

Investigating the northern Palmyrene hinterland a GIS-analysis

Tormod Storsveen Throndsen

-2017-

Without the knowledge and commitment of Jørgen Christian Meyer, the support of my father, the patience of my boys and valuable presence and advice of my Ingvild, this study could not have been conducted.

I am forever thankful - Tormod.

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1 Introduction

Palmyra has been a source of scholarly interest for decades. Scholars have investigated the city's remarkable political history, elaborate art and complex cultural expression with fascination. The Bride of the desert, as it often is called, grew from being a mere tribal settlement by an oasis in the middle of the dry Syrian steppe, into one of the largest cities in the Roman Empire, with perhaps as many as 200 000 inhabitants.¹ It was an ornamented city with temples, columnades and statues; a melting pot of Semitic, Babylonian, Arabic, Hellenic, Greek and Roman cultural expressions, prospering from long distance caravan trade between the Mediterranean and Euphrates. It became one of the major political forces in the Roman Empire when one of the few prominent women in Roman history, Zenobia, aspiring for imperial power with her young son, gained military control over large parts of the Roman Near East. At the peak of its power and prosperity, Palmyra then quickly lost its political powers and prominence in trade after Emperor Aurelian crushed Zenobia and her Palmyrene army in 272 AD. Palmyra lost its independent prominence and distinctive cultural expression. The old trading networks of the Syrian steppe changed, and the city became a stronghold along Via Diocletiana.

Knowledge of Palmyra is very comprehensive in fields like political history, art and cultural identity. However, there has been a major gap in knowledge concerning what the livelihood of the city actually was. The area around Palmyra receives less than 200 mm precipitation a year, which is far below the 400 mm of yearly precipitation believed to be the limit for stable agriculture.² Areas within the 200 mm isohyet are in general defined as marginal (referred to as the *200 mm-argument* in this study).³ This has created a notion that life in Palmyra depended on the oasis as natural resource, and on caravan trade as the source of wealth. Contrary to most other Roman cities, Palmyra seemed to be without a hinterland that contributed with foodstuff and products for the markets of the city.

Findings in the hinterland resulted in a shift in the scholarly debate. In the 1920s and 1930s French archaeologists discovered several settlements in the mountains north of Palmyra. From now on the question was not *if*, but *how* the hinterland contributed to the existence and wealth of Palmyra.

¹ Meyer (2013), p. 269.

² Syr/Nor (2008), p. 121.

³ Butcher (2003), 161.

The discoveries of the French archaeologists were somewhat marginal and limited to certain parts of the northern Palmyrene hinterland. There remained some uncertainty concerning how numerous and widespread the settlements were. During the last decade, large areas of the hinterland have undergone comprehensive research by a joint Syrian-Norwegian survey (hereafter referred to as the Syr/Nor-survey) in 2008-2011, which has increased the amount of knowledge of the northern Palmyrene hinterland drastically. A multitude of settlements from the Roman era have been discovered, distributed over a large area, indicating an active and developed hinterland. From asking how the hinterland contributed to Palmyra, scholars now asked how self-sufficient the hinterland was, and to what extent Palmyra depended on the hinterland, not the other way around. This argument was strengthened by the discovery made by the Syr/Nor-survey, that most sites continued to exist for a long time after 272 AD. The consequence of this new knowledge not only concerns the view we have on the Palmyrene hinterland, but also on the city of Palmyra.

As will be discussed in *Chapter 2 – Research*, scholars have suggested several theories concerning what the function of the northern Palmyrene hinterland might have been. Some have suggested that pastoralism was the function, that wealthy men of Palmyra developed settlements for the purpose of breeding horses and camels and herding goats. Others have suggested agriculture, the growing of barley, as its function, and argued that the settlements may have been more independent only trading with Palmyra, rather than having been organized by the wealthy men of Palmyra.

As is often the case in ancient history, there are few concluding sources on such issues. None of the theories suggested in the academic discourse can be ruled out. One can argue that the hinterland was a diverse area. This study emphasizes that the northern Palmyrene hinterland was not a homogenous entity, but consisted of several areas, probably with different functions. Each of the areas contained a range of different types of sites, probably with different functions, which might have developed over time. For all we know, a site might have been established as an estate by a wealthy man of Palmyra for the purpose of breeding horses, and then developed into a self-sufficient village, growing barley.

This study aims to contribute to the academic discourse by analysing the distribution of the sites in the northern Palmyrene hinterland using GIS.⁴ This includes compiling all relevant spatial information in a dataset (see table in appendix and GIS-project appended to this study),

⁴ Geographic Information Systems.

which concerns data contributed by all the surveys and researchers, in addition to data from paper maps digitized by this study, as well as features this study has located in satellite imagery. This data are the basis of two comprehensive analysis in GIS. The first is an analysis of the distribution of the sites. The second is an analysis of the natural resources of these sites. This creates a framework that aims to improve the basis of future interpretation.

The analysis will focus on how the sites were distributed in the northern Palmyrene hinterland. One of the main achievements of this study is the categorization of settlements into types based on size. This has led to the awareness that the hinterland contains six different types of sites; *large cluster-sites* (many buildings), *small cluster-sites* (slightly less amount of buildings), *couple-sites* (two buildings), *single-sites* (one buildings), *no building-sites* and *modern settlements* (with historical remains). The appearance of this sites quite consistent throughout the hinterland, which makes them ideal to study through GIS-analysis.

These sites are analysed based on which area in the hinterland they area located. As seen in the map in Figure 1.1, the northern Palmyrene hinterland can be divided into several parts. There are five mountains in the hinterland, reaching almost 1000 meter higher than Palmyra (at 400 mASL). These mountains contains the main areas of settlements. Jebel Bilaas (1185 m ASL) to the west, the neighbouring Jebel Chaar (1268 m ASL) and Jebel abu Rigmen (1389 m ALS) furthest to the east, are somewhat similar by being quite plateau shaped. Jebel Merah (1347 m ASL) in the middle of the area, is a sharp north/east-south/west going ridge, while Jebel Abyad (1329 m ASL) has a steep edge towards east and north, while smoothens towards south/west. The North/western-steppe is of special interest in this study. As will be shown in this study, it has favourably natural conditions, and contain several large sites. Together with Jebel Chaar and Jebel Bilaas, it creates a network of fairly large settlements.

Following the introduction in this study follows *Chapter 2 – Research*, which includes a detailed description of the research performed and evolving academic discourse. This is followed by *Chapter 3 – Method*, which contains a presentation of the method used in the making of this study. After this comes two chapters that contain GIS-analysis. *Chapter 4 – Distribution of the sites*, concerns the distribution of sites. *Chapter 5 – The water system of the northern Palmyrene hinterland*, contains a detailed description of the water system of the hinterland, accompanied by GIS. At last, *Chapter 6 – Conclusion*, contains a short summary of the results in addition to a discussion concerning the potential consequences of the results.

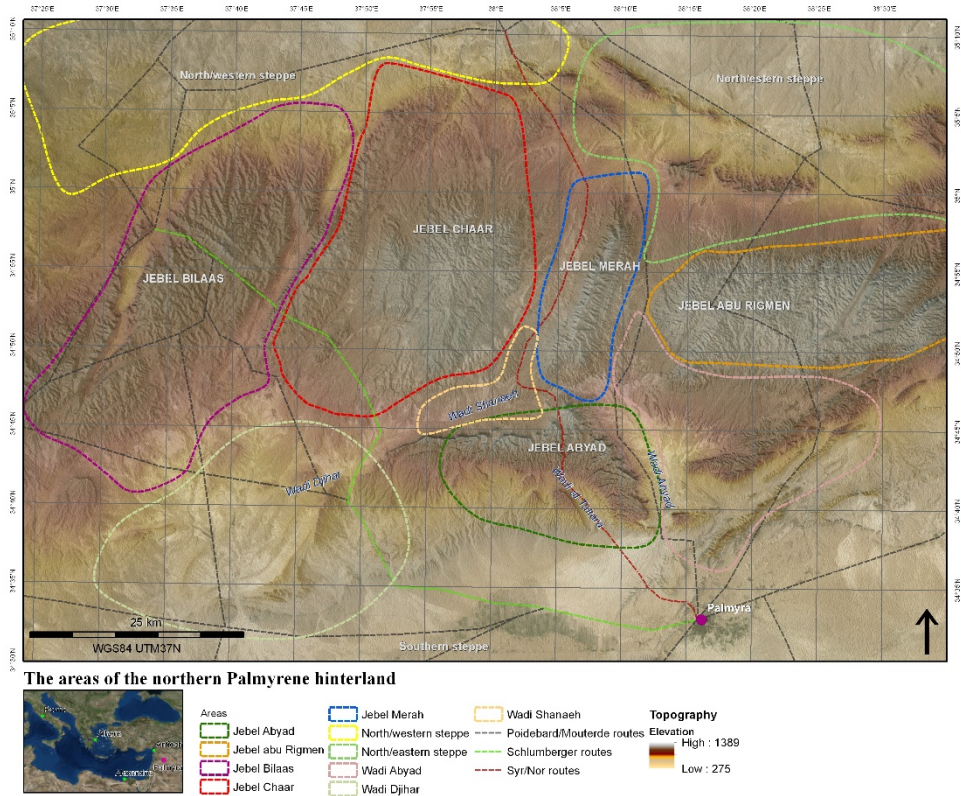


Figure 1.1: Showing map of the northern Palmyrene hinterland, including extent of the areas used in this study.

2 Research

The first scholar to investigate the sites in the mountainous area north of Palmyra was the Czech theologian Alois Musil. He was as much an explorer as an academic, travelling the Arab world in the early 20th century, where he surveyed the Palmyrene hinterland in 1912.⁵ Syria was then part of the Ottoman Empire, which made travelling for scholars more difficult than it was later.⁶ Musil's descriptions were presented in the book: *Palmyrena, A Topographical Itinerary* in 1928. Musil's book is quite narrative in style and is a mixture of how he experienced his journeys and what he observed. He travelled north-northwestwards through Wadi Abyad, and described a few sites. Besides being the first scholar to discover historical remains in the northern Palmyrene hinterland, Musil's most important contribution to the knowledge of the area were his observations of Bedouin life and the vegetation in the area.

Just a couple of years after the release of Musil's book, Michal Rostovtzeff published a book that would influence the understanding of Palmyra. In *Caravan cities* from 1932, he described Palmyra as a typical caravan city. One can assume that by this he implied that Palmyra lived on taxing and organizing long distance trade, importing the goods that were not produced in the city itself. He seems to be aware of ongoing investigations in the areas around Palmyra,⁷ and describes that some products were produced locally,⁸ which might imply that he thought the hinterland contributed to the existence of the city, but the main focus was on how Palmyra lived from the caravan trade. The chapter describing Palmyra in his book is called "Palmyra and Dura", which put Palmyra into the context of trade with the city of Dura Europos at the Euphrates.

The amount of knowledge of the hinterland increased after this, changing the understanding of Palmyra dramatically. In the aftermath of the first World War (1914-1918) and the fall of the Ottoman Empire (1922), the French gained influence in the region. This made it possible for French scholars of ancient history to perform surveys in Syria. A Jesuit priest named Antoine Poidebard surveyed the whole of Syria between 1925 and 1932. His observations were presented in the book *La trace de Rome dans le désert de Syrie. Le limes de Trajan à la conquête arabe. Recherches aériennes (1925-1932)* in 1934. After publishing the book, new

⁵ Musil (1928), p. 146.

⁶ Kennedy & Riley (1990), p. 61.

⁷ Rostovtzeff (1932), p. 92.

⁸ Rostovtzeff (1932), p. 128.

investigations started. This time Poidebard cooperated with another Jesuit priest named René Mouterde.⁹ Together they published the book *Le Limes de Chalcis. Organisation de la steppe en Haute Syrie romaine* in 1945.

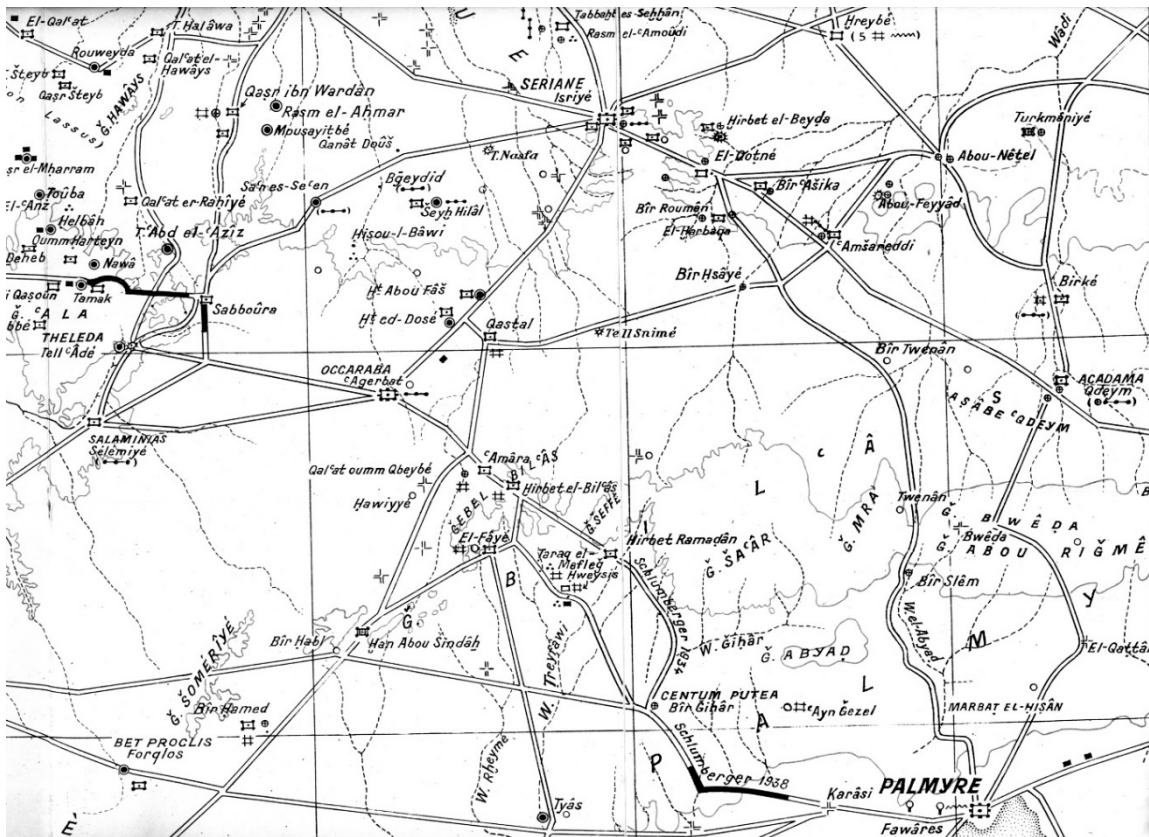


Figure 2.1: Outcrop of the map made by Poidebard and Mouterde showing the sites of his knowledge north of Palmyra, including suggested travel paths.

They performed aerial archaeology. Their method was to sit in an airplane and look for shadows of structures on the ground when the sun was low, taking photographs from the air, and on occasions land the aircraft and investigate the structure on the ground.¹⁰ Knowledge of how to make use of the vertical and horizontal angles of the sun was essential since some structures were only visible in certain light conditions.¹¹ Besides the possibility to cover large areas and discovering sites rather quickly, using an airplane helped Poidebard to see networks in the distribution of sites. This enabled him to suggest ancient roads and routes.¹²

The second book (*La Limes de Chalcis...*), is more an improvement rather than an extension of the first book (*Le limes de Trajan...*). This was probably because Poidebard in the early

⁹ Mouterde & Poidebard (1945), p. IX.

¹⁰ Kennedy & Riley (1990), p. 56.

¹¹ Kennedy & Riley (1990), p. 60.

¹² Kennedy & Riley (1990), p. 56.

phase normally flew 1500 m above the ground. This was excellent for a large overview, but not so good for detailed investigations. Therefore he started to fly 300 m above the ground for overview, and 25 m above the ground when investigating sites more in detail.¹³

Several surveys were performed in the Palmyrene hinterland in November 1937 and November 1939. Most of the surveys (at least four) were led by Poidebard, while one survey (towards the northern plain) was led by Mouterde. As Poidebard lists in the book, the surveys were accompanied by members of the Ministère de l'Air et à l'Aviation du Levant, including three pilots and three photographers of military rank.¹⁴ Poidebard and Mouterde documented a total of 20 sites in the mountain range north of Palmyra, including Jebel Bilaas to the west, the lower slopes of Jebel Bilaas and Wadi Djihar, the upper part of Wadi Abyad next to Jebel Merah and on and around Jebel abu Rigmen. The distribution of the sites they documented indicates that they did not follow a strict pattern of lines in a grid based on coordinates. Most of the sites are documented in the outskirts of the area, only a few are documented in the central parts, with Jebel Chaar not included.

While Musil was the pioneer in discovering sites in the northern Palmyrene Hinterland, Poidebard and Mouterde placed the sites into a large network, and made the existence of settlements logical in light of the communication lines between forts and large cities.

The most important investigation made in this early period was performed by the French archaeologist Daniel Schlumberger. As part of the French historical research activity in Syria, he went to Palmyra in 1924, where he later became Inspecteur des Antiquités (1929-1940).¹⁵ He performed a detailed survey in the southern part of the mountain plateau of Jebel Chaar and northern part of Jebel Abyad, areas not covered by Poidebard and Mouterde. This was presented in his book *La Palmyrene dui Nord-Quest*, published in 1951.

¹³ Kennedy & Riley (1990), p. 59.

¹⁴ Mouterde & Poidebard (1945), p. XI.

¹⁵ Gelin, Mathilde. Daniel Schlumberger In : Daniel Schlumberger. L'Occident à la rencontre de l'Orient [en ligne]. Damas : Presses de l'Ifpo, 2010, p. 19-21.

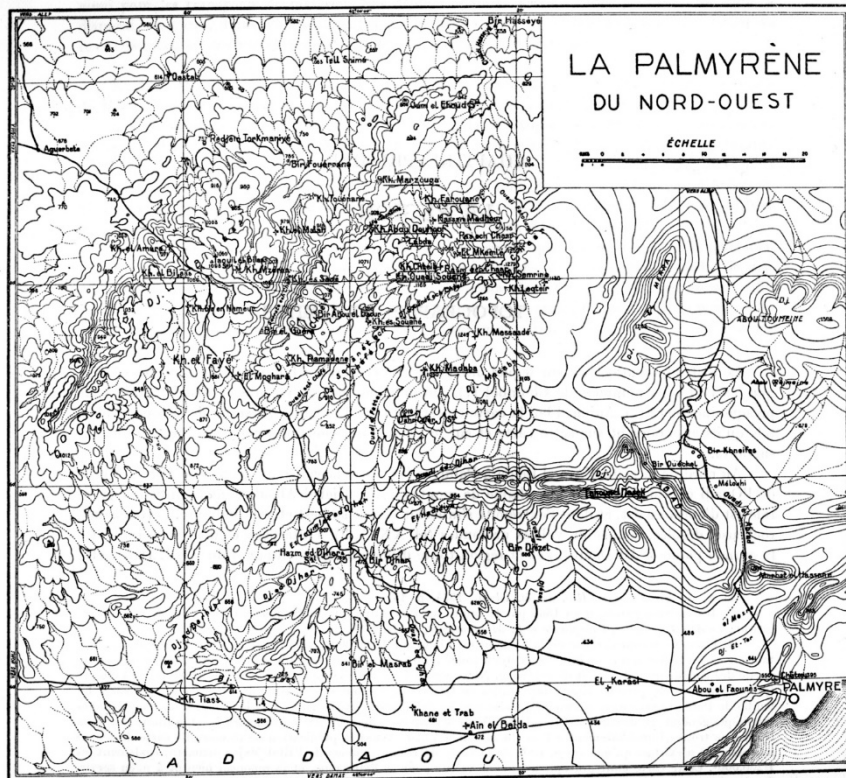


FIG. 1. — La Palmyrène du Nord-Ouest (sites fouillés soulignés).

Figure 2.1: Map made by Daniel Schlumberger that shows the distribution of sites of his knowledge in the northern Palmyrene hinterland, including suggested path north/west.

Schlumberger documented 18 sites in detail, 16 at Jebel Chaar, and two at Jebel Abyad, among them large settlements with impressive buildings with banquet halls and courtyards surrounded by a multitude of cisterns.¹⁶ The main interest of Schlumberger was sanctuaries, which he investigated in detail. He also included some information about other buildings and on some sites he included information about water resources, but not for every site. The layout of seven of the sites have been mapped in detail in Schlumberger`s book.

The documented sites are described in detail in the book, and his investigations on the ground must have been comprehensive. We know that he borrowed the airplane of Poidebard,¹⁷ but whether he used it for aerial investigations or for transport is difficult to say. He suggested the existence of some roads, which are included in the maps of Poidebard and Mouterde.

Poidebard describes how they cooperated by sharing information.¹⁸

Schlumberger`s contribution to the field of research should not be underestimated. Not only did he show that the central parts of the mountain range contained sites, he also showed that

¹⁶ Meyer (2016), p. 86; Schlumberger on courtyards: p. 13-44, banquet halls: p. 101-106, cisterns: p. 10-11.

¹⁷ Kennedy & Riley (1990), p. 51.

¹⁸ Mouterde & Poidebard (1945), p. VIII.

the sites were numerous, as well as rather large and advanced. In the academic discussion in the rest of the century, these are the sites that have been discussed. Schlumberger argued that the hinterland likely was relevant to the city of Palmyra. He suggested that the settlements were ranches used for breeding horses.¹⁹ Breeding of horses was important for the Palmyrene cavalry,²⁰ which might mean that Schlumberger linked the settlements to the Palmyrene city state. By this, he argued that Palmyra was more similar to other Roman cities than earlier believed. Schlumberger was probably still reluctant concerning the natural resources of the hinterland, and did not suggest agricultural functions like other rural hinterlands had.

A few years after Schlumberger's book came out, Ernest Will argued that the settlements was not only in related to the Palmyrene city state, but also to wealthy men dealing with Palmyrene trade. In a commentary to Rostovtzeff's theories, Will discussed the role of the *Soados* (So'adu), who were one of the most powerful of the persons involved in the caravan trade. Their power were based on their means to ensure equipment needed for caravan trade.²¹ Will listed necessary equipment as camels and staff, which he suggested came from settlements in the hinterland. By including staff on his list, one might anticipate that Will indicated that there were fixed settlers in the hinterland, i.e. more than only seasonal workers related to the breeding of animals.

In the decades following the release of Schlumberger's book, there was little academic activity in the northern Palmyrene hinterland, except for a joint Syrian/American survey, looking for sites from the second millennium B.C. in 1966,²² This means that findings by Schlumberger for a long time were at the centre of the discussion.

The academic interest for the Near East and Palmyra gained new strength in the 1990s, with the book *The Roman Near East (31 BC-AD 337)* published by Fergus Millar in 1993. After this, several other books on the Roman Near East were published, like *Rome in the East: The Transformation of an Empire* by Warwick Ball in 2000, *Roman Syria: And the Near East* by Kevin Butcher in 2003, and *The Middle East under Rome* by Maurice Sartre in 2005.

