. Thus, reasonably many tributaries cannot satisfactorily enter the Gargar at its base elevation. This opportunity ideally was utilized by Sasanians to create the most effective infrastructures of their irrigation system in this segment of the plain i.e. Band Mizan, Andam-e Abgire Darioun, Shadorvan weir, Waterfalls, etc. Conversely, the low-lying plain, mostly composed of silt and clay, in the rest of the plain toward Band-e Qir, made it possible for tributaries to adopt their system to the Gargar River base level shifts. A review of the Gargar extension will help to sketch our proposition, the Gargar Channel *avulsion*.

From north where the Gargar Channel emerges, there is a main dike known as Band-e Mizan. This sophisticated semi-dam was built right in the southern corner of a meander north of Shushtar. Further to the south in the Waterfall area, like what was mentioned before about the geological structure, the channel is deep enough to lead the water in the several sandstone labyrinths. Then the Gargar flows straightly down to the south where the ancient town of Dastva is located (fig. 1). In this point, there are two unusual tight meanders, one in the northeast and another in the southeast of Dastva (fig. 3- lines 1, 2). The northern meander (fig. 3-line 1) has not been investigated yet and it is likely that some stone structure could be found at this point as well. The second meander (fig. 3-line 2) is located where is known as Band-e Mahibazan. This is the second sophisticated infrastructure, partly natural and partly artificial, on the Gragar system after Band-e Mizan.

Band-e Mahibazan

Band-e Mahibazan is located about three kilometers south of Shushtar. The already described unusually tight meander in the present Gargar stream is vividly visible on satellite images and aerial photographs. Its exposed structure is about 570 m long and 14 m wide across the Gargar with an east-west direction. It has been famous as a major obstacle for the vessels that were navigating toward Shushtar in 19th century (Rawlinson 1839; Selby 1844; Layard 1846; Cruzon 1890; Blosse Leynch 1891). This feature continues further toward the west and even some exposed segments of it are visible south of Dastva. No sign of this feature is visible further to the west at the Karun River. However, the upraised bed of the Karun and its relative coarse-grained bedload imply that this large-scale geological feature extended regionally. These features are not unusual in the region since several low ridges can be still seen in the area between the east of the Gargar River and Dar-e Khazineh, which tend to parallel one another and are oriented from east to west or vice versa.

A precisely planned geomorphological survey and fieldwork would determine the function of Band-e Mahibazan across the Gargar valley. Nevertheless, some evidence could suggest that the structure might have functioned as *a semi dam to raise and shift the water flow to the controlled earthen channels* namely the *Gargar Channel*.

Evidently, during the Sasanian period the eastward extension of ancient Dastva developed just along the Gargar Channel while the west part of this town remained as a Middle Parthian settlement. There are some recent and crucial evidence that confirm our initial surface survey results (Moghaddam *et al.* 2005) in this particular area. Mr. Medi Rahbar, a senior archaeologist of the Iranian Center for Archaeological Research, who was conducting an excavation project in the eastern ruins of Dastva, discovered a Columned Hall with sophisticated Stucco reliefs dated to the Sasanian period (Mehdi Rahbar, personal communication 2007). The position of this newly discovered building somewhere beside the Gargar channel is noteworthy. It implies that the geological feature of the upper Gargar channel (north of Band-e Mahibazan) was strong enough to protect this Sasanian settlements and in particular important buildings such as the one mentioned above from any threatening critical changes in the channel courses..

Moreover, from Band-e Mizan to Band-e Mahibazan the Gargar channel presents a roughly straight and deep channel system with solid riverbanks; no trace of any river shift can be seen either on aerial and satellite photographs or through ground surveys.