While none of these authors were particularly interested in the Palmyrene hinterland, and only mentions it vaguely,²³ the academic discussion concerning the northern Palmyrene hinterland

¹⁹ Schlumberger (1951), p. 130; Meyer (2016), p. 91.

²⁰ Butcher (2003), p. 157.

²¹ Will (1957), p. 270.

²² Syr/Nor-2008, p. 63.

²³ Millar (1993), p. 297, 300, 328, 333, 509; Butcher (2003), p. 156, 178; Sartre (2005), p. 65.

gained new strength in 1994 when Michal Gawlikowski discussed the *Soados* in an article concerning the Palmyra Tariff. Although Palmyra clearly was a caravan city, as attested in several inscriptions,²⁴ the main document regulating the Palmyrene trade, the Palmyra Tariff, concerned only small and local trade, describing no international trade at all.²⁵ Gawlikowski described the *Soados* as masters of great herding estates around Palmyra.²⁶ If Gawlikowski includes herding of goats in his definition of “herding”, this indicated that the hinterland was also used as provider of products for the trade, not only providers of equipment as Will suggested. The Palmyrenes seem to have specialized in making goatskin sacks for carrying water, in fact this practice seems to have been enforced by law.²⁷ Moreover, goat was possibly the preferred meat, knowing that pork and beef consumption was low.²⁸ The herding of large flocks of goats in the hinterland seems likely.

Gary K. Young also discussed the role of the *Soados* in his book, from 2001, *Rome`s eastern trade: International commerce and imperial policy, 31 BC – AD 305*. Here, he agrees with Will and Gawlikowski that the estates north of Palmyra probably belonged to wealthy men of Palmyra. He actually uses the word farming,²⁹ which might indicate that he included some form of growing of crops to the contribution of the hinterland.³⁰ Young disagreed with Will in how much involvement in trade the *Soados* had. Rather than patrons, protectors or leaders who were enriched by the trade, they performed services to the traders, and owed their original wealth to the estates in the hinterland.³¹ One might suggest that by this, Young indicates an indirectness in the hinterland`s relationship to the large city, and in turn that the settlements had some independence from the city.

At this point one had quite limited information about the hinterland in terms of actual findings on the ground. Most of the knowledge of sites in the area came from Schlumberger, and he had only investigated settlements at Jebel Chaar and in limited parts of Jebel Abyad. Even though Will describes how the settlements were scattered all over the area, Jebel Bilaas, Jebel Merah, Jebel abu Rigmen, Wadi Shanaeh, Wadi Djihar, Wadi Abyad and most parts of Jebel Abyad, were to a large extent undescribed. In addition, Schlumberger was mostly interested in

²⁴ Gawlikowski (1994), p. 28.

²⁵ Gawlikowski (1994), p. 28.

²⁶ Gawlikowski (1994), p. 31.

²⁷ Sartre (2005), p. 244.

²⁸ Butcher (2003), p. 170.

²⁹ Meyer (2013), p. 170.

³⁰ Young (2001), p. 150-151.

³¹ Young (2001), p. 151.

special buildings as sanctuaries, with water resources outside his main scope of interest. This meant that one had very limited knowledge of how water was managed in this dry region, leaving scholars reluctant to conclude as to how self-sufficient the region was.

During the last decade, a Syrian/Norwegian research team has surveyed the area, and documented a large number of new sites at Jebel Abyad, Jebel Shanaeh and Jebel Merah. Several new sites were also discovered at Jebel Chaar in addition to many sites discovered in satellite imagery at Jebel Bilaas and Jebel abu Rigmen. In 2008 a joint Syrian/Norwegian (Syr/Nor) team started to survey the region. In total three comprehensive surveys were performed. Several new sites were documented and three comprehensive survey reports were published in 2008, 2009 and 2011. Except for the American survey in 1966, these were the first historical surveys in the northern Palmyrene hinterland since Poidebard's last visit in 1939.

The first investigations were performed in cooperation between the Museum in Palmyra and the University of Bergen.³² This included three detailed surveys performed in 2008, 2009 and 2011. The team was led by Michel al-Maqdissi (Direction Générale des Antiquités et des Musées, Ministère de la Culture), Walid El-Assad (Directeur des Musées de Palmyre) and Jørgen Christian Meyer (University of Bergen).³³ The goal was to "...elucidate the exploration of the landscape north of Palmyra, and by that the relationship between the large city of Palmyra and the hinterland."³⁴

In total the survey investigated 65 sites in detail. They investigated 21 sites at Jebel Abyad, seven sites in Wadi Shanaeh, one in the southern slopes of Jebel Chaar. At Jebel Merah they investigated 12 sites at the western side, 20 sites southern and eastern side and two at the northern side. Towards the northern steppe they investigated two sites.

In addition the team observed (and plotted) 22 settlements and two isolated water resources outside the scope of the survey. These sites were located on Jebel Chaar (one overlapping with Schlumberger), Jebel Bilaas and in Wadi Shanaeh and Wadi Djihar,

The Syr/Nor-survey improved the knowledge of the area drastically. It showed that Jebel Chaar was even more densely settled with sites than the sites Schlumberger had discovered. It showed that Jebel Merah was quite densely settled. In addition it showed that Jebel Abyad

³² Syr/Nor (2009), p. 112.

³³ Syr/Nor (2008), p. 1.

³⁴ Syr/Nor (2011), p. 4.

had several sites, although not as densely settled as Jebel Chaar. One of the objectives of the survey was to suggest another main route towards the north from Palmyra than the route suggested by Musil and Poidebard. The previous suggestion was that the route went straight north from Palmyra, through Wadi Abyad on the eastern side of Jebel Abyad, up east of Jebel Merah and west of Jebel abu Rigmen. The Syr/Nor-survey made it likely that a main route went north through Wadi Takara, to Wadi Shanaeh, and on the western side of Jebel Merah, east of Jebel Chaar. The investigations also provided detailed information about structures and water resources, which makes it possible to understand how the sites functioned – something Schlumberger was not too concerned with. The Syr/Nor-surveys only observed and measured, they didn't perform any digging.

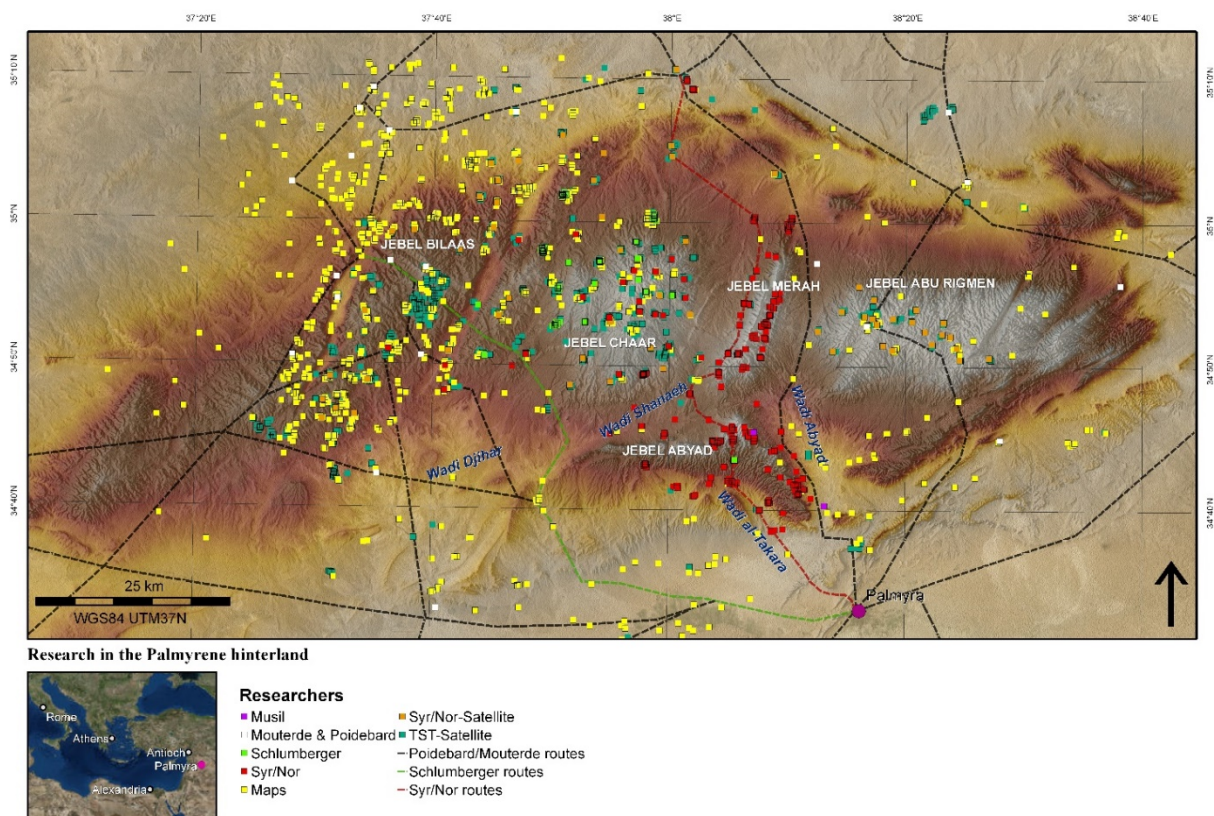


Figure 3.6: Map showing the documented buildings, structures and water resources mapped by different researchers in the northern Palmyrene hinterland.

Meyer stated in an article from 2013 that the hinterland must have been much more abundant in resources than earlier believed. Where Young vaguely mentioned farming in a broad sense as a possible activity in the region, Meyer argued comprehensively that far from being an area of mere pastoralism,³⁵ the hinterland was a possible provider of wheat and barley for the city.

³⁵ Breeding and/or herding of animals.

Circumstantial evidence supports this argument. The great population of Palmyra probably needed more grain than what could have been produced in the immediate surroundings of the city.³⁶ The density of the investigated settlements, especially at Jebel Chaar and Jebel Merah, resemble areas involved in grain agriculture, not only animal breeding and herding.³⁷ Meyer emphasized that the area was more vegetated in former times.³⁸ Several quite recent attempts at dry farming have been performed in the area,³⁹ and the recent investigations show a variety of water management systems in the area, not only for human and animal usage.

This gives a new perspective to the idea of a tribal-identity in Palmyra. Schlumberger observed a nomadic connection in the settlements at Jebel Chaar.⁴⁰ The relationship was later discussed by Will and Gawlikowski,⁴¹ and as the latter argues, cooperation with nomadic sheiks was essential for the success of Palmyrene trade.⁴² Andrew M. Smith II, in his book *Roman Palmyra: Identity, Community, and State Formation* from 2013, saw the settlements organized as tribes with strong connections to Palmyra. He argued that nomadic and sedentary, pastoralists, herders and farmers, were not exclusive categories, but rather intermixed.⁴³ By this he indicated that the settlements were not owned by wealthy men of Palmyra, but were more independent.

The relationship between Palmyra and the hinterland was discussed in a recent article by Meyer. He argued that if the area produced grain, which is indicated in the Palmyra Tariff,⁴⁴ it was probably more self-sufficient, a perhaps more indirect in its relation to Palmyra than earlier thought. According to Meyer, this theory is strengthened by the observations made by Schlumberger, who stated that the settlements were somewhat culturally different from the city of Palmyra.⁴⁵ This independence from Palmyra is further supported by the fact that most of the newly documented sites can be dated to have continued to exist after Aurelian's actions in the 270s, well into Byzantine and Umayyad periods. Schlumberger and scholars until the last decade assumed that the settlements were abandoned after the fall of Palmyra in 272-3 AD.⁴⁶ Concerning the nomadic connection mentioned by many other scholars, Meyer

³⁶ Meyer (2013), p. 270.

³⁷ Meyer (2013), p. 271.

³⁸ Meyer (2013), p. 272.

³⁹ Meyer (2013), p. 172.

⁴⁰ Schlumberger (1951), p. 129-131.

⁴¹ Will (1957), p. 272.

⁴² Gawlikowski (1994), p. 32.

⁴³ Smith (2013), p. 49-50.

⁴⁴ Matthews (1984), p. 173; Meyer (2016), p. 91.

⁴⁵ Schlumberger (1951), p. 124-128.

⁴⁶ Butcher (2003), 157.

suggested that the settlements were part of nomadic herding circles, and that the natural resources were so rich that they could have economic relations than just with the city of Palmyra.⁴⁷

In the years following the on-ground surveys of the Syr/Nor-team, they have performed investigations in satellite imagery (i.e. Google Earth and Bing maps) as part of after phase of the survey on ground. This has resulted in 65 new sites in the whole area being described, including 21 at Jebel abu Righmen (where no other survey has previously been performed), and seven additions to existing sites at Jebel Merah.

⁴⁷ Meyer (2016), p. 90.

3 Method

As mentioned, the basic method of this study is using GIS. Using GIS for analysis to the extent done in this study, is not very widespread in the field of history and archaeology. GIS is often used for mapping and visualizing historical features, which it is done in this study too. Using GIS to analyse historical features is less common. In that context, GIS-analysis as historical method is quite new territory. It is essentially quantitative, a way of analysing statistical data spatially. This includes defining objects and analysing where they are located. The main challenge with this method is that qualitative aspects are not always possible to analyse as quantitative objects. As is often a concern in ancient archaeology, it is not always easy to define what an object is. Compared with modern statistical analysis in general, the data in which the GIS-analysis in this study are based is extremely uncertain. However, as is made evident in this study, the results of the GIS-analysis is still a great way of creating a framework for historical interpretation, and a great way of seeing historical objects in a the context of its natural conditions.

This study aims to contribute to the academic discourse concerning the northern Palmyrene hinterland in three ways: The first is gathering all relevant spatial information in a dataset. In this chapter, the way the data have been acquired and put into the dataset is discussed. The second way is to analysing the dataset using GIS by categorizing the data and analysing the distribution of it. This is often done in the analysis in modern transport sector, not so usual in the field of ancient history. The third way this study contributes to the academic discours is by analysing the water resources and water management in the area using GIS. This involves advanced analysis of interpolated surfaces, more usual in the field of geoscience and hydrology.

These three ways will be discussed in the following section.

3.1 Gathering spatial information

All the research performed in the northern Palmyrene hinterland, including that of this study, is gathered in a dataset containing 2850 features. 975 of these are building or structures, while 1875 are water resources. The detailed data is gathered in a GIS dataset and listed in table format as appendix to this study. The are of many different types and are categorized according to the following list:

- *Forts* are military buildings built to house soldiers, either to defend or police the area. They could also have a role in local tax farming.
- *Stations* are smaller military buildings along main travel routes, which housed soldiers to secure travellers, and functioned as resting place for travellers. As forts, they could also have a role in the local tax farming.
- *Sanctuaries* are buildings built for religious purposes, either temples of worship, or small shrines only a few square meters large.
- *Buildings* are houses of different purposes and different sizes.
- *Structures* are remains that either are diffuse buildings or some kind of enclosures.
- Tells are usually collapsed houses beneath newer houses, that also might be covered with soil.
- A *wall* is a structure that does not have the function of a building, and is often related to water management.
- A *corral* is an enclosure built with stones often used as animals pens.
- A *cave* can be natural or cut into rock, and are often used as tombs or shelters.
- A *tomb* is a rock cut grave chamber, but in this study the category also include grave fields.
- *Inscriptions* are remains of text written at stone tablets, or at walls of buildings.
- A *spring* is a natural water resource where ground water comes up to the surface.
- A *well* is a water resource which receives water from the water bearing strata.
- A *cistern* is subsurface vessel that receives water from the surface. The category *cistern* is mostly used to describe possible water resources documented in satellite imagery in this study, even though the water resource might be a spring or well. As will be discussed later, many cisterns are connected to catch-arms in order to improve the amount of water flowing into the cistern.
- A *dam* is a water resource that receives and stores water on top of the surface.
- A *water installation* is, in this study, defined as a water management system that distributes the water for further use from a water resource.

The sources of these features are different, and the level of information and level of accuracy differs. 598 of the features are documented by a survey, 852 features are documented in the maps and 1400 features are located in satellite imagery. Some historical features are investigated on the ground and the location is accurately measured with GPS, while other features are detected in satellite imagery without knowing whether they are actual historical

features. One can not rule out wrongful plotting and misinterpretation made by this study. How the different features have been gathered, will be discussed in the following sections.

3.1.1 Surveys

3.1.1.1 *Poidebard and Mouterde*

The 20 sites documented by Poidebard and Mouterde are located by digitizing and geo-referencing⁴⁸ the map included in their book *La lime de Chalcis* (seen in Figure 2.1). The map is geo-referenced using locations in the map that are known, for instance Palmyra. It is a hand drawn, rather rough map, but it is made with geographical reference, which makes it useful with the help of digitized items in the Maps and satellite imagery.

Poidebard and Mouterde originally documented their features on a vast scale, and their level of detail is often rather low. Many of the sites were not visited on ground, and they have been criticized for being too eager to date sites as Roman, when they have been of later origin.⁴⁹

3.1.1.2 *Schlumberger*

The sites documented by Schlumberger are presented in an overview map, and in narrative descriptions in his book. Just the same, there is some uncertainty concerning the specific position of many of the sites.⁵⁰ The included map is quite coarse in scale, and there is often a challenge to pin point the exact location. Using satellite imagery, the maps and descriptions of Schlumberger, in addition to on-ground information from the Syr/Nor-survey Meyer has made suggestions about the positions of the sites. Still, the positions only are of high confidence for eight of the sites at Jebel Chaar, leaving the positions of the rest of the sites to less certainty. Schlumberger included detailed drawings of the plan of some of the sites he investigated. Using these drawings combined satellite imagery, this study has plotted buildings and water resources.⁵¹ There is some uncertainty concerning the water resources attributed to Schlumberger. They are not specifically mentioned in the text, and is based on an assumption by this study that the spots marked with “c” in the drawing indicates cisterns. Schlumberger, however, mentions for most of these places that they cisterns.

⁴⁸ Geo-referencing is a way of relating a map or an image to real coordinates. By this one can digitize all items in an old map and get their coordinates.

⁴⁹ Kennedy & Riley (1990), p. 16.

⁵⁰ Syr/Nor (2009), p. 107.

⁵¹ These features are described as contributed by Schlumberger in the dataset.

3.1.1.3 *Syr/Nor-survey*

All the Syr/Nor-surveys are investigated on the ground. The locations are therefore certain. There is, however, some difference in the level of detail between the sites. In the Syr/Nor-surveys of 2008, 2009 and 2011 each feature is plotted with GPS. A range of sites are also located by the Syr/Nor-team in 2008 and 2009, not as part of the survey. In 2009 this was in cooperation with Petro-Canada. Only the position of these sites were plotted with GPS, none of the features of the sites. Suggestions of potential features and water resources based on satellite imagery are added by this study at the sites located by the Syr/Nor-team not the part of the survey.⁵²

3.1.2 The Maps

Included in the dataset is information on historical sites and water resources from general paper maps made in the course of the 20th century. They consist of German maps made by the in the 1940s, French/Arabic maps made in the 1950s and Russian maps made in 1960s and 1980s. They are referred to as the Maps in this study. What they include and how they were added to the dataset, is described in the following sections.

3.1.2.1 *German maps*

During the Second World War, German cartographers mapped the whole region, including some historical locations and water resources. There are 22 unique sites in the German maps that are described as historical remains.⁵³ They are mostly distributed on Jebel Bilaas and Jebel Chaar, with some on the plain south of Jebel Abyad, and some on the plain south of the mountain range. Five of these are visible historical sites in satellite imagery. Nine of the sites are located at modern settlements, and eight sites are less obvious in satellite imagery. All the modern settlements are located on the western side of Jebel Bilaas.

⁵² These features are described as contributed by TST (the author of this study) in the dataset. The credit of the features belongs to the Syr/Nor-Survey, but the reason for describing them as contributed by TST is that the Syr/Nor-Survey is not responsible in any errors made in the plotting of these features.

⁵³ Symbolized as “Ruins” or “Tells”, which are ruins covered by earth.

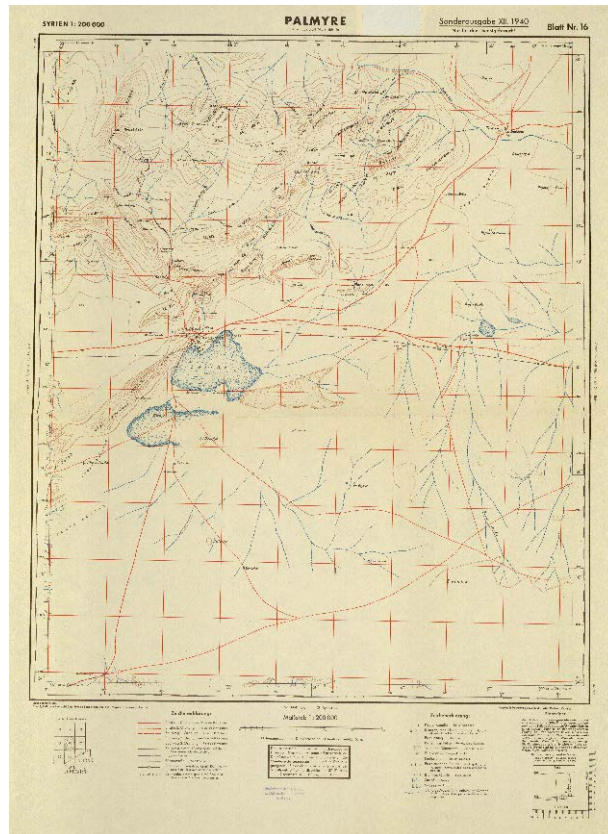


Figure 2.1: Showing one of the German maps from the 1940s the Syrian steppe.

3.1.2.2 French maps

As the 20th century progressed, the French regained control after the Second World War. In the 1950s French cartographers mapped the region. The French maps have 23 unique historical sites, with several sites at Jebel abu Rigmen and the southern parts of Jebel Merah. Some sites are in the southern slopes of Jebel Abyad, and one is located far to the south/west of Jebel Bilaas. Twenty of the sites are described as tells, while three are described as ruins. None of the sites are obvious in satellite imagery. This may have to do with a general difficulty of identifying tells in satellite imagery. The maps do not contribute with any major sites.

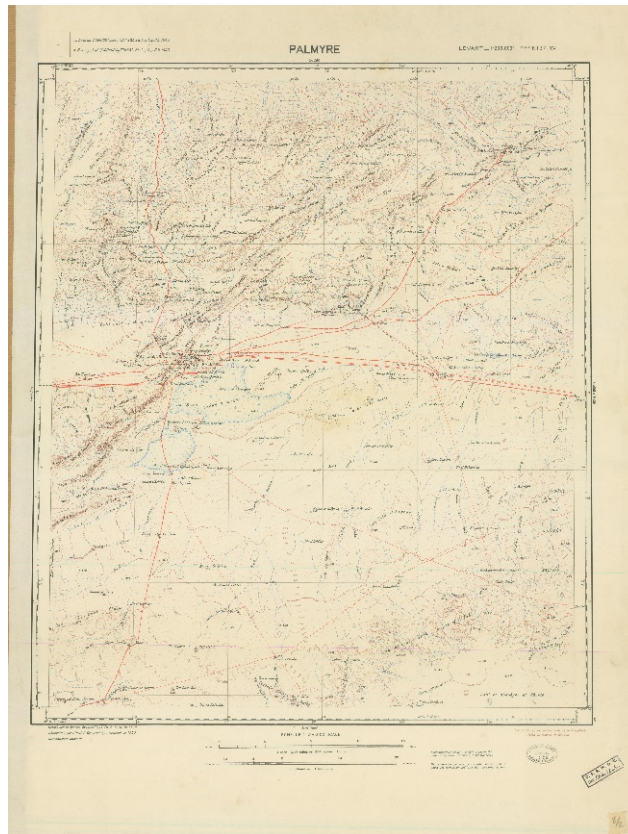


Figure 3.2: Showing French map from the 1950s covering Palmyra.

During the 1960s to 1980s it was the Russians turn to gain influence of the area. Russian cartographers mapped the area in 1962 and performed a revision 1981.⁵⁴ Their maps contain 50 unique historical sites. Most of the sites are in the outlet of Wadi Djihar and at Jebel Bilaas, with a couple sites at Jebel Chaar, one in the upper parts of Wadi Abyad, and one on the southern side of the mountain range. Of these, 16 are quite evident in satellite imagery. Eleven are located at modern settlements, and 23 are more less obviously identified in satellite imagery.

⁵⁴ Syr/Nor-2009, p. 35.

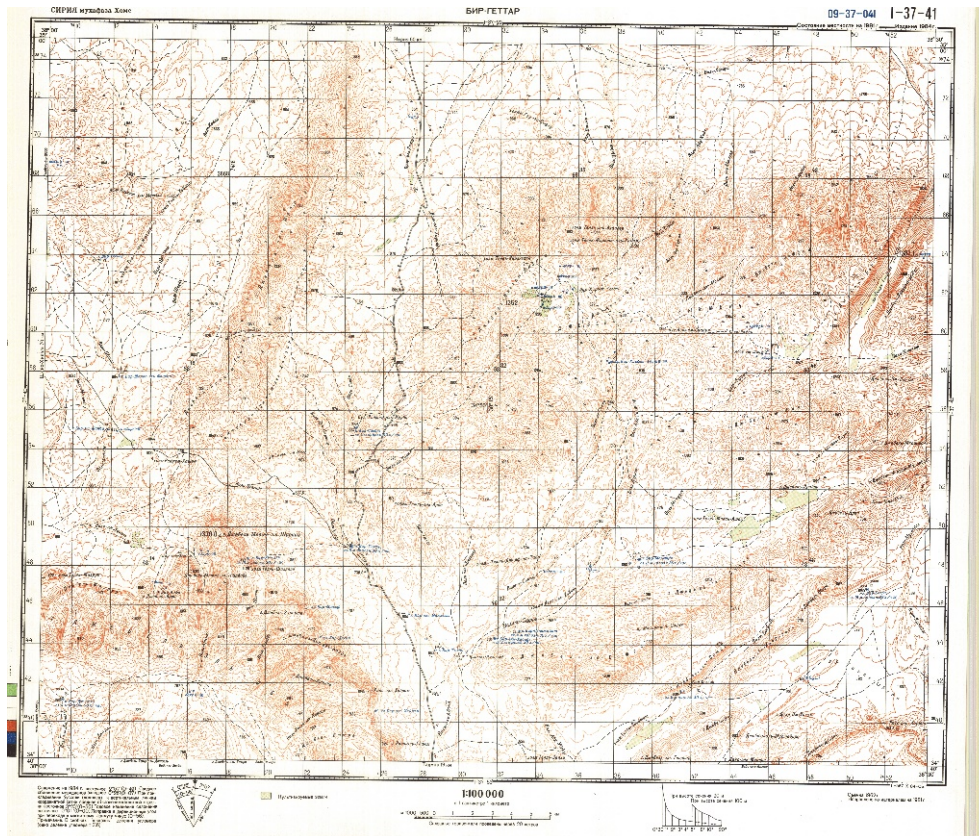


Figure 3.4: Showing Russian map from the 1960s/1980s covering the Palmyrene hinterland.

There are 94 historical sites altogether plotted on the maps. Water resources were of more interest to the cartographers, and 762 water resources are documented in the maps. They are categorized by type: spring, well, and pits/reservoirs (mostly cisterns).

In the same way as with the maps of Poidebard and Mouterde, the German, French and Russian Maps were digitized and geo-referenced by this study, before the relevant items they contain were plotted using GIS. The maps are far more accurate than the maps of Poidebard and Mouterde, but being large scale, paper maps, some inaccuracy must be expected – at least for what is required for in a detailed GIS-analysis.⁵⁵ The German- and French maps can be several hundred meters off compared to satellite imagery. The Russian Maps are more accurate, but also these maps can have items more than 100 m off.

Since historical sites are not the main scope of the cartographers, we have little information about them, and many large sites documented by others, have been overlooked by the

⁵⁵ For the GIS-analysis in this MA-thesis, all the items in the Maps have been adjusted manually when they are recognisable in satellite imagery. In cases where the items in the different Maps overlap, the Russian items have been used.

cartographers. Of the 94 sites, 21 are modern settlements, while 19 are visible structures in satellite imagery. The rest are hard to confirm based on satellite imagery, but there are no obvious reasons why the German, French, and Russian cartographers should plot them if they weren't there.

The plotting of water resources in the Maps is not perfect. Several water resources located by other surveys are not included in any of the Maps. On the other hand, the Maps include a large number of water resources the surveys do not include, especially at Jebel Bilaas and Jebel abu Righmen where no surveys have performed research on ground.

One might question the consistency of how the cartographers searched. The water resources documented in the Maps are more densely distributed at Jebel Bilaas and Jebel Chaar than other areas. This might be due to a majority of water resources in these areas, but there is a total lack of water resources around Jebel Merah where the other surveys have documented a huge amount of cisterns, and there are relatively few water resources documented at Jebel abu Righmen where a number of sites have been discovered in satellite imagery.

It is also important to emphasize that errors made in the manual plotting of the maps in GIS may have occurred. The Maps cover large areas, include much information that is not relevant for this study and can be unclear in certain places.

3.1.3 Satellite imagery

Satellite imagery (Google Earth and Bing Maps) has been used by Meyer of the Syr/Nor-survey to locate the sites documented by Schlumberger, as well as for discovering new sites. Satellite imagery has been used by the author of this study for three purposes:

- Locating sites and features documented in digitized paper maps.
- Locating additional features in sites already discovered by a survey or in the Maps.
- Discovering new features and sites.

This has been performed using Bing Maps as a background layer in the ArcGIS software,⁵⁶ and plotting features that are visible in the satellite imagery directly into the dataset. The Bing Maps consist of several layers with different resolution based on how close one is to the ground. This means that when looking at a feature at the scale 100 000 : 1, fewer things are actually visible than when looking at the same feature at the scale 1000 : 1, because one is looking at two different images, taken at different dates, with a different resolution. For most

⁵⁶ Google earth is not available as background layer in ArcGIS.

parts of the northern Palmyrene hinterland this follows a natural change in detail that comes with zooming in and out on a map.⁵⁷

As with flying an airplane, the closer one get, the higher the level of detail, and the lower the degree of overview. Ideally, one would search for new sites at a small scale. Most of the remains in the northern Palmyrene hinterland are more or less covered with soil. Many of the sites investigated by the Syr/Nor-survey on the ground would have been very hard to detect in satellite imagery, and one lacks the possibility to look for shadows at certain times of day like Poidebard did.

Water resources can also be difficult to spot in satellite imagery. They can be shown as green areas of vegetation, distinct holes in the ground, or piles of dirt from the up-cast.⁵⁸ Any of these might be something other than water resources, and there is often no way of telling what type of water resource it is.⁵⁹ The only certain definition is when there are large catch arms close to the water resource, which indicate that there was a cistern charged with surface water. The type of the potential water resources documented in satellite imagery is defined as the undefined category “wrs” in the dataset.

Discovering new sites in satellite imagery needs careful study. This study has used a combination of three approaches:

- *Systematic approach:*⁶⁰ One approach is to study systematically along lines that ensures that every part of the area has been looked at. A challenge with this is that it might lead to over-detection. When performing visual interpretation, many can attest that there is a tendency to see more things the longer one interprets. Natural formations and traces of recent activity might therefore be eventually interpreted as historical remains.
- *Relational approach:* Another approach is to search in areas where other features have been detected. A house or a village tends to be in a network with other houses and networks. The downside of this approach is that isolated houses or settlements might be overlooked.

⁵⁷ With a couple of exceptions: The images with highest resolution at the eastern side of Jebel Abyad are grey scale, not coloured, and large areas far to the north are of poor quality.

⁵⁸ Deposits from digging and maintaining the water resource.

⁵⁹ Spring, well or cistern.

⁶⁰ Names of methods are suggested by the author of this study.

- *Empirical approach*: A variant of this to learn how already documented objects look in satellite imagery, and search for similarities in other areas. By this method one can detect buildings, water resources and catch-arms with greater certainty.

Many of the items identified by this study in satellite imagery are additions to documented sites. There are also a number of new sites discovered.⁶¹ In total, 1254 items are plotted by this study, including 436 buildings/structures and 818 potential water resources.

3.2 Categorizing the data

The documented features are located all over the Palmyrene hinterland. In several areas they are geographically related to each other. 311 locations contain remains of human building activity, buildings, structures, corrals, cairns etc. These locations are called *sites* in this study. In addition there are more than 110 locations that contain water resources without any evident building activity visible in satellite imagery.⁶² While these water resources are, in most cases, developed by humans and should be investigated, they are often isolated and in sparsely settled areas.

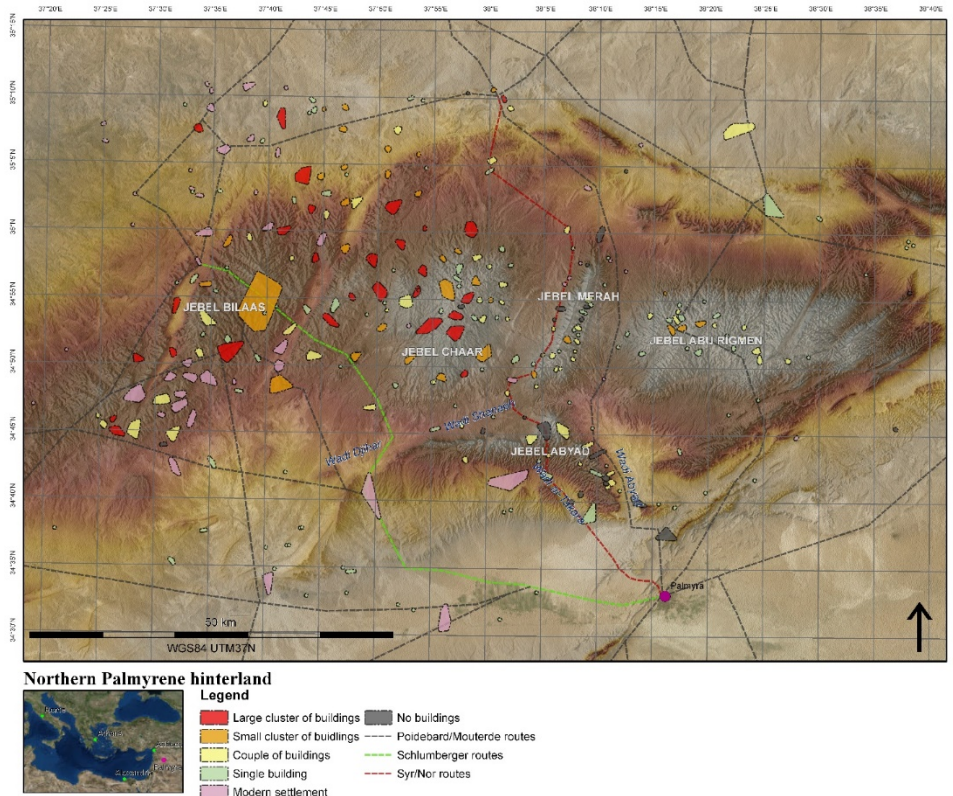
The sites are different in size and layout, and contain different types and numbers of items (Fig. 3.6). The sites are categorized into six types based on subjective interpretation and are limited by the type of information contained in the appendix tables and GIS geodatabase:⁶³

- Large cluster of buildings (referred to as *Large cluster-site*).
- Small cluster of buildings (referred to as *Small cluster-site*).
- Couple of buildings (referred to as *Couple-site*)
- Single buildings (referred to as *Single-site*).
- No buildings (referred to as *No building-site*).
- Modern settlements (Referred to as *Modern settlement*).

⁶¹ Each of the sites discovered by this study are named with TST as part of their name, until better names comes up.

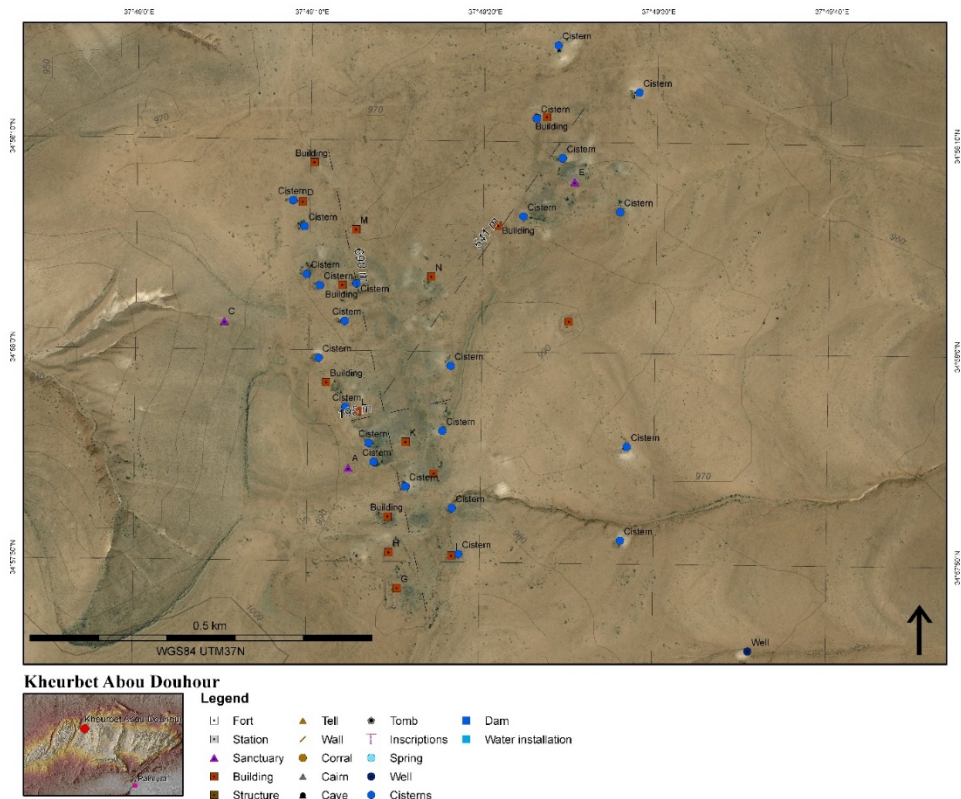
⁶² The locations with mere water resources without any special building activity documented by the Syr/Nor-Survey on ground, like several of the water resources in Cisterns, Jebel Merah east and west, are defined as sites, even though one may argue that they should not have been based on the definition in this study.

⁶³ In this study, locations with modern settlements that have no documented historical remains are left out even though one might argue that there is a big chance that the settlement has an ancient history. The amount of modern settlements only becomes a significant factor in the far western parts of the mountain range, and do not have a great impact on the impression in most areas.



Figur 3.5: Showing distribution of type of sites in the northern Palmyrene hinterland

A *Large cluster-site* is typically one of the larger settlements investigated by Schlumberger at Jebel Chaar, for instance Kheurbet Abou Douhour as seen in Figure 3.6. In this study, a large cluster is defined as buildings relatively close together in an area larger than about 250 x 250 m.



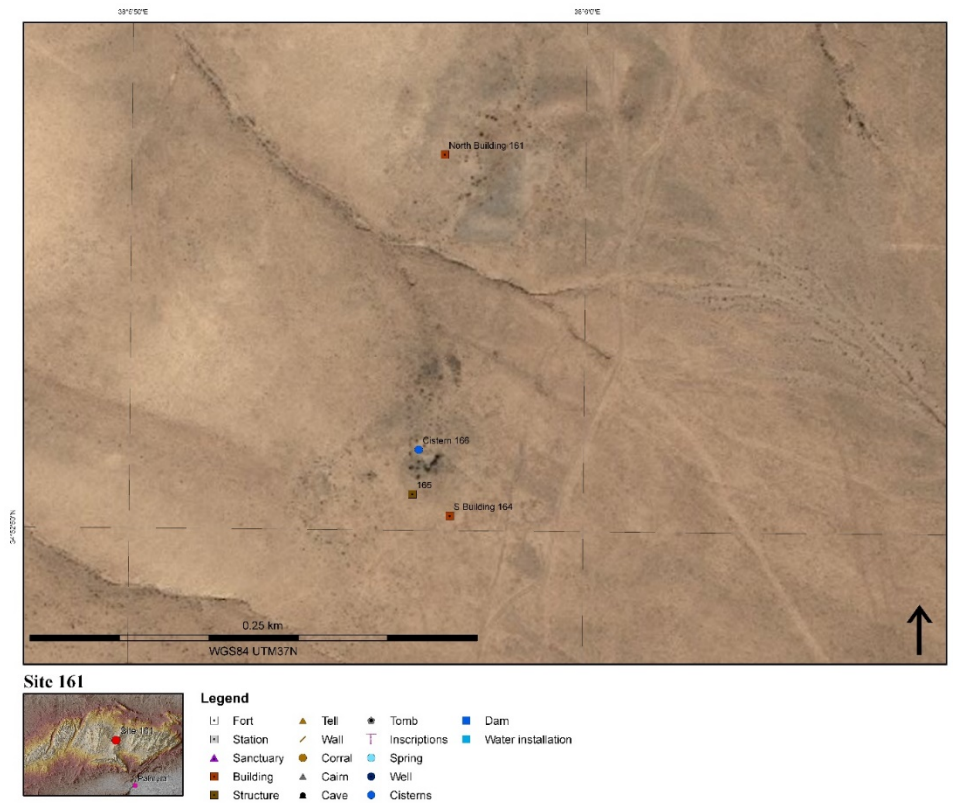
Figur 3.6: Showing satellite imagery of the site Kheurbet Abou Douhour as a typical example of the type "Large cluster-site".

A *small cluster-site* is a site that resembles the density of buildings in *large cluster-sites*, but is of a smaller area, smaller than 250 x 250 m. An example is Abu Hayaya on the southern slopes of Jebel Bilaas, located by the Syr/Nor-survey, as seen in Figure 3.7.



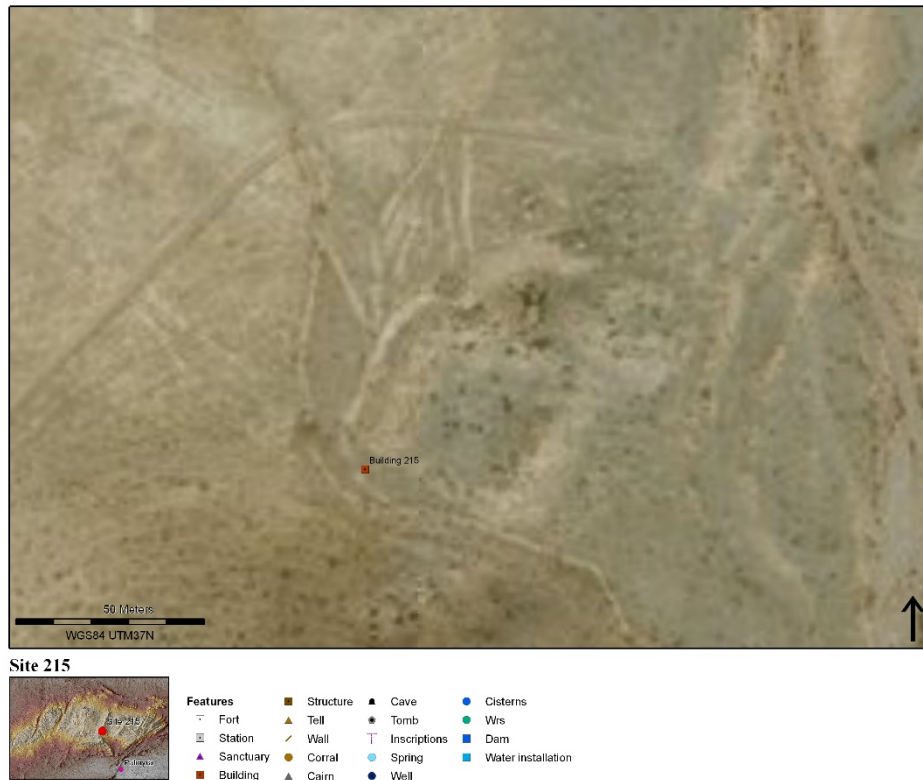
Figur 3.7: Showing satellite imagery of the site Abu Hayaya as a typical example of the type "Small cluster-site".

A *couple-site* represents two or more quite large buildings within a relatively short distance from each other, but not as large or densely located as *small cluster-sites*. Site 161 at Jebel Merah, investigated by the Nor/Syr-Survey is an example of this, as seen in Figure 3.8.



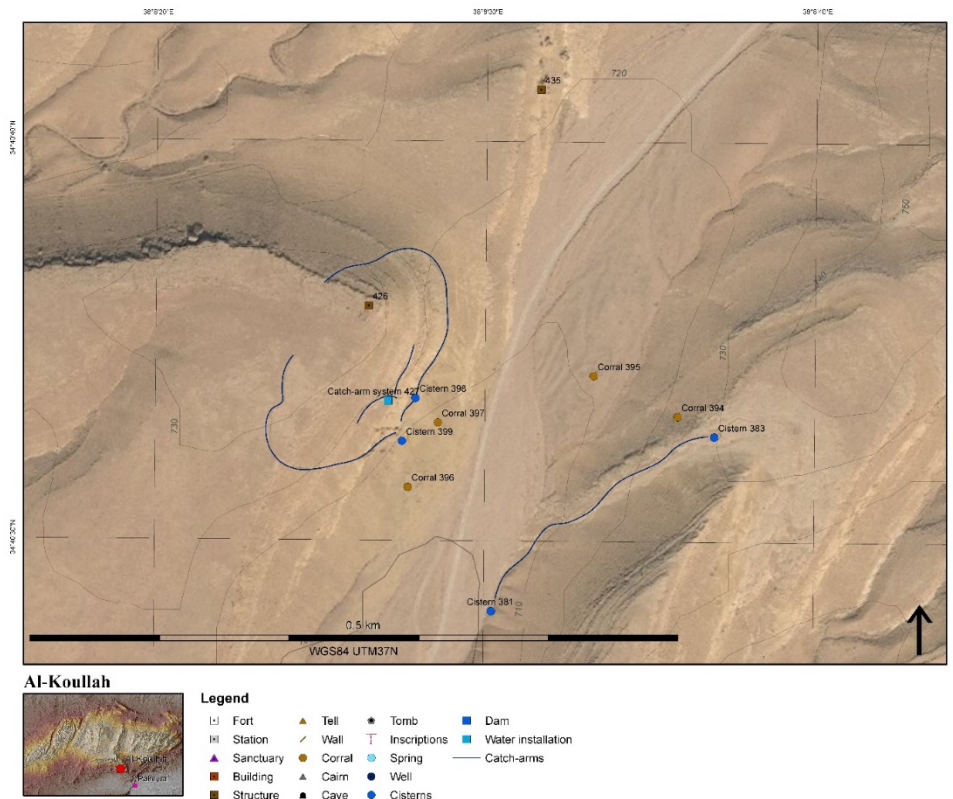
Figur 3.8: Showing satellite imagery of the site Site 161 as a typical example of the type "Couple-site".