The average minimum and maximum elevation

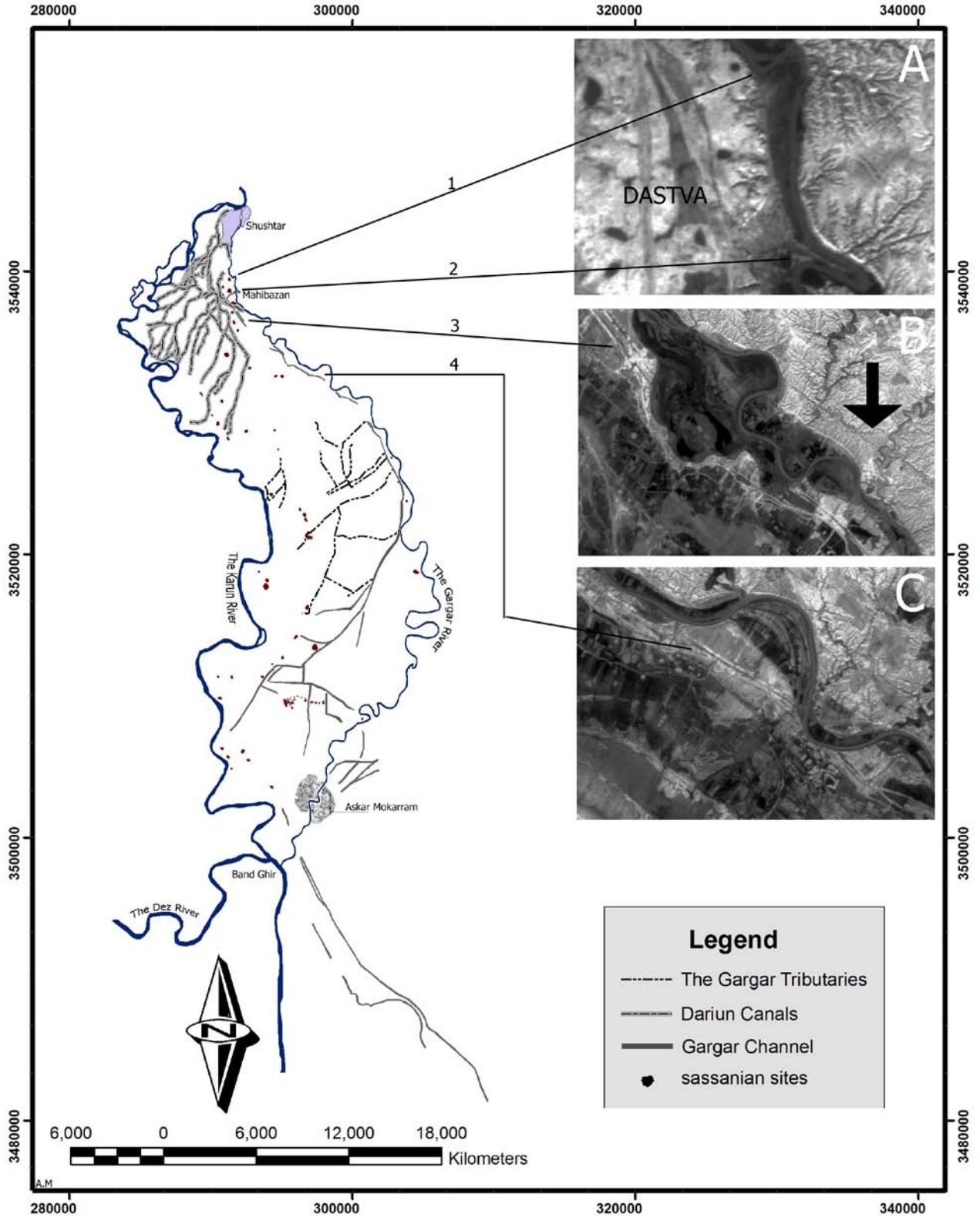


Fig.3: *Tracking the proposed Gargar irrigation system in the upper Mianab Plain.*

points in the area to the north of Band-e Mahibazan are respectively about 34 and 51 meters. In contrast, the minimum average of elevation in the south of this dike is about 29 meters and maximum elevation point is about 41. This remarkable drop in elevation points provides an ideal situation for a hydraulic system based on gravity.

Different restoration activities on Band-e Mahibazan itself indicate the importance of this dike during different periods. There are some examples that show this particular *band* has been frequently repaired even in later historical era. Some heavily oxidized coins were found in the mortars of the only remained baked brick wall in Band-e Mahibazan. According to Ali Jahangir and Mohsen Nabavi, two talented engineers who study the ancient relicts of Shushtar, the tradition of putting coins in the cement was common during the Safavid or Qajar periods in Shushtar while important infrastructures were being repaired such as Band-e Shadorvan, Pole Lashgar (Ali Jahangir and Mohsen Nabavi, personal communication 2002).