A *single-site* is an isolated building without any immediate other buildings in its surroundings. Site 215, investigated by Syr/Nor-survey at Jebel Merah, is a typical single building, as seen in Figure 3.9. *Single-sites* can be a diffuse category. While *large cluster*, *small cluster* and *couple-sites* usually contains larger buildings, *Single-sites* may contain small and uncertain buildings as well.



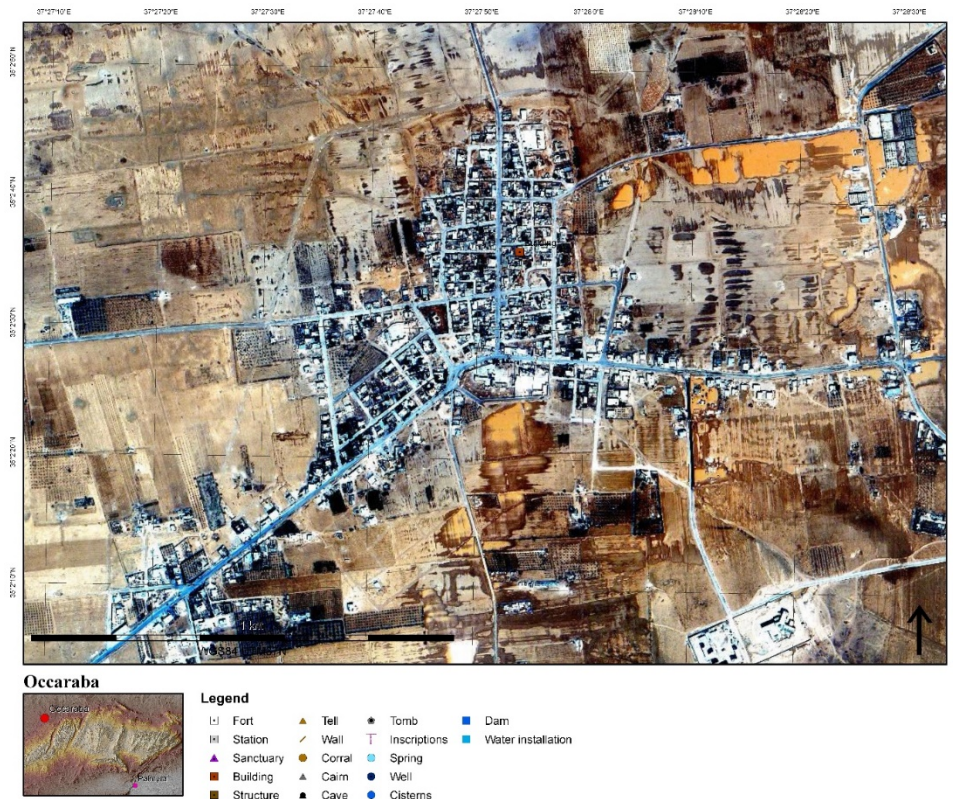
Figur 3.9: Showing satellite imagery of the site Site 215 at Jebel Merah, as a typical example of the type of site: "Single building".

The *no buildings-site* is without any evident buildings, but with other remains of human investment at the site. A typical No buildings-site is Al-Koullah, investigated at Jebel Abyad by the Syr/Nor-survey, see Figure 3.10. Even though the site has no evident buildings, there are several catch-arms for water, measuring several hundred meters in length, indicating that significant investments have been put into the site.



Figur 3.10: Showing satellite imagery of the site Al-Koullah as a typical example of the type of site: "No buildings".

A *modern settlement* in this context can be a city, village or single houses, covering historical remains investigated roughly by a survey or cartographer, that is not evident in satellite imagery. A typical example of a Modern settlement is Occabara, investigated by Poidebard and Mouterde at the western side of Jebel Bilass, as in Figure 3.11.



Figur 3.11: Showing satellite imagery of the site Occaraba as a typical example of the type of site: "Modern settlement".

3.3 Analysing the distribution of the sites

As will be discussed in detail later, how the different type of sites are distributed, and the density of them, may be important in order to understand the different functions the sites may have had. The method is discussed in detail in *Chapter 4 – Distribution of sites*. It is based on two ways of calculating density in GIS, presented in two types of formats. The first method of calculating density is called *Point density analysis* in a toolset for ArcGIS. It is a method that can calculate the distance to the nearest neighbour of each point in a dataset. The second method is a tool called *Thiessen polygon analysis* in ArcGIS. It calculates an even areal for each point in a dataset based on its surrounding neighbours. The more dense the points in an area are, the smaller area they get in the analysis.

The reason why both methods are used is because none of them are perfect, and needs careful interpretation. The *Point density analysis* only tells how close a point is to its nearest neighbour. This means that two points that are close to each other, but isolated from all other points, will be given the same value as points in dense areas with several points. This is where the *Thiessen polygon analysis* helps. For two isolated points close together, the area would be

large towards the sides that do not face the nearest neighbour. In dense areas with several points, the calculated area would have been small. The downside with the *Thiessen polygon analysis* is that points in the outskirts of a dense area will have a large calculated area, even though they are as much part of the network the other points are part of.

The two formats used are bar charts and maps. The results presented in the bar charts are only based on the *Point density analysis*, while the maps contain the results of both. An important part of the density analysis is the mentioned categorisation of type of sites. This makes the analysis much more detailed than if one only were to analyse all sites in general.

The reason why both bar chart and maps are used to present the results of the density analysis, is that they can reveal different kinds of patterns. A bar chart highlights similarities and differences in amount and categories, while a map concerns the spatial distribution. As will be seen, both ways are useful. Bar chart are in addition great ways of comparing information from different areas.

3.4 Analysing the water system

As will be discussed in detail in *Chapter 5 – The water system of the northern Palmyrene hinterland*, understanding the water system might explain how life could exist and how productive it might have been. The GIS-analysis uses a range of datasets. Information of the location of water resources sites from the compiled dataset, are analysed and used to extract information from geological, climatic and topographic data. Geological data have been digitized, and climatic data have been interpolated by this study. A number of calculations of the terrain are performed using the SRTM (Shuttle Radar Topographic Mission) 30m terrain model, developed by NASA. Based on this, a calculation of slope and hydrological features have been performed. Slope is the calculated gradient for each cell in the dataset.

Hydrological features in this includes drainage lines (flow routes) and catchment areas. A catchment area is the area in which all the water would theoretically flow to a specific outlet.

The hydrological features are made using ArcHydro-tools in ArcGIS. The fundamental methods of this analysis are recognised and extensively used by engineers in a variety of different branches. The results of the analysis are of great value for a project like this, but must be interpreted with care. From a hydrologist`s point of view, the method contributes with a rough frame work, but for a detailed study, it cannot replace the comprehensive research of a hydrologist. Besides lacking detailed information of geological aspects, the resolution of the SRTM terrain model is also an issue. While being a useful and impressive

representation of the terrain, the resolution of 28.23m x 28.23m smoothens details like obstructions and edges of mid-sized wadis, details that might be of great importance when calculating hydrological features. At the end of the day, nothing can replace being at the spot.

4 Distribution of sites

Even though the area north of Palmyra often is referred to as a single entity, as done multiple times in this study, the northern Palmyrene hinterland is really a diverse region that contains several areas of settlements, and many types of sites. This has been observed by researchers several times. The difference between Jebel Abyad and Jebel Chaar must have been evident to Schlumberger, as it was for the Syr/Nor-survey.⁶⁴ As must the difference in size and appearance of the sites have been.⁶⁵ The *distribution* of the sites has, however, not been comprehensively analysed.

The aim of this chapter is to contribute to the field of research with an analysis of the distribution of sites in the hinterland. This includes looking at how the different sites are distributed within each area, comparing the areas to each other, and discussing how related the areas might have been. This study analyses two aspects of distribution; it analyses the distribution of types of sites, and it analyses how densely settled the sites are.

There can be many reasons why sites were distributed in the way they were. The terrain and the access to natural resources can be important. It may also be related to human activity, and be the results of power structures and the economical base. The size of the site can give insight into how prominent it was. Schlumberger documented elaborate ornamented art in the largest sites at Jebel Chaar.⁶⁶ One could suggest that the large sites were prominent over other sites, like the *metrokomai* (mother-villages), which are discussed among scholars researching the Hauran further west in Syria.⁶⁷ On the other hand, one could also suggest a scenario where a *couple-site*, that contained an estate of a wealthy man, presided over larger sites that contained workforce, animals and other features related to economy. There is much uncertainty concerning this among scholars. Schlumberger described the settlements as villages,⁶⁸ a term also used several times by the Syr/Nor-survey.⁶⁹ If “village” is understood

⁶⁴ Syr/Nor (2009), p. 27, 35, 56, 103, 107, 126, 128; Syr/Nor (2011), p. 32, 114.

⁶⁵ Schlumberger investigated large settlements as Kheurbet Semrine: Schlumberger (1951), p. 34, as well as the smaller sites with few buildings as the sanctuary at Labda: Schlumberger (1951), p 27, and fort at Rasm ech Chaar: Schlumberger (1951), p 44-46; The Syr/Nor-survey investigated a range of different type of sites like Ras al-Matna that didn't contain any buildings: Syr/Nor (2008), p. 44-55, and the large settlement Village 539: Syr/Nor (2009), p. 110-122.

⁶⁶ Schlumberger (1951), Pl. XXI - XLVIII.

⁶⁷ Sartre (2005), 231; Kennedy (2013), p. 647.

⁶⁸ As is evident of the full title of his book: *La Palmyrène du nord-ouest. Villages et lieux de culte de l'époque impériale. Recherches archéologiques sur la mise en valeur d'une région du désert par les Palmyréniens*, i.e. “villages and places of worship”.

⁶⁹ Syr/Nor (2008), p. 33, 108, 123; Syr/Nor (2009), p. 27, 35, 56, 103, 107, 122, 126, 128; Syr/Nor (2011), p. 114

as a larger settlement with a certain amount of inhabitants, it is fair to assume that this relates to *large* and *small cluster-sites*. Schlumberger and the Syr/Nor-survey also refer to the sites as possible estates.⁷⁰ This may still relate to the *large* and *small cluster-sites*, but it must at least relate to *couple* and *single-sites* (with large buildings), since they hardly can be described as villages. The layout of the settlements is peculiar, since the large sites only seem to contain large, expensive, buildings, not small holdings as one would expect to find in villages developed by poor farmers.⁷¹ This strongly indicates that wealthy people were involved in the development of the settlements. This also means that the main difference between a *large cluster-site* and *couple-site* with large buildings, as many *couple-sites* have, is the number of large buildings.

The second type of distribution that is analysed in this chapter is density. The distance between sites probably relates to the power structure in the area. It may also indicate the economical base. The Syr/Nor-survey argued that the short distance between the sites at Jebel Chaar, described as 2 – 4 km,⁷² indicates that the sites practiced more than pastoralism,⁷³ i.e. some form of agriculture. The smaller the space each site had, the lesser the probability that they had extensive pastoralism as economical basis. Herding and breeding of animals usually requires much space. However, nothing can be ruled out. According to the Syr/Nor-survey, sites at Jebel Merah, an area even more densely settled than Jebel Chaar, probably practiced both pastoralism and agriculture or horticulture (supplemental gardens).⁷⁴ A comprehensive discussion on what the distribution of sites, analysed in this chapter, can mean, is performed in *Chapter 6 – Conclusion*.

In the rest of this chapter, the distribution of the sites are analysed and discussed. This is done analysing the sites area by area. First, a general description of the area is presented, combined with a discussion of the visual appearance, based on a map of the sites. This is followed by a discussion on the amount of different types in the area. This is visualized in a bar chart. The bar chart makes it easy to see patterns in the distribution, and makes it easy to compare the different areas. After this follows a discussion concerning the density of the different types of sites in the area. The discussion is based on the results of the *Point density analysis* performed in GIS, which measures the distance of the nearest neighbour of each site. The results are

⁷⁰ Meyer (2016), p. 89; Syr/Nor (2009), p. 27.

⁷¹ Syr/Nor (2009), p. 128.

⁷² Syr/Nor (2011), p. 114.

⁷³ Syr/Nor (2009), p. 128.

⁷⁴ Syr/Nor (2011), p. 114.

presented in a comprehensive bar chart, where the density of each type of site, within certain ranges of distance is visualised. The results of the *Point density analysis* is also presented spatially in a map. This map also includes the results of a *Thiessen polygon analysis*, which is a calculation of the area each site has based on the distance to its nearest neighbours. This serves as a background layer that indicates density and continuance of sites. For last there is a brief discussion concerning if the sites in area show a pattern of continuance towards other areas.

4.1 Jebel Chaar

There are a total of 64 documented sites at Jebel Chaar. As seen in the map in Figure 4.1, the sites are located all around on the plateau, surrounding the only fort in the area, Rasm ech Chaar.⁷⁵ This is dated to the Umayyad period, and was therefore probably not a part of the initial development of the area.⁷⁶ The Syr/Nor-survey suggest that the fort had a function related to tax-farming.⁷⁷ Just south of the fort there are a number of large sites, including Kheurbet Semrine, which is often used as a geographical reference point by Schlumberger.⁷⁸ The southern slopes towards Wadi Shanaeh contain a range of larger sites quite sparsely located, and the west and north/western sides of the plateau contain a number of *large cluster-sites*, also quite sparsely located. The northernmost is Marzouga,⁷⁹ one of the largest sites in the northern Palmyrene hinterland with its 16 buildings and two sanctuaries. The eastern side of the plateau, on the other hand, contains a number of smaller sites.

⁷⁵ Schlumberger (1951), p. 44-46.

⁷⁶ Meyer (2013), p. 88.

⁷⁷ Syr/Nor (2009), p. 126.

⁷⁸ Schlumberger (1951), p. 9; 13-22.

⁷⁹ Schlumberger (1951), p. 41-44.

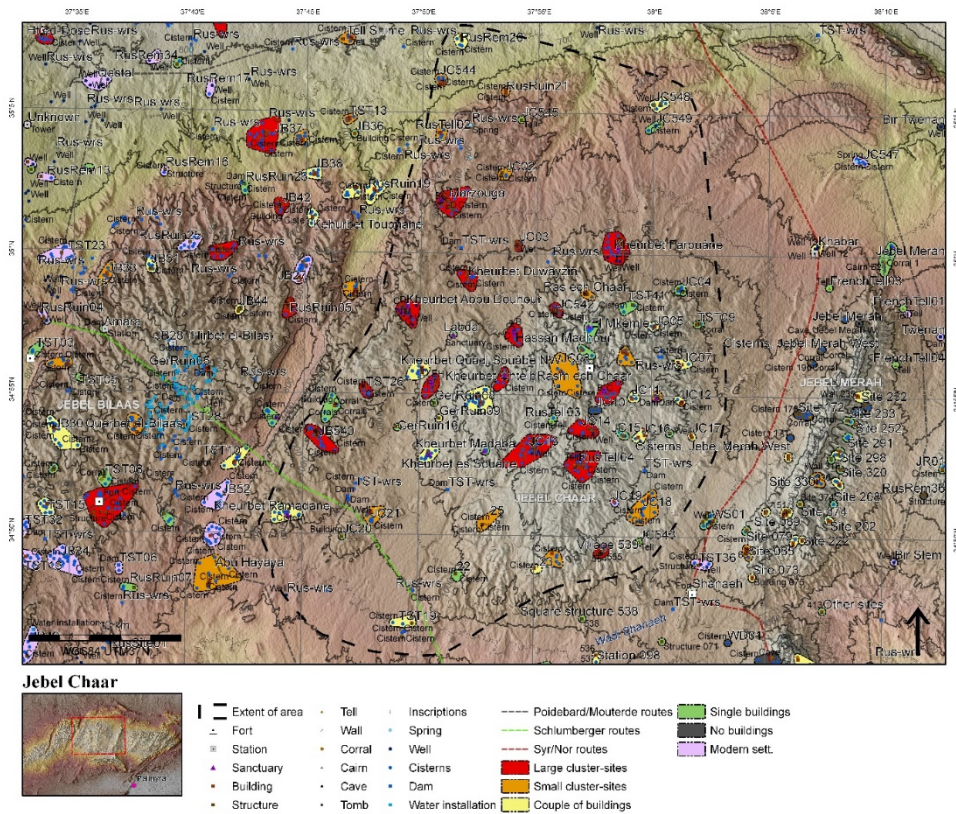


Figure 4.1: Map showing the distribution of sites at Jebel Chaar.

The large sites at Jebel Chaar are often referred to when scholars describe sites in other areas of the hinterland. As seen in the bar chart in Figure 4.2, a large number (44 %) of the sites at Jebel Chaar are *large* and *small cluster-sites* (red and orange bars in the chart). These might be defined as villages, and are probably the most developed and prominent sites in Jebel Chaar. While Jebel Chaar is known for its large sites, as many as 52 % of the sites are *couple* and *single-sites* (yellow and green bars in the chart). This means that Jebel Chaar has a range of different types of sites, which might indicate a variety of functions and stages of development within the area.

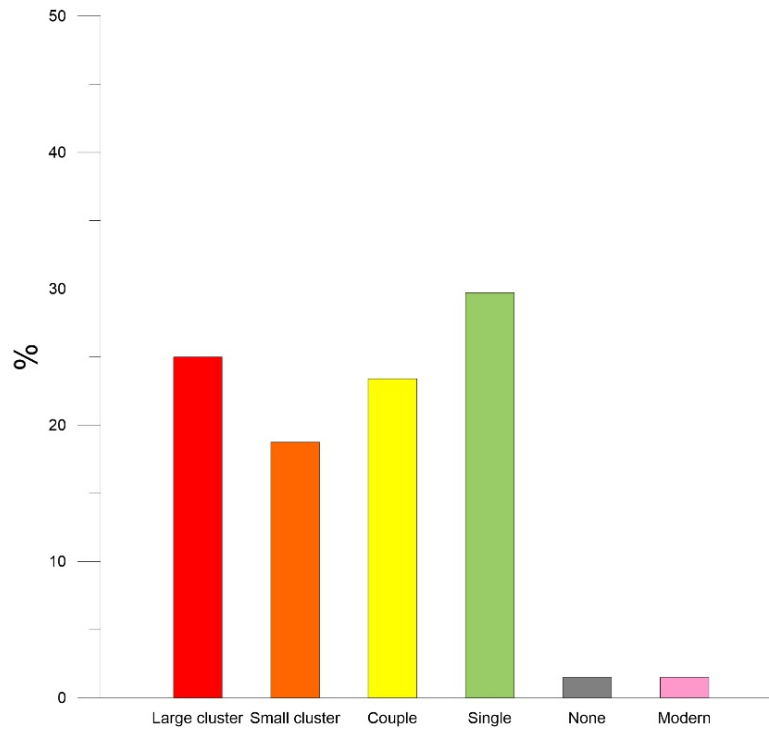


Figure 4.2: Column chart showing distribution (%) of type of sites at Jebel Chaar, made by this study. The colours refers to the colours used for the different type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

As mentioned, the Syr/Nor-survey observed that the distance between the sites in Jebel Chaar was quite small.⁸⁰ This is confirmed in the bar chart in Figure 4.3. It is based on the results of *Point density analysis* in GIS, and shows the distance each type of site has to its nearest neighbour. It is evident from the chart that most of the sites are within 2 – 3 km from each other. There are also a great deal of sites within 1 – 2 and 3 – 5 km from each other.

It is difficult to say what this distribution means in terms of function. Most *large* and *small cluster-sites* have developed in areas with 2 – 3 km distance from each other. Fewer have developed with 3 – 5 km distance from each other, and even fewer have developed in quite dense areas with 1 – 2 km from each other. While *single-sites* follow the pattern of *large* and *small cluster sites*, *couple-sites* (yellow bars) are mostly represented in areas with 1 – 2 km distance, with a steady decrease presence the less dense the areas are. To some extent, these patterns relate to spatial distribution, which will be discussed in the following sections.

⁸⁰ Syr/Nor (2009), p. 128.

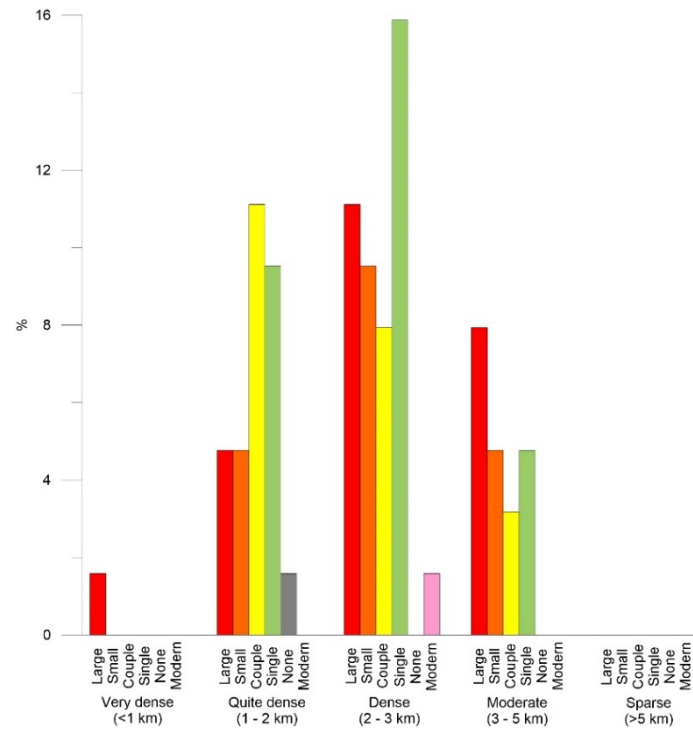


Figure 4.3: Column chart showing the distribution (%) of type of sites based on distance to nearest other site, made by this study based on GIS-analysis. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

The map in Figure 4.4 shows how the density of the sites are distributed spatially. The coloured points are the result of the *Point density analysis* in GIS, which is the basis of the charts in this study that involves density. The background layer show the results of the *Thiessen polygon analysis*, which indicates areas of density. The map indicates that Jebel Chaar is divided into several areas with different patterns of density. With a very dense centre, most of the sites south/east of the centre have 1 – 2 km distance (orange colour), and most of the sites north/east of the centre have 2 – 3 km distance (yellow colour), as do the sites at the south-south/western outskirts of the central area, while most of the sites at the north-north/western area have 3 – 5 km distance (green colour). While these patterns might just be coincidental, it is interesting that they are so clearly defined.