In the spot where the northwest angle of Band-e Mahibazan engaged with the right bank of the Gargar channel (fig. 3-line 2, fig. 4) there was a massive channel orienting northeast to southwest roughly leading to the point in which we suppose the actual Gargar channel flowed after Band-e Mahibazan (fig. 3-line 3). Unfortunately, later land use developments made much difficulty for further assessments of this phenomenon.

Interestingly, after Band-e Mahibazan toward the south, the modern Gargar River flows as a meandering river with several tortuous meanders. In addition, from this point to Band-e Qir, the configuration of the Garagr River dominated on young point bars. As a result, this critical point, Band-e Mahibazan, is the point that the *avulsion* on the *Gargar Channel* could have happened. By any reasons, which are still unknown, this huge dike collapsed and the water began to run away from its actual path (*Gargar Channel*) and consequently the Gargar River was emerged.

Tracking the *Gargar Channel*

While the obstacles to obtain and use aerial photographs and expensive low resolution satellite images in a suitable way was always a thorny part of any fieldwork (Philip *et al.* 2002), recent declassification of military satellite images such as CORONA has offered excellent opportunities for archaeologists to identify ancient remains much better than before (Kouchoukos 2001). It is true that the satellite view confirms some ground features at a glance; however, the clarity of the landscape elements in CORONA images guarantees a more careful ground survey, especially when the objective of the survey is to clarify the linear elements like irrigation canals. Thus, the high-



Fig.4: *Band-e Mahibazan in the south of ancient Dastva.*

resolution CORONA images and their large-scale coverage made a unique opportunity for us to have a holistic view on what is not simply distinguishable on the ground.

To track the *Gargar Channel* we utilized 1968 CORONA images of the region. On these images, parallel to the modern Gargar River, some clear marks of one or two straight canals down towards the south are visible. The most evident feature, which is clearly observable in the field as well, is a pair of channel in the south of Hesam Abad, a small village south of Shushtar (fig. 3-line 3). In addition, another channel mark, which is sliced by the modern Gargar River, is visible on the CORONA images. However, the ground surveys have not confirmed it yet. Possibly the Gargar River changes its banks since 1968 when the CORONA images were acquired. (fig. 3-line 4).

After this point, the *Gargar Channel* is taking a course parallel to the Gargar River until reaching the middle of the Mianab Plain. Technically, the leveling projects and extensive agricultural activities have planed away many signs of the *Gargar Channel* partly in the north and mainly in the mid-north. Besides, the saline land in the middle of the plain has made it difficult to evaluate linear features like the *Gargar Channel* in this area (figs. 3 and 5- the section between lines 4 and 5). While in the middle part of the Mianab Plain much remains uncertain about the *Gargar Channel* to be drawn by field observations, the southern Mianab presents much clearer evidence as regards the linear soil marks. The Gargar Channel was in fact a complimentary strategy for northern Darioun base irrigation system and was designed to water southern plains of Shushtar as far as Ahwaz. Thus, it is expectable that the density of the *Gargar Channel* irrigation system is found mostly in the south (fig. 5- the section between lines 5 and 6).

Sasanian settlements in the south of the Mianab plain are indicating a linear expansion along the crisscrossed canals. Sites such as KS 1615, KS 1559, KS 1562, KS 1664, and KS 1567 present a clear intimacy to the *Gargar Channel.* Among them KS1615 (fig. 5-line 5) presents a much clearer relationship with this *Channel*.

Further to the south (fig. 5-line 6), another set of dense crisscrossed channels are visible in the CORONA images. Heavy dissections however did not allow us to assess these linear features accurately on the ground.

One of the key points, which need to be considered in further detailed studies, is where exactly the Early to Middle Islamic town Askar Mukarram was located. Ibn-e Howqal has recorded Askar Mukarram as a station between Ram Hormoz and Shushtar along the road from Arrajan to Susa (Ibn-e Howqal 1967). Our surveys have confirmed the existence of a huge collapsed backed brick bridge which crossed the Gargar River in the middle of the ruins of Askar Mukarram (Moghaddam *et al.* 2005; for historical account see Istakhri 1976: 89). On one hand, this might challenge our preposition on the extension of the *Gargar Channel* across the plain and especially in the point where this town was located. On the other hand, it may help us to put the Gargar avulsion in a chronological order. It means that the time when this military base town was established or more likely when this town became a major station along the eastward Islamic trade road later in the Middle Islamic era, at least the *Gargar Channel* and its tributaries in the south of the Mianab Plain were already transformed. Besides, this bridge could be similar to what is known as Pol-e Lashgar. Interestingly Pol-e Lashgar was built across one of the main branches of the Darioun canal, which passed through Band-e Khak and made the famous moats or *Halqeh-e Abi-e Shushtar*.

The CORONA, aerial and satellite TM images confirm the continuation of the *Gargar Channel* as a linear feature south of Band-e Qir along the south western slope of the Kupal anticline (fig. 5-line 7). Nevertheless, there is some evidence that is worth to be pointed out here. Firstly, we need to bear in mind that the *Gargar Channel* was an "single" irrigation system originated at the point known as Band-e Mizan and passed through the plain south of Shushtar and ended up somewhere along the Kupal anticline in the east and the Karun flood basin in the north east of Ahwaz. Secondly, to make irrigation channels, ancient engineers were well aware of their natural landscape in such an alluvial plain. They must have predicted sever hazardous consequences