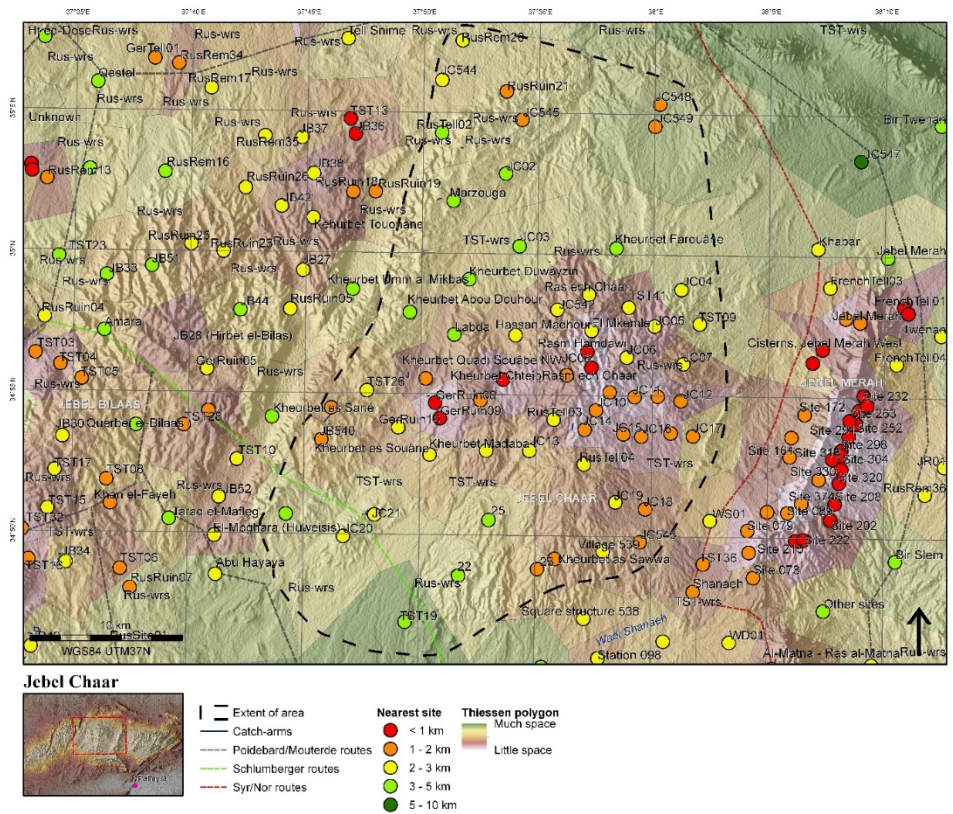
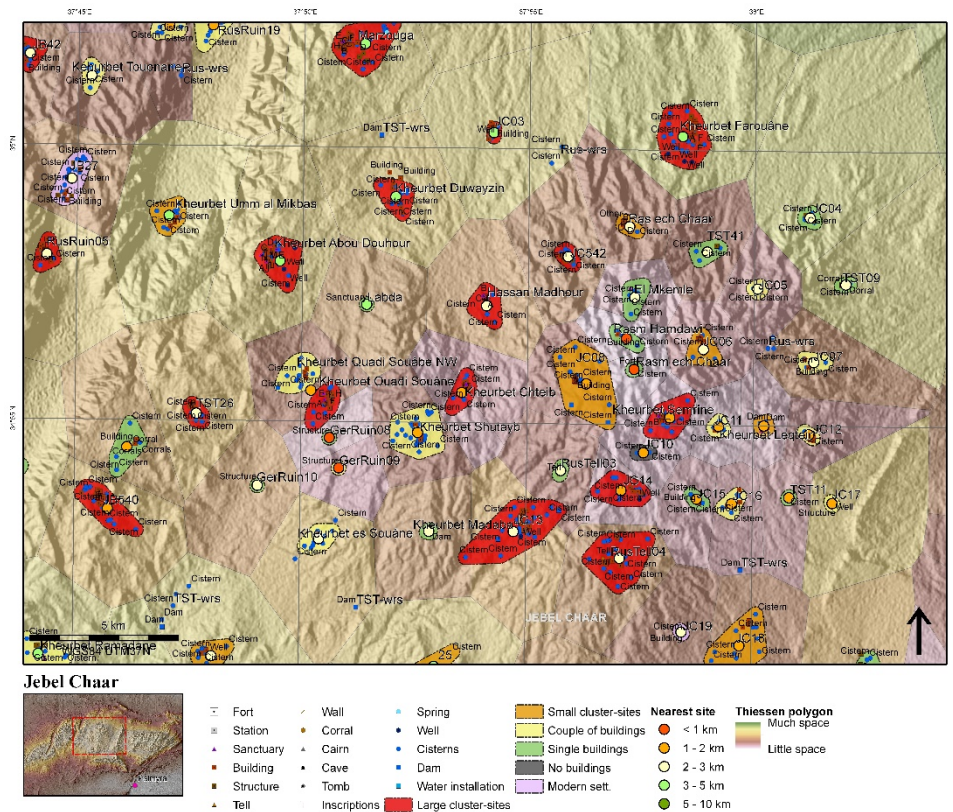


Figure 4.4: Map showing the results of the density analysis (points) on the results of the Thiessen polygon analysis.

Looking at the density in combination with type of site, as seen in Figure 4.5, the large sites just south of the fort of Rasm ech Chaar do not follow any strict density pattern. The area to the south/east does, however, contain a majority of smaller sites, with *couple-sites* as the dominant one in numbers. This might explain the mentioned pattern in the density chart (Figure 4.3). The north/eastern part, which is slightly less dense, has a majority of *single-sites*. The north/western part is dominated by large sites. This includes the slightly denser sites closer to the central areas.



Figur 4.5: Map showing the results of the density analysis (points) on the results of the Thiessen polygon analysis, and type of site.

In terms of relation to other areas, there seem to be continuance of sites towards the fort of Shanaeh in the south/east, towards Jebel Bilaas in the west, and a more sparse continuance towards north/west.

4.2 Jebel Abyad

Jebel Abyad is the southernmost of the mountain areas, and the one closest to Palmyra. The terrain is markedly different from Jebel Chaar, and as seen on the map in Figure 4.6, the distribution of the sites is different as well. The 26 sites at Jebel Abyad, a little more than a third of the amount of sites at Jebel Chaar, seems to be more dictated by terrain features and natural resources. The main sites at the eastern edge that contain large buildings, Akerem,⁸¹ Al-Mazraah,⁸² Awtayt,⁸³ Majouf⁸⁴ and Shalalah (Quéchel),⁸⁵ are located close to springs. Of these, al-Mazraah and Shalalah (Quéchel) are described as having similarities to the larger

⁸¹ Syr/Nor (2009), p. 7-17.

⁸² Syr/Nor (2009), p. 60-67.

⁸³ Syr/Nor (2009), p. 17-18.

⁸⁴ Syr/Nor (2009), p. 21-24.

⁸⁵ Syr/Nor (2008), p. 24-39; Syr/Nor (2009), p.74-75.

sites at Jebel Chaar,⁸⁶ though they do not contain as many buildings.⁸⁷ In Wadi al-Takara, there are two stations (Wadi al-Takara south⁸⁸ and north⁸⁹) and one fort, Tweihina (Tahoun el Masek),⁹⁰ located along the logical route through the steep valley. At the northern outlet of Wadi al-Takara lies Ras al-Matna,⁹¹ and to the west of that, Bir al-Arfa.⁹² Bir al-Arfa is suggested as a site that contains buildings that have similarities to the sites at Jebel Chaar.⁹³ Ras al-Matna is together with Al-Koullah,⁹⁴ which is located in a hillside further south in Wadi al-Takara, an area without any evident buildings, where elaborated water management systems have been built. The main site in the Jazal plain (Jazal)⁹⁵ is located by a well-area. Since the terrain and natural resources are so important in Jebel Abyad, a density analysis as such is not relevant. It is worth noting that The Couple-sites Akerem, Al-Mazraah and Awtayt is so densely distributed around the spring of Akerem that they must have been related in some way.

⁸⁶ Syr/Nor (2009), p. 126.

⁸⁷ Syr/Nor (2009), p. 128.

⁸⁸ Syr/Nor (2009), p. 30-35.

⁸⁹ Syr/Nor (2009), p. 46-57.

⁹⁰ Syr/Nor (2008), p.10-23.

⁹¹ Syr/Nor (2008), p.44-55.

⁹² Syr/Nor (2009), p.89-98.

⁹³ Syr/Nor (2009), p. 126.

⁹⁴ Syr/Nor (2009), p.36-45.

⁹⁵ Syr/Nor (2009), p.78-86.

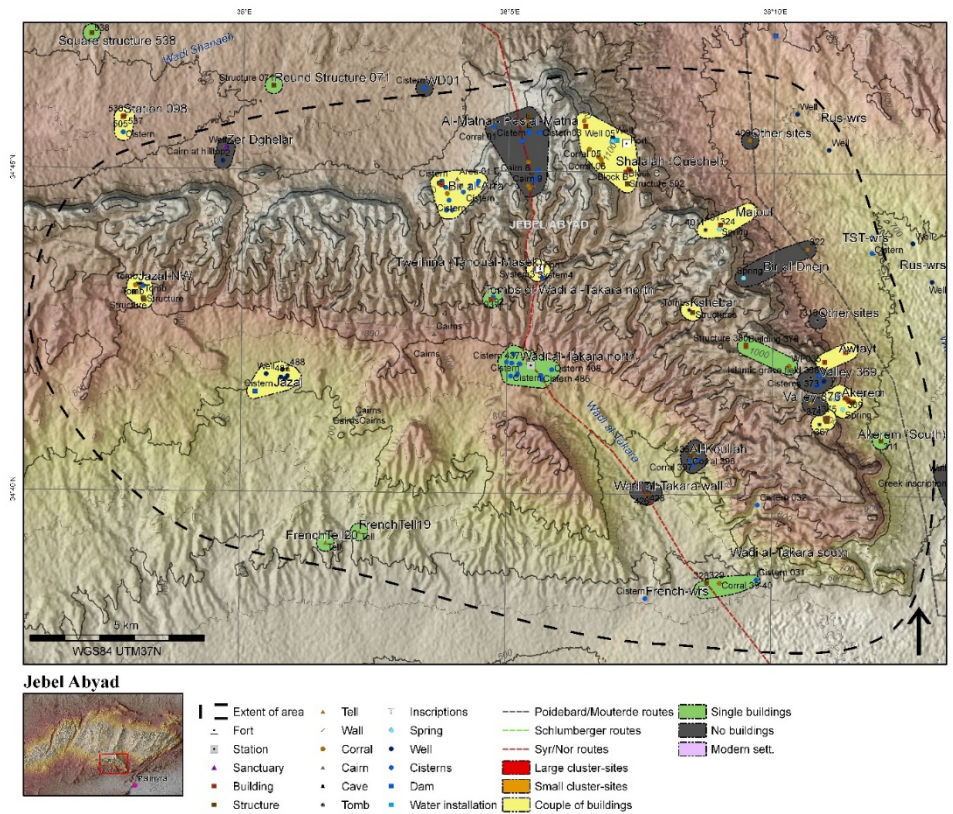


Figure 4.6: Map showing the type of sites at Jebel Abyad.

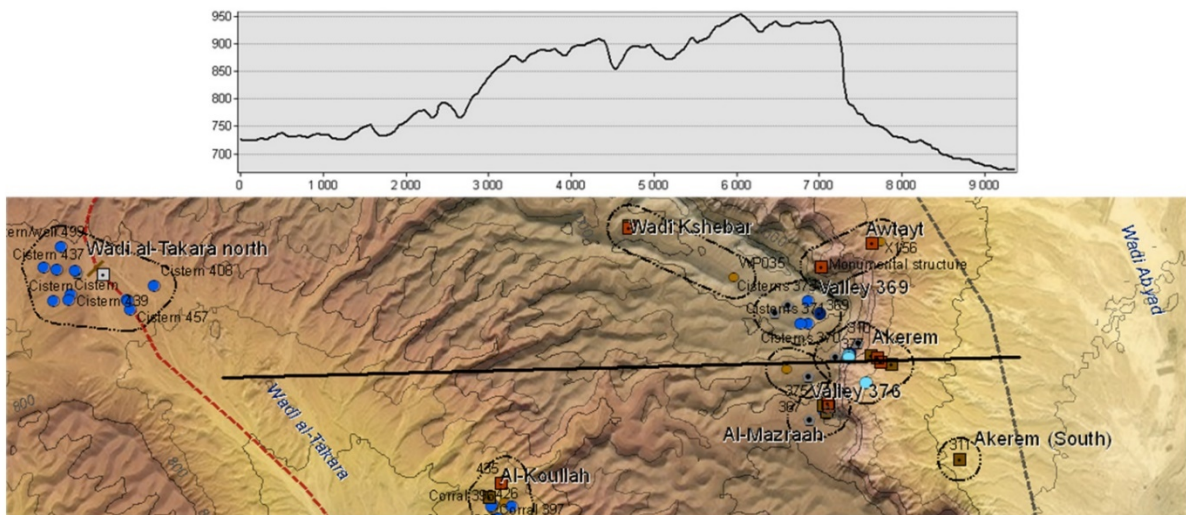


Figure 4.7: Showing a profile of the steep edge of Jebel Abyad.

The distribution of? type of sites differs quite a lot from Jebel Chaar. As illustrated in the bar chart in Figure 4.8, none of the sites are defined as *large* or *small cluster-sites*, while 10 of the

sites are defined as *couple-sites*,⁹⁶ seven are defined as *single-sites*, nine are defined as *no buildings*. Since the area was researched in detail on ground by the Syr/Nor-Survey, the absence of *large cluster-sites* and *small cluster-sites* gives a realistic impression of the area in historical times. *couple-sites* are the dominant type and seems to be the framework of the settlements at Jebel Abyad.

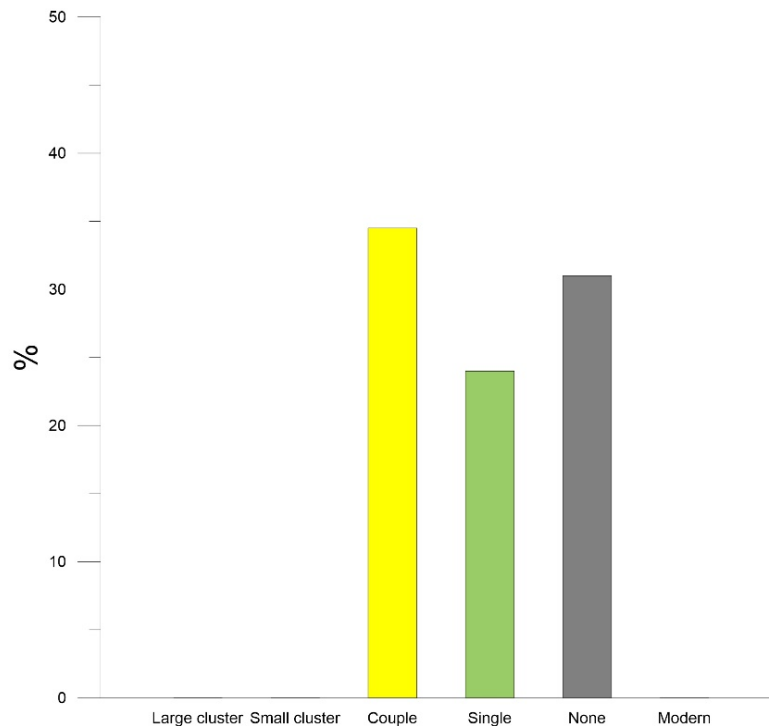


Figure 4.8: Column chart showing distribution (%) of type of sites at Jebel Abyad. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

If Couple-site most probably are estates, and much space indicates pastoralism, Jebel Abyad is one of the best examples of large estates that dealt with breeding and herding of animals.

In terms of its relationship to other areas, there is not any close connection northwards. The fort of Tweihina (Tahoun el Masek) is about one days travel away from the fort of Shanaeh,⁹⁷ which is connected to the sites at Jebel Chaar. To the south Jebel Abyad must have been related to the city of Palmyra, though there is no dense continuance of sites between the two.

⁹⁶ Jazal is really a *modern settlement*, but may have been a *couple-site*.

⁹⁷ Syr/Nor (2009), p. 124.

4.3 Jebel Merah

Jebel Merah is a steep north/east-south/west trending ridge with flanking plateaus about 200 m below the summit on each side. The eastern and western hillsides contain a range of short wadis that are so steep that it is unlikely that any main route went across the summit, while the slopes are more gentle on the southern and northern sides. As seen in the map in Figure 4.9, the main area of settlement is at the eastern and southern part of the mountain. As indicated in the map, most of these sites contain large buildings (red square building symbols in map), while the sites at the south/east and southern sides have no major buildings, with the exception of the fort at Khabar along the route towards the northern steppe.⁹⁸

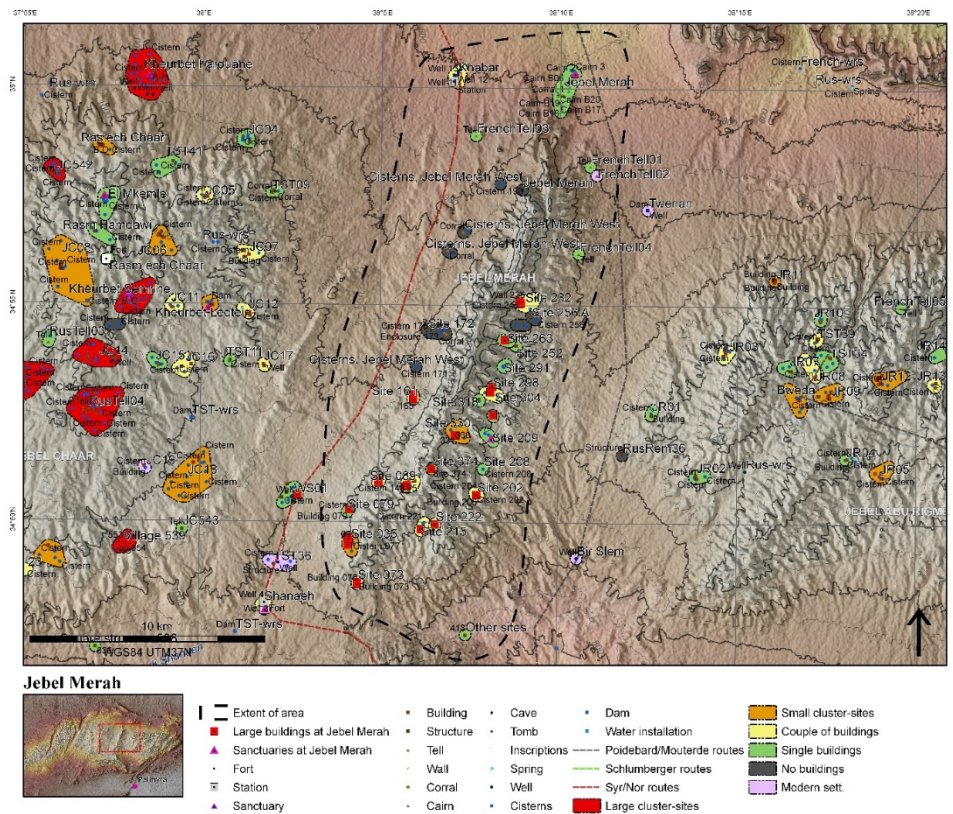


Figure 4.9: Map showing the type of sites at Jebel Merah.

As can be seen in the bar chart in Figure 4.10, of the 37 sites located at Jebel Merah, there are no *large cluster-sites*. Unlike Jebel Abyad, there are two *small cluster-sites*, but also at Jebel Merah, most of the sites are *couple* and *single-sites*.

⁹⁸ Syr/Nor (2008), p. 87-97.

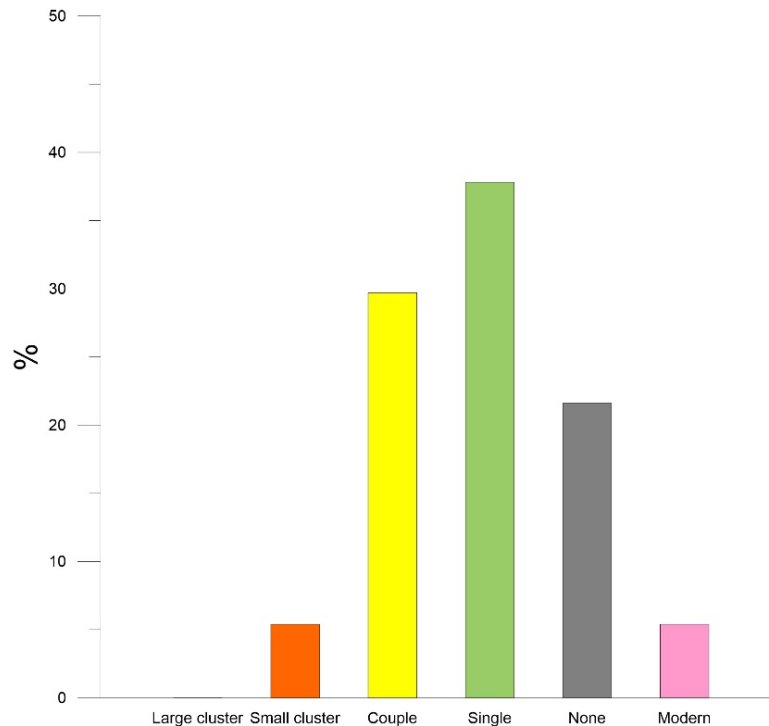


Figure 4.10: Column chart showing distribution (%) of type of sites at Jebel Merah. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

The bar chart in Figure 4.11 shows that most of the sites are located in very dense areas (>2 km), in fact, quite many sites are located with less than 1 km distance to its nearest neighbour. Very few sites are distributed in less dense areas.

Looking at the map in Figure 4.12 all of the sites on the eastern and southern sides are located within 2 km distance from each other. There seems to be a slight difference in density from the eastern side to the southern side, since all the sites in the eastern hillside are distributed with <1 km distance between them, while the sites at the southern side are distributed with 1 – 2 km distance. It is in the southern part both the *small cluster-sites* have developed, and it is also worth noting that Site 089, which include elaborate water management system, is located in this southern part,⁹⁹ as does Site 083,¹⁰⁰ which contains a building described as having a typical urban architecture.¹⁰¹

⁹⁹ Syr/Nor (2011), p. 28-41.

¹⁰⁰ Syr/Nor (2011), p. 24-27.

¹⁰¹ Syr/Nor (2011), p. 27.

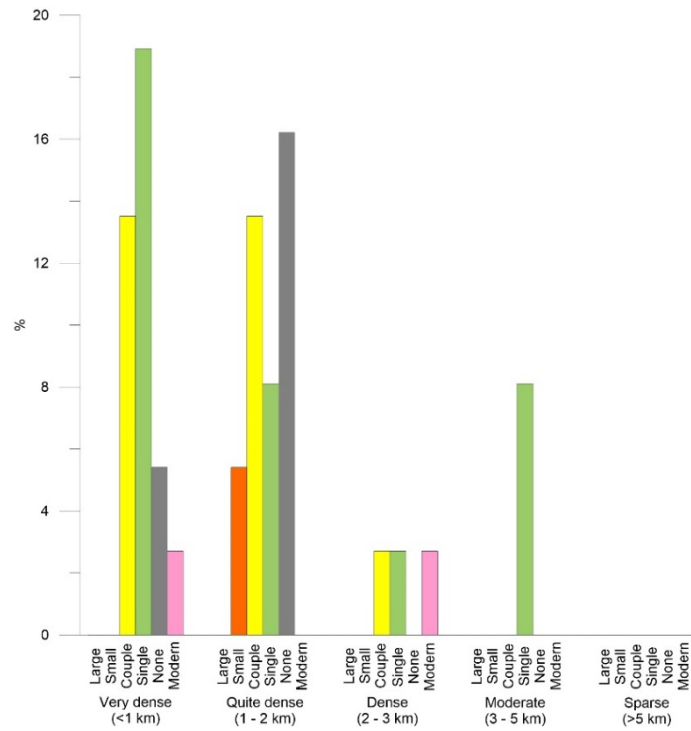


Figure 4.11: Column chart showing the distribution (% of total) based on Point analysis of type of sites based on distance to nearest other site. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

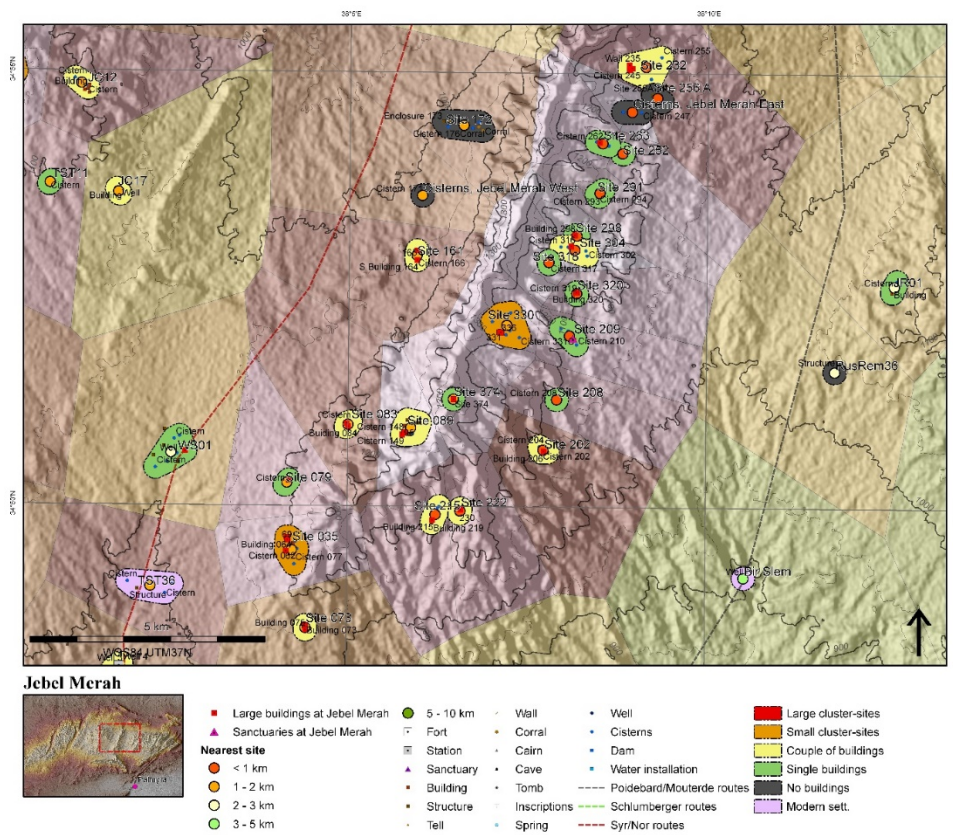


Figure 4.12: Map showing a combination of geographic distribution of type of sites and the results of the density analysis, in the central parts of Jebel Merah

Jebel Merah is in many ways a mixture of Jebel Abyad and Jebel Chaar. The sites have similarities to the major sites at Jebel Abyad and the distribution of the sites are quite affected by the terrain. If *couple-sites* indicates estates, this is widespread at Jebel Merah. The density of the sites is more similar to Jebel Chaar, and even more dense. Due to the terrain, however, the density of the sites at the eastern side cannot be compared to Jebel Chaar. Since they are distributed in a line, they have got much space to the east, which means that the argument that dense areas might practice agriculture, does not apply in the same way.

Concerning relationships to other areas, there is an evident tendency of continuance towards the fort of Shanaeh. In that respect, Shanaeh serves as a junction point towards Jebel Chaar, and towards Jebel Abyad and Palmyra. There is less evident connection towards Jebel abu Rigmen.

4.4 Jebel Bilaas

Jebel Bilaas, further to the west in the northern Palmyrene hinterland, is geographically divided by two north/south going valleys on each side of a large oblong plateau. There are 66 sites in Jebel Bilaas. Looking at the map in Figure 4.13, the central plateau seems to be divided into three parts. To the north there is an area with mixed types of sites. In the middle there are fewer sites, but a couple of stations and a large modern flood field system. The two stations, JB28¹⁰² – Hirbet el-Bilas and Amara,¹⁰³ are located along the route suggested by Schlumberger in the Poidebard and Mouterde maps. The flood field system is a large area (8 x 5 km) with modern flood field systems, containing more than 94 walls or dams for managing surface water. Just south of the flood field system there is a *large cluster-site* with a fort, Khan el-Fayeh.¹⁰⁴ This fort is in the northern part of a network with several *large cluster* and *couple-sites* in addition to many *modern settlements*. The map also includes modern villages (without documented historical remains) symbolized with pink dots in the map. As can be seen, there are quite many modern villages towards the western steppe.

In the western valley there are two forts or stations, one Qalat oumm Qbeybe¹⁰⁵ and TST03¹⁰⁶, not far from the road suggested by Schlumberger towards Occabara.¹⁰⁷

¹⁰² Located by the Syr/Nor-survey in satellite imagery

¹⁰³ Located by Poidebard & Mouterde.

¹⁰⁴ Located by the Syr/Nor-survey in satellite imagery.

¹⁰⁵ Located by Poidebard & Mouterde.

¹⁰⁶ Located by this study in satellite imagery.

¹⁰⁷ Located by Poidebard & Mouterde.

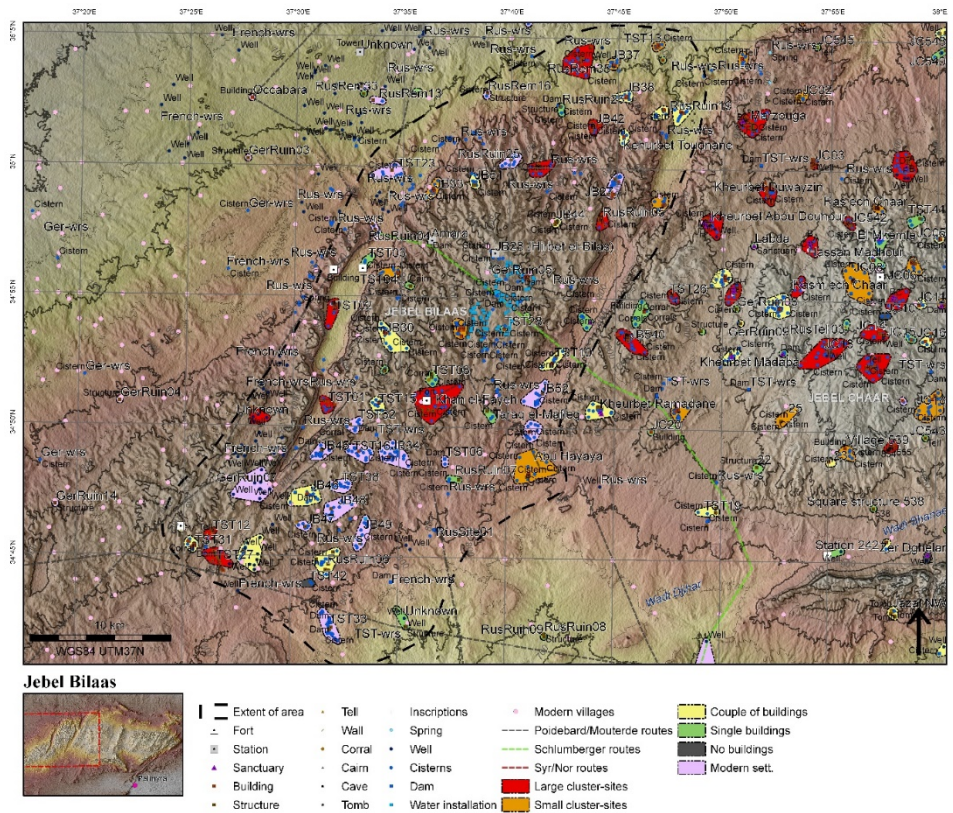


Figure 4.13: Map showing the type of sites at Jebel Bilaas.

The bar chart in Figure 4.14 shows that the distribution of sites is interestingly similar to that of Jebel Chaar. As in Jebel Chaar, the number of *large cluster*, *small cluster*, *couple* and *single-sites* are quite evenly distributed. This means that the function of the area might have been quite similar. The notable difference from Jebel Chaar is that Jebel Bilaas has a large number of *modern settlements*, something Jebel Chaar has not. *Modern settlements* are hard to interpret in satellite imagery, so it is uncertain what type of site they may have been in the Roman era.

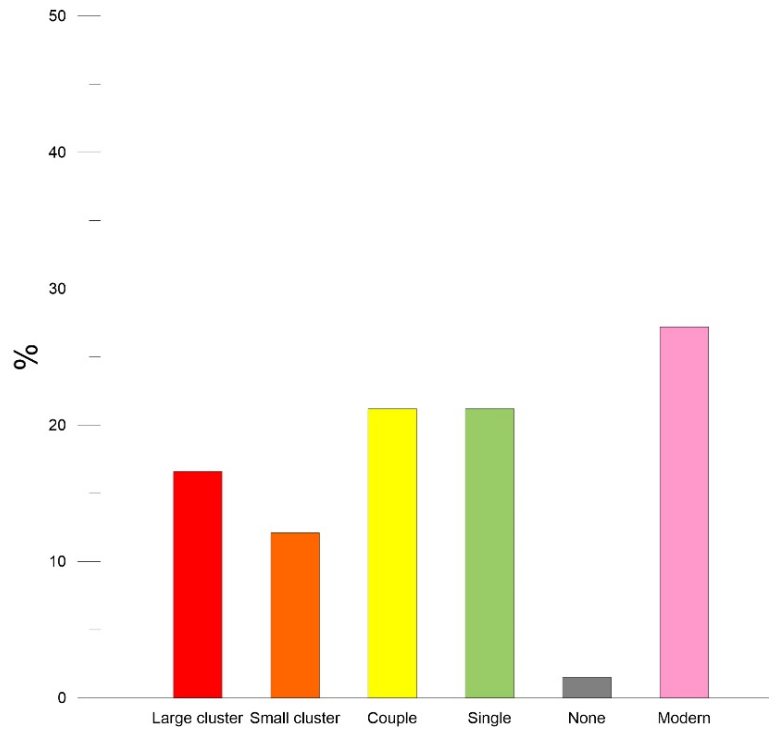


Figure 4.14: Column chart showing distribution (%) of type of sites at Jebel Bilaas. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

The results of the density distribution analysis in the bar chart in Figure 4.15, show that the area is similar to Jebel Chaar in the way that most of the sites are distributed within 2 – 3 km from each other. As with Jebel Chaar, a number of sites are also distributed within 1 – 2 and 3 – 5 km from each other. There are some differences from Jebel Chaar. One difference is the presence of *modern settlements*, which seem to follow the main pattern of the other sites in Jebel Bilaas. A second difference is that *couple-sites* follow the main pattern of the other sites, not like in Jebel Chaar where *couple-sites* have a different pattern. This might indicate that the area has developed somewhat differently compared to Jebel Chaar. A third difference is that Small cluster do not follow the pattern of the other sites, but has a decrease in amount in areas with 2 – 3 km distance.

Looking at the spatial distribution in the map in Figure 4.16, there seems to be a difference in density in the northern part, which is slightly less dense than the southern part. *large cluster*, *small cluster* and *couple-sites* seem to be quite intermixed in most areas, while there is a cluster of *modern settlements* in the denser southern part of the plateau.

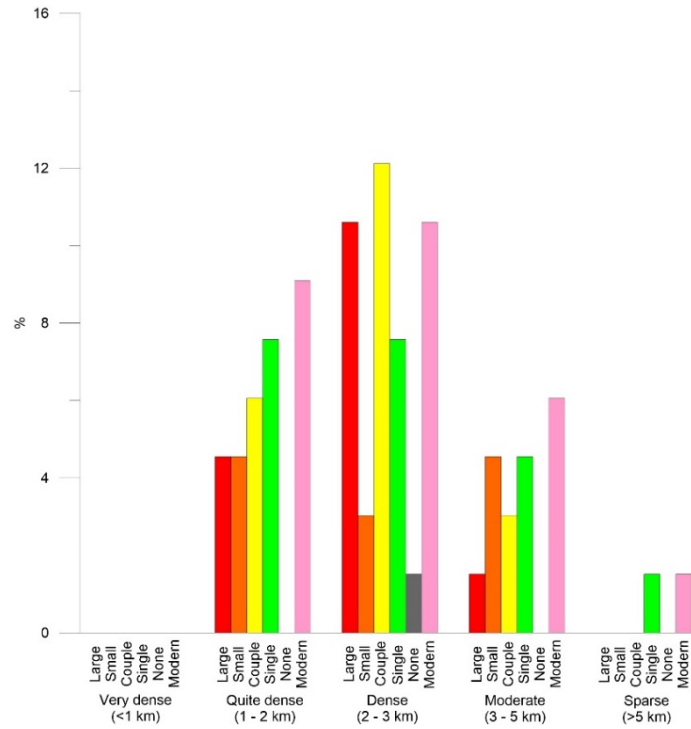


Figure 4.15: Column chart showing the distribution (% of total) based on Point analysis of type of sites based on distance to nearest other site at Jebel Bilaas. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

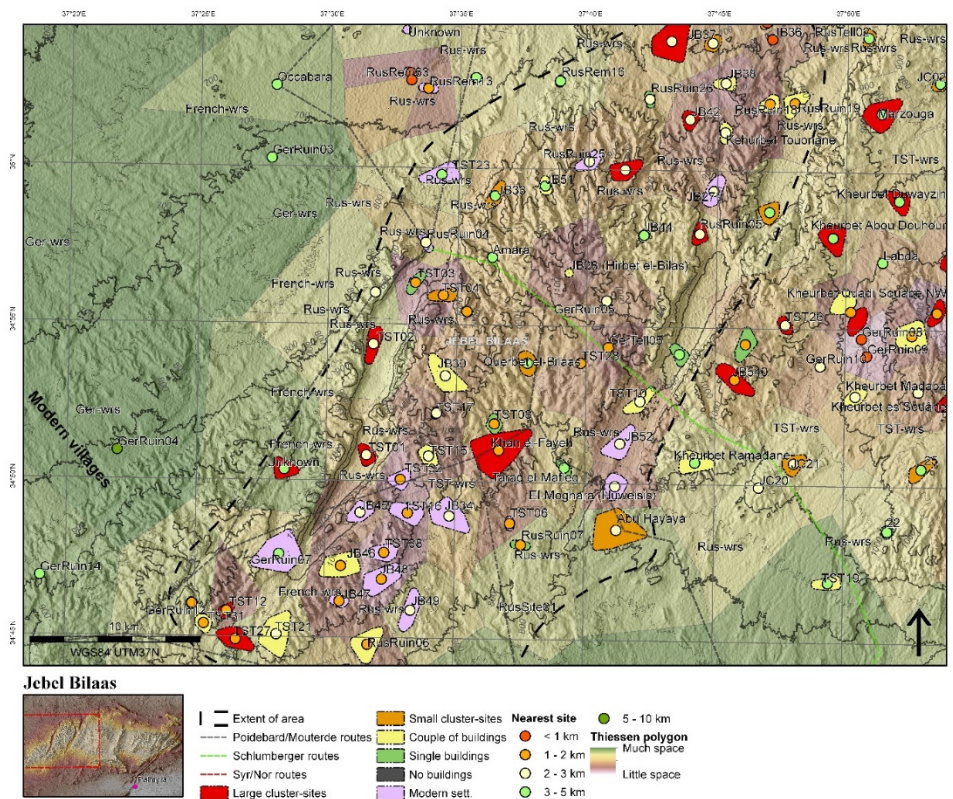


Figure 4.16: Map showing a combination of geographic distribution of type of sites and the results of the density analysis, in the central parts of Jebel Bilaas.

Looking at how Jebel Bilaas relates to other areas, the cluster of *modern settlements* seems to create a centre of sites, including the fortified village Khan el-Fayeh, which is related to the continuous network of sites towards Jebel Chaar. The northern part of the plateau is separated from the southern part by the mentioned field system in the middle, and is possibly related to the large sites on the north/western side of Jebel Chaar.

4.5 Jebel abu Rigmen

Jebel abu Rigmen is located furthest to the east in the mountain range, east of Jebel Merah, north/east of Jebel Abyad, on top of Wadi Abyad. In many ways it resembles Jebel Chaar and Jebel Bilaas by having a plateau at the top of the mountain with gentle terrain, and it is therefore interesting to compare it these areas.

There are 29 documented sites at Jebel abu Rigmen, less than half the amount at Jebel Chaar. Looking at the map in Figure 4.17, most of the sites are located in the central plateau. There is a quite even mixture of *small cluster-sites*, *couple-sites* and *single-sites*, and there are no distinct patterns in the distribution.

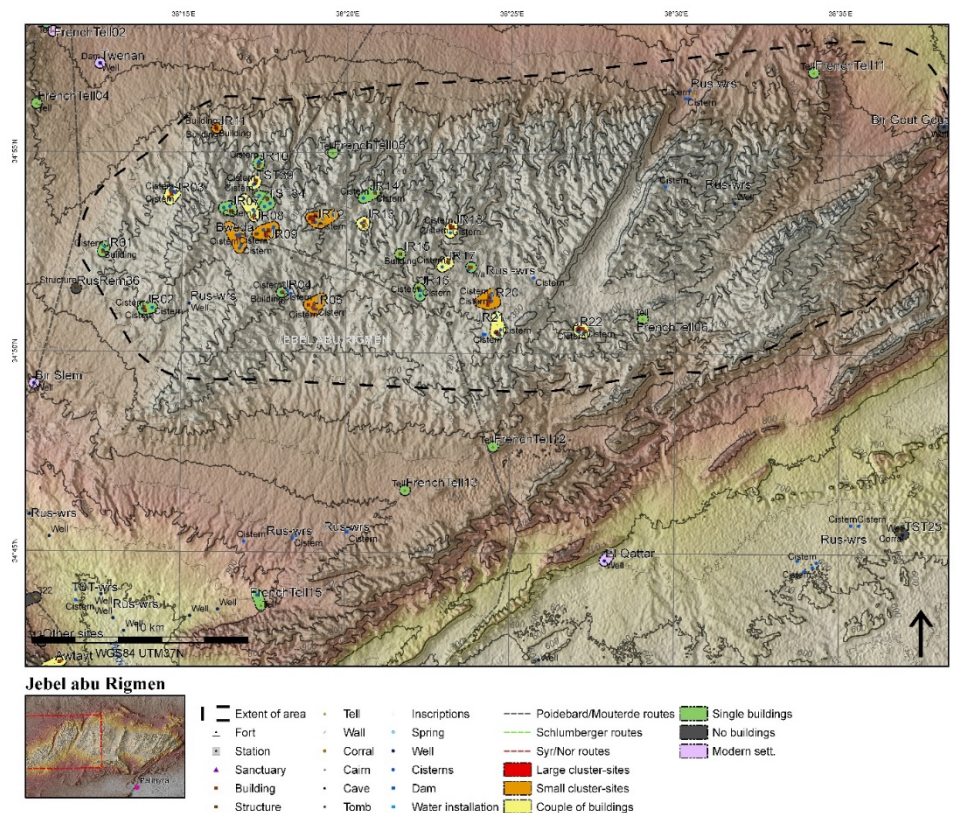


Figure 4.17: Map showing the type of sites at Jebel abu Rigmen.

As seen in the bar chart in Figure 4.18, no sites are defined as *Large cluster-sites*, which differs Jebel abu Rigmen from Jebel Chaar and Jebel Bilaas. There are, however, six *Small cluster-sites*, eight *Couple-sites* and 13 *Single-sites*, which is more similar to the mentioned other areas.

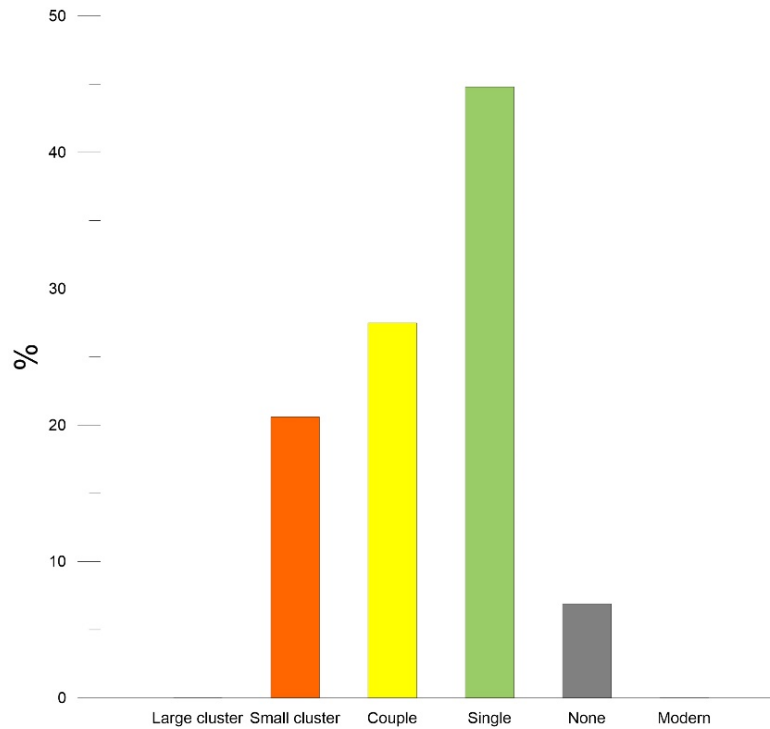


Figure 4.18: Column chart showing distribution (%) of type of sites at Jebel abu Rigmen. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

Looking at the density distribution in the bar chart in Figure 4.19, most of the sites are located in quite dense areas with a distance of 1 – 2 km. This resembles Jebel Merah, and density is higher than most of the sites at Jebel Chaar. Some sites are even denser, while also a number of sites are in areas with less dense distribution.