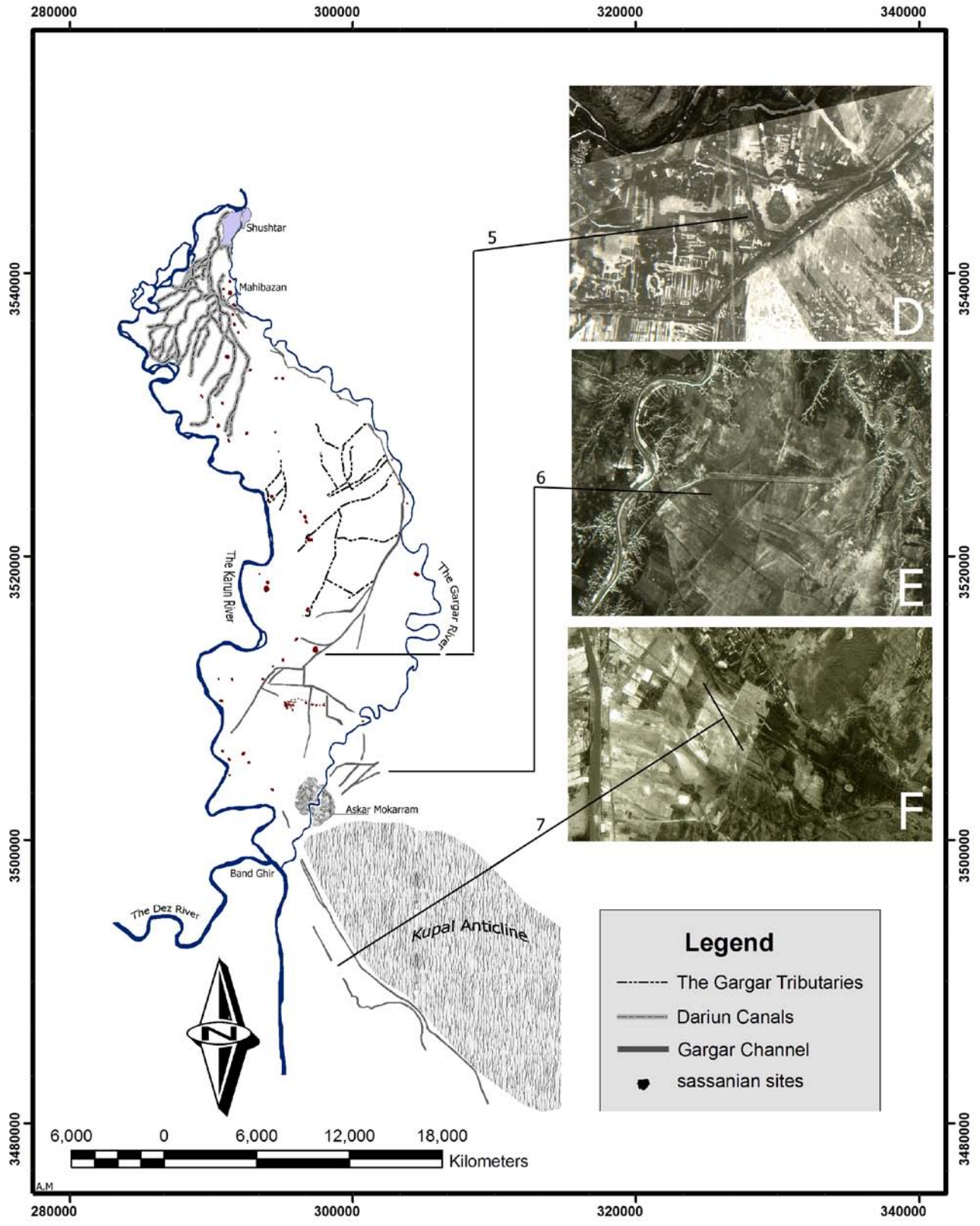


Fig.5: *Tracking the proposed Gargar irrigation system in the lower Mianab Plain.*

to their earthen based channels and hence they would choose moderately higher grounds to be dug, and then utilized various barrages and Bands to regulate the flow in channels. Thirdly, the most crucial point for such a system was to choose the proper location where the slope allows water to drain perfectly. Indeed, the main objective of building the *Gargar Channel* was to allow sufficient water to drain off "westward" for the due irrigation of the plains south of Shushtar. This strategy was achieved in the north by constructing Band-e Mahibazan, which could provide controlled water mostly for the right side that was topographically lower than the left side of the *Gargar Channel.* Modern landscape does not allow tracking the left side of the Gargar River. However, at least one linear feature can be identified on the east bank of the Gargar River (fig. 3- B). This linear feature could be a drainage channel to keep away the eastern wadi channels that previously flowed westward from Naft-e Sefid anticline to the *Gargar Channel*. Thus, Band-e Qir, the third and apparently the last Band /dike along the Gargar system was built to keep the water flow along the Kupal anticline not "between the Karun River and its flood basin" (Alizadeh et al. 2004: 81). The most significant aim for shifting the *Gargar Channel* to the east could have simply been extending the irrigation zone between the elevated bed along the Kupal anticline and the low-laying basin near the Karun River, where the geological features could ideally provide a gently sloping alluvium toward the west and south.

To the south and somewhere between the Kupal anticline and the Ahwaz ridge, the plain is dominated by soft and mottled brown sandy loams with sporadic very low sandy hills and shallow salty lakes covered by patchy reeds (fig. 6). Our field reconnaissance brings us to suggest this "bounded" area to be the last destination for the Gargar irrigation system. The situation could ideally provide an artificial *out flow zone* or *marsh* to be used as a diverse ecosystem with its plant composition, species richness and productivity or a Garden of Eden.

Conclusion

Two general lessons can be learned from this brief discussion on the Gargar irrigation system. First, apart from different obstacles to elucidate the irrigation landscape of the region and sever lack of proper evidence about the Sasanian world, new tools and techniques provide unprecedented possibilities to see beyond the corners. Shushtar example is definitely not the only extraordinary development project that was created by the Sasanians. Jondishapur, Ivan-e Karkheh, and many other areas and regions in Iran's southwestern alluvium have many to present. Thus, we need to move ahead quickly before the unpleasant developing projects wipe out remains of such significant investments forever. Second, the case of Shushtar potentially adds to our previous understanding of the Sasanian imperial policy in the Near East. Here, the Sasanian policy not only monopolize distinctive regional socio-economic organization that mainly labeled as vast agricultural production zones in the region, but they also employed a more progressive approach in which spatial, temporal and systemic regularities were firmly committed. It is expected that, all the aforementioned irrigation organs and systems worked together to make a suitable land across the plain from north (Shushtar) to the south (marshland). The Gargar irrigation system itself offered various advantages along its long path from north by running mills, making waterfalls, watering ca 60000 ha fields and at the end feeding the marshland in the south.