The map in Figure 4.20 shows that there is a cluster of very dense *couple* and *single-sites* in the western part of the plateau, flanked by three *small cluster-sites* at the south and eastern sides. Further east there is a steady distribution of *small cluster*, *couple* and *single-sites*. The relatively isolated location of the two Small cluster-sites JR05,¹⁰⁸ on the southern side, and

¹⁰⁸ Located by Syr/Nor-survey in satellite imagery.

JR11¹⁰⁹ on the north/western side is peculiar. Their isolated location might indicate that there are more sites to discover in the area. It is in any case interesting that no *large cluster-sites* are found. They are the easiest to locate in satellite imagery due to their size. If compared to Jebel Chaar, this might indicate that Jebel abu Rigmen has not develop as much.

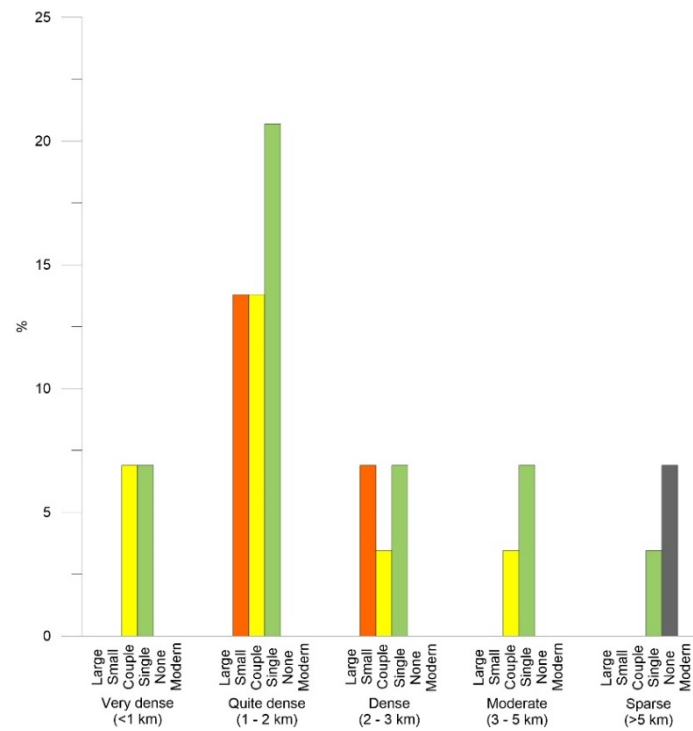


Figure 4.19: Column chart showing the distribution (% of total) based on Point analysis of type of sites based on distance to nearest other site at Jebel abu Rigmen. The colours refers to the colours used for the different kind of type of sites in maps in this study: Red = Large cluster-site, orange = Small cluster-site, yellow = Couple-site, green = Single-site, grey = No buildings-site and pink = Modern settlement.

¹⁰⁹ Located by Syr/Nor-survey in satellite imagery.

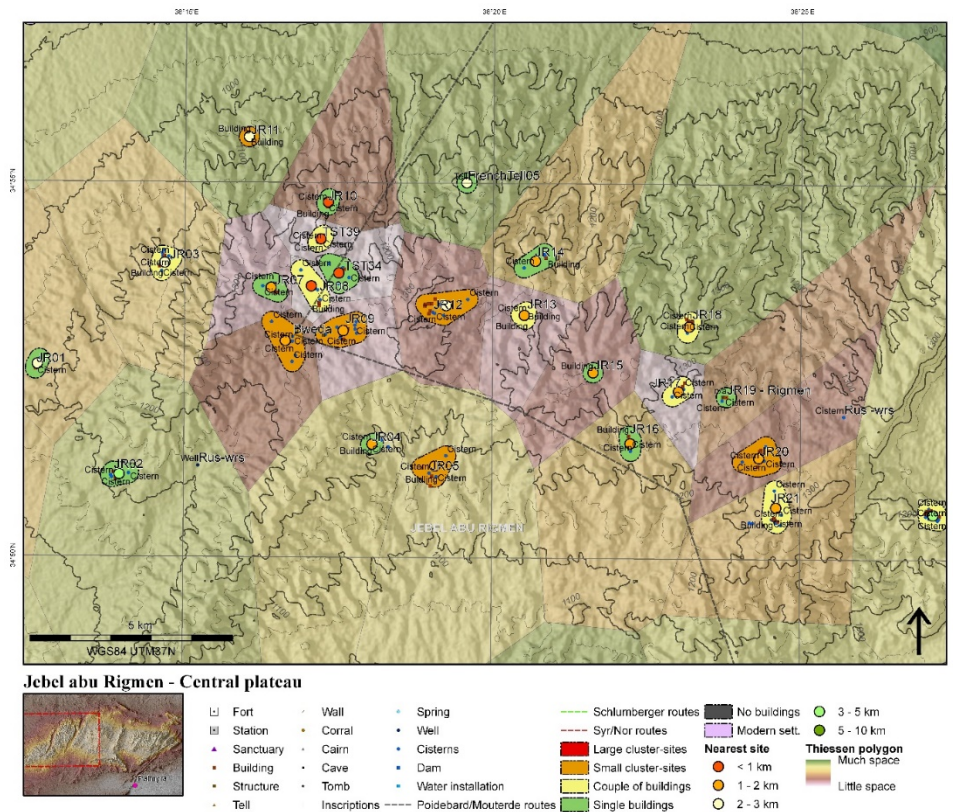


Figure 4.20: Map showing a combination of geographic distribution of type of sites and the results of the density analysis, in the central parts of Jebel abu Rigmen.

Concerning how Jebel abu Rigmen relates to the other areas, there is no evident continuance of sites towards Jebel Merah. Jebel Merah has a concentration towards south/west, and it is quite far to the plateau of Jebel abu Rigmen. In fact, as it appears, Jebel abu Rigmen is a relatively isolated area of settlements.

4.6 Other areas

Besides the major areas of sites in the mountains of the northern Palmyrene hinterland, there are some sites in the large wadis and in the northern and southern steppe areas. These areas are discussed in the following sections. As revealed, while most of these areas contain some impressive but rather isolated sites, the North/western steppe can be compared to areas of settlements at Jebel Char and Jebel Bilaas, and is therefore a very interesting area.

On the southern steppe, in the area west of Palmyra towards ancient Emesa, there are several modern fields, some historical remains, and many wells and water resources have been documented in the Maps. Probably there was significant activity in this area in historical times, but the area needs more investigations on ground in order to document this.

Wadi Djihar is a large catchment area being charged by Wadi Shananeh and large gentle slopes coming from Jebel Chaar and Jebel Bilaas on the western side of Jebel Abyad. As seen in Figure 4.21 there are a few sites located in the long and gentle slopes of the wadi. These are mostly small and/or diffuse sites documented in the Maps. The main area of sites seems to be Tyas, in a bottleneck in the wadi. It is a *modern settlement* that contains historical buildings and several wells. Several sites are located within some distance from this site. Another major site in the area is RusRuin01 towards the southern steppe,¹¹⁰ which contains a large number of water resources next to a *modern settlement*. Centum Putea located in the Russian Maps is also interesting, and contains several wells.

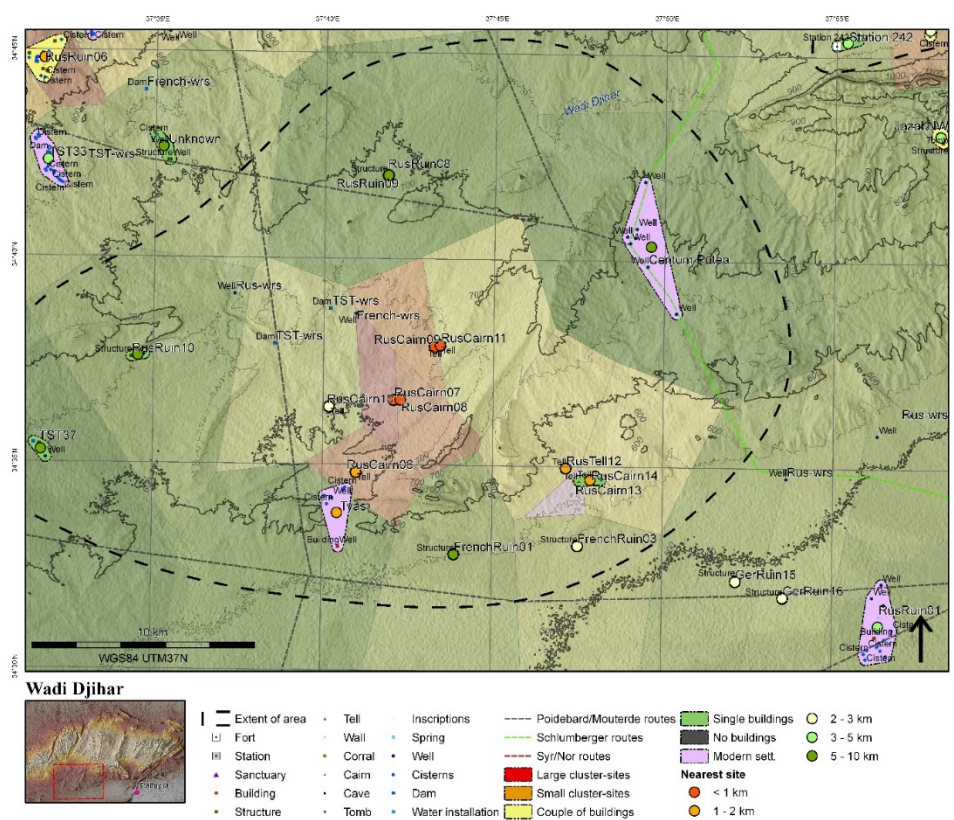


Figure 4.21: Figure showing site distribution, including density analysis in Wadi Djihar.

Wadi Abyad at the eastern side of Jebel Abyad is a large catchment area, which include a large natural basin, mentioned by Musil,¹¹¹ but does not seem to contain any major sites.

Wadi Shanaeh is a different from Wadi Djihar and Wadi Abyad, see map in Figure 4.22. It has not been densely settled, but is located in the middle of an area with much activity. The

¹¹⁰ Located in the Russian Maps.

¹¹¹ Musil (1928), p. 148.

valley is L-shaped, and runs from the area between Jebel Chaar and Jebel Merah, turns 90 degrees north of Jebel Abyad, and heads westwards. Two stations in the western part indicates a route coming from Wadi Djihar.¹¹² In between Jebel Chaar and Jebel Merah lays the mentioned fort of Shanaeh, which serves as a junction between these two areas and the suggested main route through Wadi al-Takara in Jebel Abyad. This makes the fort of Shanaeh important. Just north of the fort of Shanaeh, there are some relatively large sites, the *modern settlement* TST36¹¹³ and the *single-site* WS01¹¹⁴.

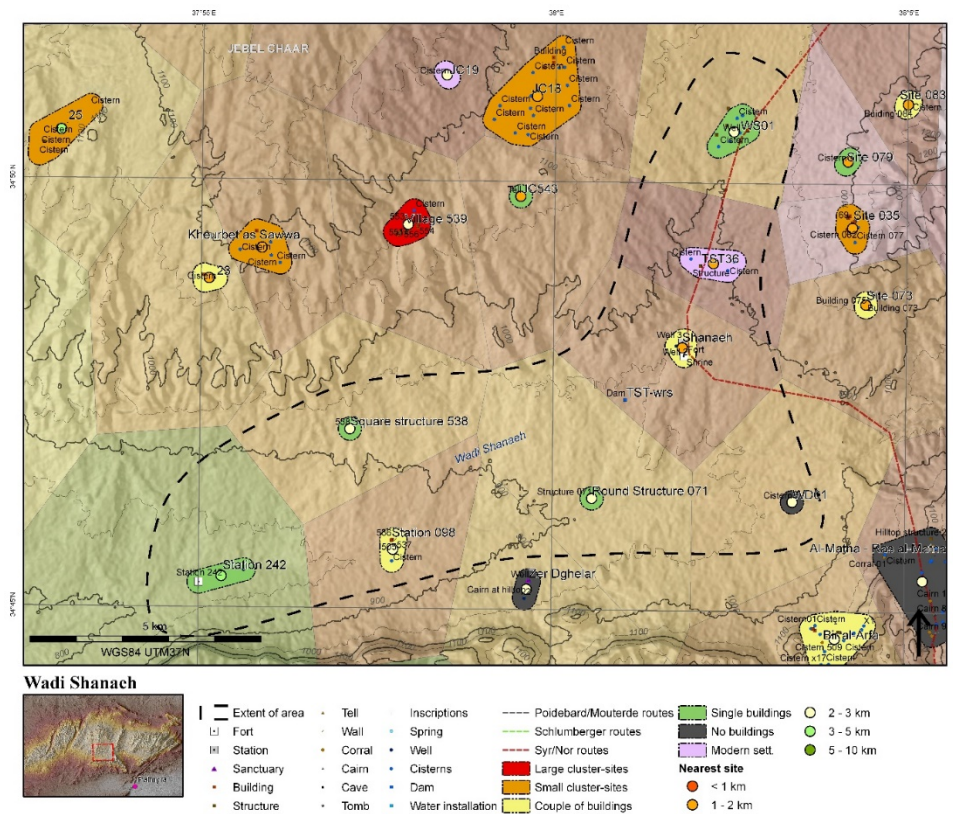


Figure 4.22: Figure showing site distribution, including density analysis in Wadi Shanaeh.

The areas towards the steppe north of Jebel Merah are sparsely settled, but contain impressive sites like Fasida,¹¹⁵ Khaled al-Ali¹¹⁶ and BingX21,¹¹⁷ located by the Syr/Nor-survey, in addition to Acadama and Birke,¹¹⁸ located by Poidebard and Mouterde, which all contain

¹¹² Station 242: Syr/Nor (2008), p. 85-86; Station 098: Syr/Nor (2008), p. 83-84, Syr/Nor (2009), p. 99-103.

¹¹³ Located by this study in satellite imagery.

¹¹⁴ Located by the Syr/Nor-survey in satellite imagery.

¹¹⁵ Syr/Nor (2008), p.105-112.

¹¹⁶ Syr/Nor (2008), p. 112-120.

¹¹⁷ Located by the Syr/Nor-survey in satellite imagery.

¹¹⁸ Located by Poidebard & Mouterde.

forts, stations and elaborate water resources. These sites seem to have a special function related to the main routes going from Palmyra towards the northern steppe.

The area north/west of Jebel Chaar, north of Jebel Bilaas (referred to as the North/western steppe from now on), that gently slopes towards the northern steppe, is far more interesting in terms of estates and villages (see map in Figure 4.23). It contains forts, stations and *large cluster-sites*. Among these is the impressive fortified village of Ht ed-Dose.¹¹⁹ There are also four *small cluster-sites*, three *couple-sites*, 11 *single-sites* and a range of *modern settlements* quite evenly distributed in the whole area. It seems to be a continuance of the network of *large cluster-sites* in the north/western parts of Jebel Chaar, as well as a continuance of the network at the northern part of the central plateau of Jebel Bilaas. As discussed later, the geological and climatic conditions are favourable, and there good reasons for comparing the North/western steppe to the other mountains in the hinterland.

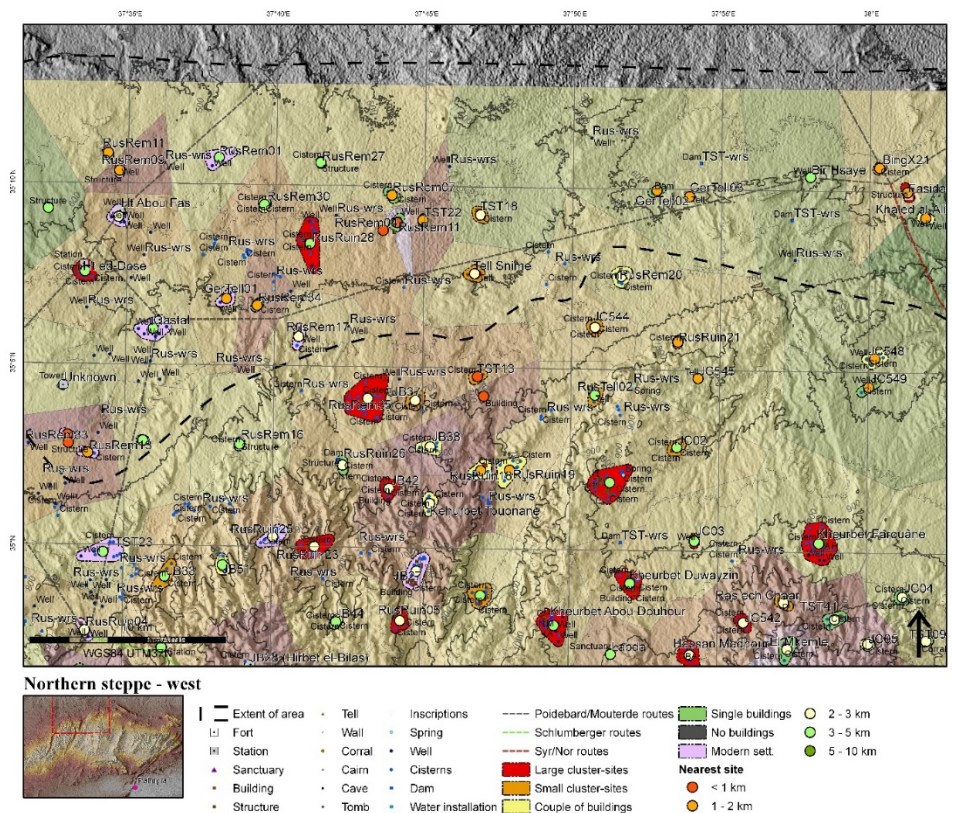


Figure 4.23: Figure showing site distribution, including density analysis in the Northern Steppe.

¹¹⁹ Located by Poidebard & Mouterde.

5 The water system of the northern Palmyrene hinterland

One of the main questions in the academic discourse is how productive the northern Palmyrene hinterland may have been. As described in chapter 2, for years, scholars thought herding and breeding of animals was the only activity of the hinterland. The main argument for this reluctant view was *the 200 mm-argument*, the thumb rule that states that areas that are located within the 200 mm isohyet are marginal,¹²⁰ This stands in strong contrast to the several hundred sites located in the northern Palmyrene hinterland, which tell a story of a quite probably productive area. It is obvious that the *200 mm-argument* is inadequate in explaining the natural conditions of the northern Palmyrene hinterland. This knowledge is well established in the present academic discourse,¹²¹ and this chapter aims to explain how the *200 mm-argument* is inadequate, and how water have contributed to the existence and potential productivity of the northern Palmyrene hinterland.

The fundamental inadequacy of the *200 mm-argument* is that it only relates to the yearly amount of precipitation, not the amount of water available for human exploitation. The yearly amount of precipitation is of course important, but it is only one of several variables involved in the hydrological cycle, that shapes how much water, which is potentially available for human usage. The *200 mm-argument* neither take into account the many ways human intervention can increase the amount of water available for human usage. This is illustrated in the diagram in Figure 5.1, which clearly differs between how water is a source for human exploitation (*source*),¹²² the way in which water is made available for human usage (*method*), and how it is used (*function*), i.e. existence and productivity. The reference to the contents in the diagrams in the rest of this chapter are with italic letters.

In the following sections the water system is reviewed in detail. This includes looking at relevant data from the compiled dataset and information from academic research, circumstantial information like climatic, geological and topographical data, which is analysed using GIS.

The review of the water system will follow the structure of the diagram in Figure 5.1. The contents will be reviewed as listed in the diagram. The lines drawn between the boxes of

¹²⁰ See page 1 for discussion.

¹²¹ See Meyer (2013).

¹²² Source of water, defined as the way water is distributed in the hydrological cycle, is deliberately differed from Water resource, defined as bodies of water, often artificially developed, in which humans can collect and access water.

content in the diagram indicates relation, which show the whole logic of the sources of water relates to the functions suggested in the academic discussion.

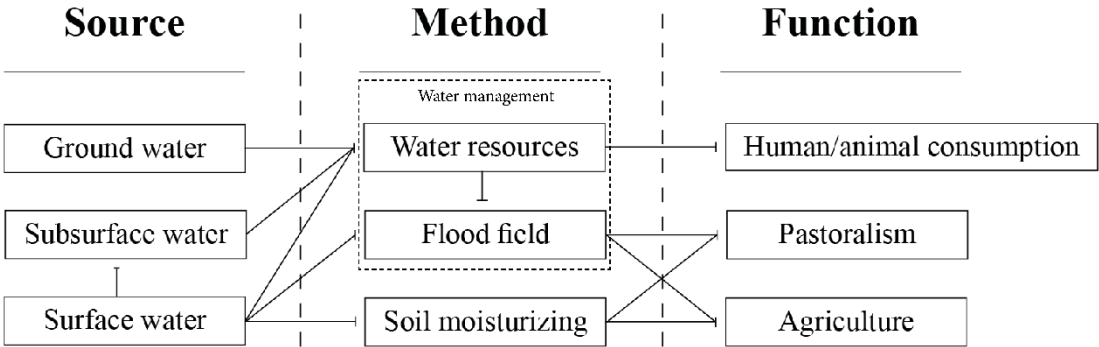


Figure 5.1: Diagram showing the relation between water sources and usage in the northern Palmyrene hinterland. Diagram is made by this study.

5.1 Detailed description of the water system in the northern Palmyrene hinterland

In the following section a detailed review of contents of the diagram (Figure 5.1) will be presented. The structure in the presentation is the same as that of the diagram, and the headers of the detailed description relates to the mentioned content. The aim of the presentation is to discuss what we know about how water was made available and used.

5.1.1 Source

As illustrated in the diagram (Figure 5.1), there are three sources of water in the northern Palmyrene hinterland: *Ground water*, *subsurface water* and *surface water*. These represent the fundamental ways water is possibly available for human exploitation, the basis of existence and activity. *Ground water* is old water stored in the aquifer of the source rock. *Subsurface water* is precipitation that has infiltrated the surface and joined the subsurface water system of the water bearing strata. *Surface water* is precipitation that flows on the surface and moisturizes the upper parts of the soil. The relation between *surface water* and *subsurface water* is illustrated with a line in the diagram. In the following sections, the fundamental mechanisms of these sources of water are discussed.

5.1.1.1 Ground water

Geological conditions are of essence in order to understand *ground water*. *Ground water* is very old water stored in a porous or fractured geological layer. It is the *source* of the springs, which are described later. The majority of the *ground water* in the mountainous areas north of Palmyra can be millions of years old, from a time when geological conditions were different

and the climate was much more humid in the region.¹²³ This makes *ground water* a stable *source* of water that is not affected by variation in climate.