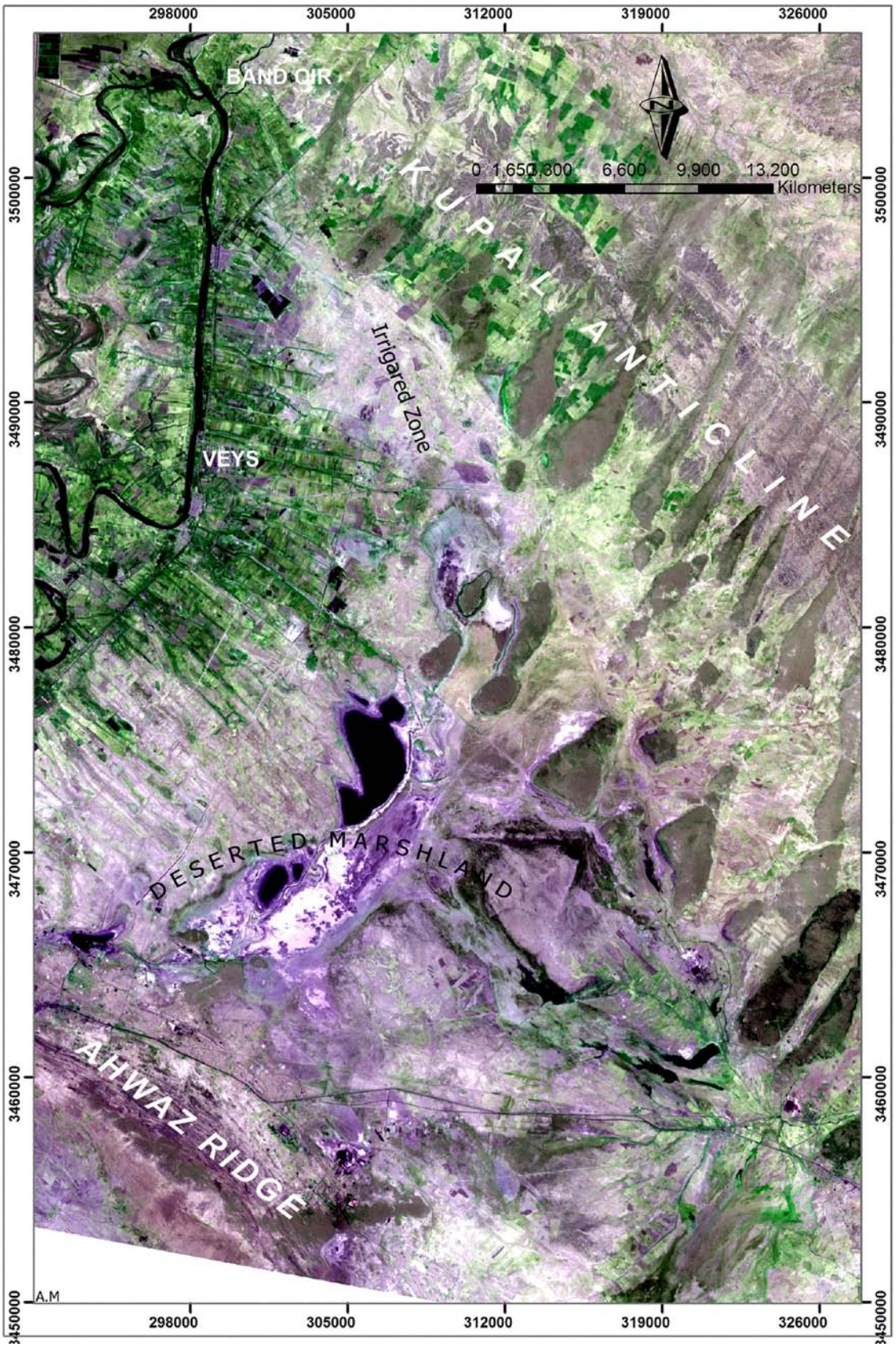


Fig.6: *Image showing the Ahvaz ridge and the proposed deserted marshland.*

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