The tectonic map in Figure 5.2 shows that most of the northern Palmyrene hinterland consists of Cretaceous source rock. This is a hard limestone,¹²⁴ which also contains the main aquifer that contains the ground water in the area. A notable exception to the distribution of Cretaceous source rock in the area is Jebel Abyad, which consist of Paleogene source rock. This source rock consists of chalk,¹²⁵ which also has aquifer abilities.



Figure 5.2: Tectonic maps that shows the distribution of source rock in the northern Palmyrene hinterland. The map is made by this study based on Tectonic map in the appendix of: *Tectonic and Geologic Evolution of Syria*, by G. Brew, M. Barazangi, A.K. Al-Maleh and T.Sawaf, *GeoArabia*, 2001. (<http://atlas.geo.cornell.edu/people/brew/gbthesis5.html> 08/05-2017).

5.1.1.2 Subsurface water

Subsurface water the *source* of wells, which are discussed later. In most cases of the northern Palmyrene hinterland, *subsurface water* concerns *surface water* that has infiltrated the loose soil of the wadi beds, and through a long process joined the subsurface channels beneath the wadis in the water bearing strata. The water bearing strata is the hard layer of source rock beneath the loose soil of the surface. The thickness of the eroded loose soil might vary. Some

¹²³ <http://geology.uprm.edu/Morelock/carb.htm> (09/10-2015)

¹²⁴ <http://geology.uprm.edu/Morelock/carb.htm> (09/10-2015)

¹²⁵ Wagner (2011), 3.4.4.1.

places it can be up to hundreds of meters thick. In other places have source rock at the surface, as observed by Musil in the higher parts of Jebel Abyad,¹²⁶ and can be observed in satellite imagery at Jebel Merah and at the north/western parts of Jebel Bilaas. The water bearing strata creates channels in which the infiltrated water flows. Some places there are faults that trap the water and creates subsurface bodies of water. The amount of water that infiltrates the eroded soil and enters the *subsurface water*-system is difficult to suggest. It is one of several parts involved in the hydrological circle of *surface water*, which will be discussed in the following section.

5.1.1.3 *Surface water*

Surface water concerns how precipitation contributes in the hydrological cycle. It is the *source* of cisterns, and the main source of *flood field* systems, which are described later. After the precipitation hits the surface, there are four mechanisms that occur in the hydrological cycle: One part infiltrates the surface and enters the subsurface water system, a second part evaporates, a third part flows on the surface and a fourth part stays in the upper parts of the surface moisturizing the soil. The way this turns out is influenced by the distribution of precipitation over time, temperature, layout of the terrain, and the type of soil and vegetation. These topics are the key elements of three factors: Infiltration factor, evaporation factor and runoff factor. In the following sections these three factors will be discussed in detail.

The first of the three factor is the infiltration factor. It describes how much of the precipitated water that infiltrates into the ground. This concerns how much water the soil can be subjected to for a certain period of time before it exceeds its capacity to infiltrate water. This is determined by the amount of precipitation and intensity of the rain over a period of time, steepness of the terrain and the ability of the soil and vegetation to absorb water.

The amount of precipitation and intensity of rain for a certain period of time relates directly to the *200 mm-argument*. The *200 mm-argument* does however not concern distribution in space or time. As seen in Figure 5.3, the mountainous area north of Palmyra normally receives between 130 and 200mm of precipitation a year. According to the ecologist Eugene Wirth, the climatic conditions are quite similar today as in the Roman era.¹²⁷ The precipitation seems to be lowest towards the southern steppe, and increases with altitude and the further west one

¹²⁶ Musil (1928), p. 147.

¹²⁷ Wirth (1971), p.98.

gets. It is notable that precipitation does not decrease to the north/west even though the altitude does.

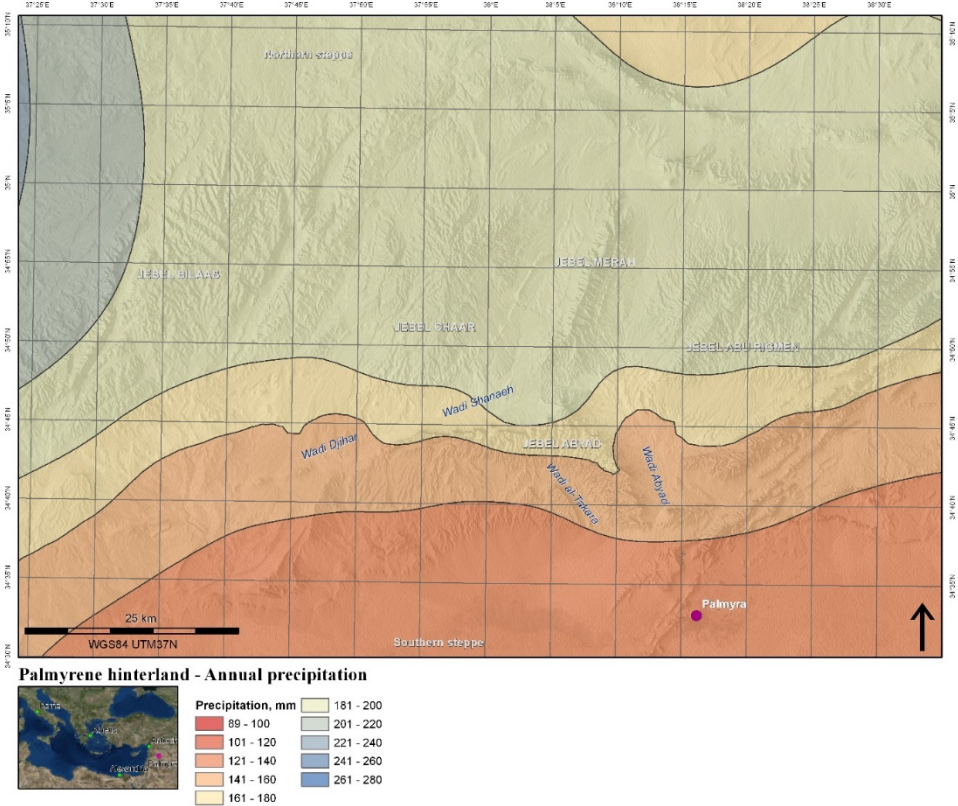


Figure 5.3: Map showing annual precipitation in the northern Palmyrene hinterland. The map is interpolated by this study based on map in Oweis, Theib, Briefing notes on the circe rural case studies: Tel Hadya, ICARDA (International Center for Agricultural Research in the Dry Areas), Aleppo, Syria, 2007, page 1.

Looking at the spatial distribution of precipitation in, (as shown in the table in Figure 5.3), the four northernmost mountains, Jebel Bilaas, Jebel Chaar, Jebel Merah and Jebel abu Rigmen, share the average precipitation of around 190 mm a year. Jebel Abyad has about 17% less precipitation in average than the other mountains. The minimum precipitation calculated in the table shows that there can be a big difference in precipitation between the lower and higher parts of the mountains. It is interesting that the north/western steppe receives more precipitation than the mountains, with 197 mm a year.

Name	Minimum	Maximum	Average
Jebel abu Rigmen	166	195	190
Jebel Abyad	134	189	156
Jebel Bilaas	154	204	189
Jebel Chaar	161	194	190
Jebel Merah	174	191	190
North/western steppe	182	224	197

Wadi Djihar	129	162	142
Wadi Abyad	134	191	159
Wadi Shanaeh	161	191	182
North/eastern steppe	160	192	185

Figure 5.3: Showing precipitation in the different areas of the northern Palmyrene hinterland. Based on map shown in Figure 5.2.

These numbers represent the yearly average. Figure 5.4 shows a detailed chart of how the current precipitation in Palmyra is distributed during the months of the year. It shows that precipitation is distributed quite evenly in the winter months (December – April), while the four summer months (June-September) are dry.

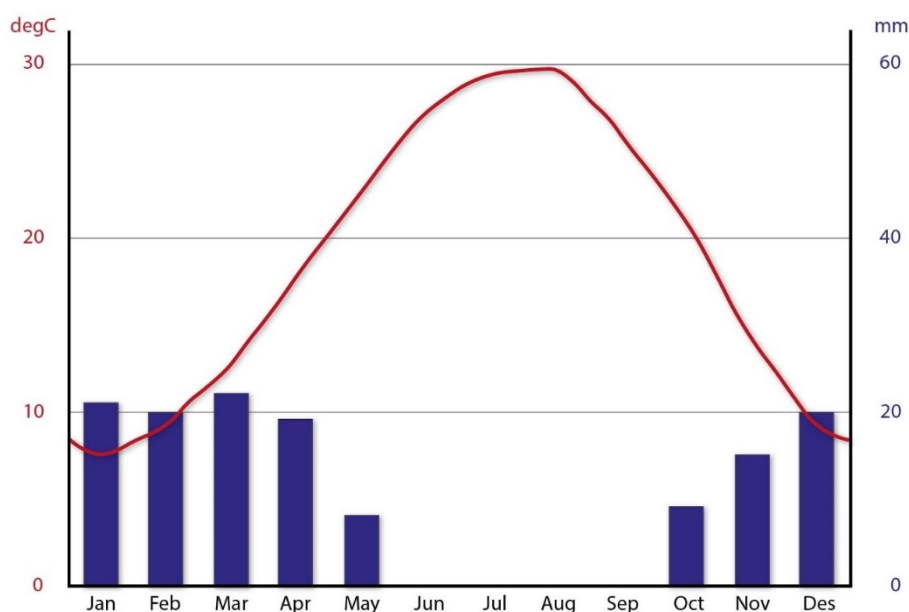


Figure 5.4: Chart that shows the distribution of precipitation and temperature during a year in the city of Palmyra. The chart is made by this study based on: <https://en.climate-data.org/location/47708/> (04/05-2017)

For a period of time there is a great variation from this average. The rainfall tends to come in intense showers, and the amount of precipitation can vary as much as four times from one year to another.¹²⁸ The city of Palmyra, which on average receives about 135 mm precipitation a year, actually varies from 64-255mm,¹²⁹ and the dry periods often tend to last

¹²⁸ Sartre (2005), p.219.

¹²⁹ Syr/Nor-2008, p. 121.

for three to four years.¹³⁰ The soil will probably be quite dry and compacted in those periods. This means that how the precipitation is distributed over time speaks in favour of a relatively low Infiltration factor compared to the total amount of precipitation.

The second of the three factors that is important in the hydrological cycle of *surface water* is the evaporation factor. The evaporation factor is the opposite of the infiltration factor, and describes how much of the water that evaporates into the air. The evaporation factor is roughly a result of how long a certain amount of water is subjected to a certain temperature. The higher the temperature and longer the time, the higher the evaporation factor. This is determined by the temperature, steepness of the terrain and type of soil and vegetation, in addition to the amount and intensity of the precipitation.

The current average temperature of Palmyra is 18.8 °C,¹³¹ ranging from below 10 to almost 30 °C during the year (see the temperature line in the chart in Figure 5.4). Looking at the distribution of precipitation and temperature during the year, it is important that most of the rain falls when the temperature is at its lowest. This means that the evaporation factor is low. In the summertime, when there is no precipitation, the evaporation is at the highest.

The map in Figure 5.5 shows the distribution of maximum temperature in January – March. It shows that the higher in elevation and further to the west one gets, the lower the temperature.

¹³⁰ Meyer (2013), p. 171.

¹³¹ <https://en.climate-data.org/location/47708/> (04/05-2017).

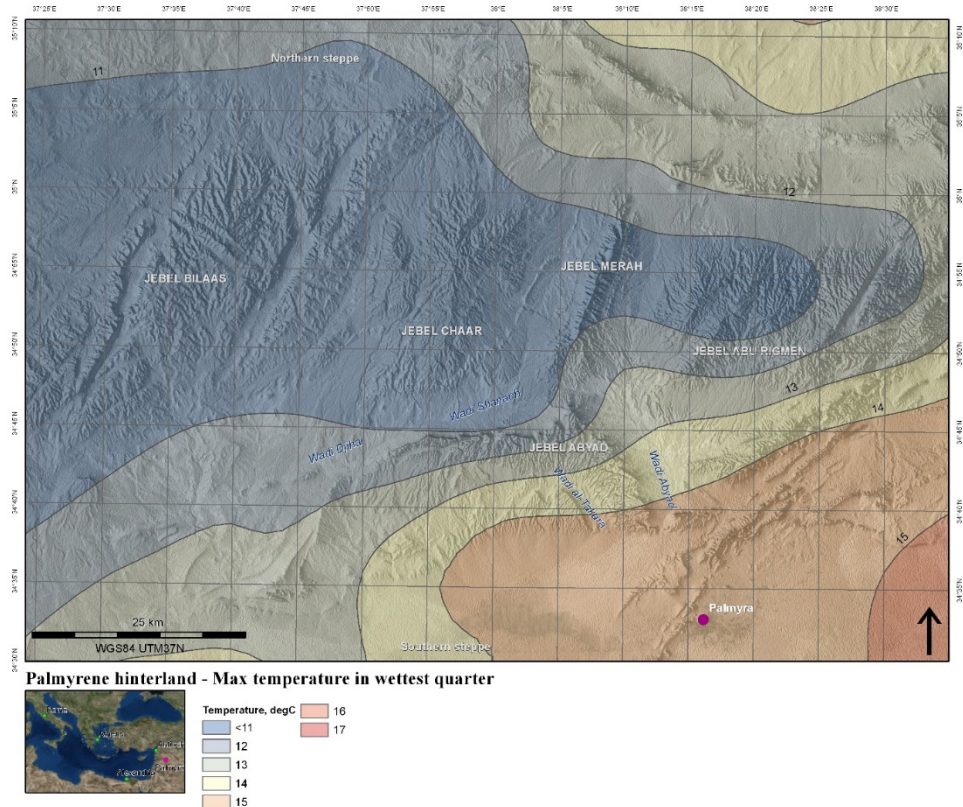


Figure 5.5: Map showing maximum temperature in the wettest quarter of the year. The map is interpolated by this study based on http://wheatatlas.org/Maps_countries/environment/SYR/SYR_MAXTEMP_WET.jpg (08/05-2017)..

The table in Figure 5.6 shows that the two westernmost mountains, Jebel Bilaas, Jebel Chaar, are the coldest with 10 °C, while Jebel Merah and Jebel abu Rigmen have 11 °C. Jebel Abyad to the south is notable warmer, with 13 °C (30 % higher than Jebel Chaar). It is also notable that the north/western steppe has not an increase in temperature as the southern and north/eastern steppe, but shares the temperatures of the high mountains Jebel Merah and Jebel abu Rigmen of 11 °C. As Meyer suggests, the cooler temperatures of the areas of higher altitude in the norther Palmyrene hinterland, may have made the area popular for summer pasture when the Syrian steppe in general received little precipitation.¹³²

Name	Minimum	Maximum	Average
Jebel abu Rigmen	10	13	11
Jebel Abyad	11	14	13
Jebel Bilaas	10	12	10
Jebel Chaar	10	12	10
Jebel Merah	10	12	11
North/western steppe	10	12	11
Wadi Djihar	11	13	12

¹³² Meyer (2013), p. 97.

Wadi Abyad	11	15	13
Wadi Shanaeh	10	11	10
North/eastern steppe	11	14	13

Figure 5.6: Showing max temperature in the wettest quarter in the different areas of the northern Palmyrene hinterland. Based on map shown in Figure 5.5.

Both infiltration and evaporation factors are affected by the steepness of the terrain. The steepness influence how much time the water is given to infiltrate and evaporate. The map in Figure 5.7 shows the results of a GIS analysis of the roughness of the terrain (background layer), and the average slope in the main catchment areas of each site (coloured circles). The catchment area is the area of all the surface water that flows to a certain outlet. It is also called basin and watershed. All of the sites, with very few exceptions, are related to a catchment area with more than 2 % gradient in average. In other words, they are not like the flat steppe. The map shows that most of the sites at Jebel Abyad and Jebel Merah have steep (> 10 % gradient), or quite steep (5 – 10 % gradient) catchment areas. In contrast, Jebel Chaar has in general less steep catchment areas (usually 2 – 5 % gradient). This fits with the characterization by Meyer that Jebel Chaar has an undulating terrain.¹³³ There are, however, differences within the plateau of Jebel Chaar, and the sites that are immediately north and north/east in the central plateau have slightly steeper catchment areas (5 – 10 %). The two other plateau shaped mountains in the hinterland. Jebel abu Rigmen and Jebel Bilaas, seem to share the steepness found in the catchment areas at Jebel Chaar. The central plateau of Jebel Bilaas seems to have slight differences between the northern/western and southern parts, since the southern part dominated by catchment areas with low steepness (2 – 5 %), while the north/western part of the central plateau, the catchment areas area slightly steeper (5 – 10 %). Towards the northern steppe, the terrains smoothens, and the gradient of the catchment areas are in general with low steepness (2 – 5%).

¹³³ Syr/Nor (2008), p. 128.

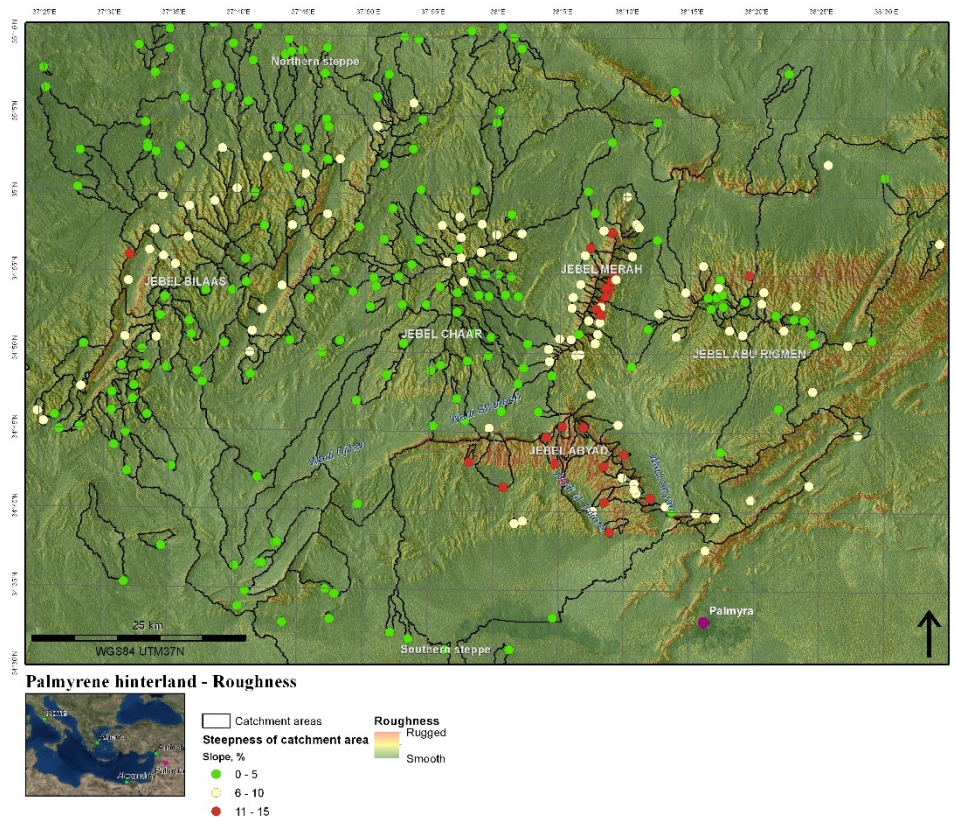


Figure 5.7: Map showing general roughness of terrain and steepness of the catchment areas of the sites in the northern Palmyrene hinterland. The map is made by this study using GIS-analysis.

The last aspect that can have a huge impact on infiltration and evaporation factor is the type of soil and vegetation. The soil's ability to absorb water and the vegetation's ability to store humidity, affects the time the water is subjected to infiltration and evaporation. If the abilities of the soil and vegetation to store water are good, it will create a microclimate that will nurture the growth of vegetation.¹³⁴

Looking at the area around Palmyra, it is obviously quite dry (see Figure 5.7). Besides the natural causes for this dryness, the soil and vegetation in the area north of Palmyra is also a result of human intervention. As part of official policies for re-organization of laws in 1958, a huge number of trees were chopped down.¹³⁵ This means that the area probably was more vegetated in historical times than it appears today.

¹³⁴ Syr/Nor (2008), p. 121; Meyer (2013), p. 172

¹³⁵ Jabbur (1995), p.56; Syr/Nor (2008), p. 121.



Figure 5.7: Photo of Bir al-Arfa taken by Jørgen Christian Meyer as part of the Syr/Nor-survey in 2009. ©Meyer. (<http://www.hist.uib.no/antikk/dias/Palmyrena/BirArfa/Overviews/Data/page.htm?0,0> 08/05-2017).

As can be seen in the image of Bir al-Arfa in Figure 5.7,¹³⁶ soil appears dry and there are few trees. The vegetation is actually more promising than it would appear. The ground is in general covered by small grass roots covering the surface.¹³⁷ Trees have also been documented in each of the five mountains. At Jebel Bilaas several trees are visible in satellite imagery, and as can be seen in the image in Figure 5.8, recent photos show both vegetation and trees. At Jebel Chaar, several photos taken before the deforestation show trees,¹³⁸ and the area is assumed to have been covered by trees in the Roman era.¹³⁹ Trees were observed at Jebel Merah in the early 20th century, and Jebel abu Rigmen was described as having so many Terebinth trees that the area looked like a “...vast natural park”.¹⁴⁰ Also Jebel Abyad has several accounts that attest to the existence of trees from before the deforestation, both descriptions and images.¹⁴¹ One valley without trees today is called “valley of the oil trees” by

¹³⁶ Documented by the Syr/Nor-survey in 2009: Syr/Nor (2009), p. 89-98.

¹³⁷ Syr/Nor (2009), p. 107.

¹³⁸ Referring to several of the images taken by Daniel Schlumberger: Schlumberger (1951), Pl. I - XX

¹³⁹ Syr/Nor (2009), p. 128.

¹⁴⁰ Musil (1928), p. 149; Butcher (2003), 178.

¹⁴¹ See: Syr/Nor (2008), p. 121; Syr/Nor (2009), p. 128.

locals,¹⁴² and it is assumed that also Jebel Abyad was quite covered by trees in historical times.¹⁴³



Figure 5.8: Photo of a *Pistacia Atlantica* tree in the north Palmyrene hinterland taken by Jørgen Christian Meyer. ©Meyer. (<http://www.hist.uib.no/antikk/dias/Syria/PalmyraN/Tree/Data/page.htm?23.0> 08/05-2017).

The third of the three factors that is important in a hydrological system is the runoff factor. Since it is difficult to know what the infiltration and evaporation factors are without a proper hydrological investigation. One can measure the runoff. The runoff is the amount of precipitation that has not infiltrated the surface or evaporated, but has continued to flow on the surface through the catchment area. This amount of precipitation is described with the runoff factor. A study performed in Jordan in quite similar conditions suggests a runoff factor of 7-8 % in general.¹⁴⁴ The hydrologist Mamdouh Shahin says that the runoff factor can be as high as 40 % for whole drainage areas in certain places in Syria with steep slopes.¹⁴⁵ *The Handbook for Agrohydrology* suggest as much as 80 % runoff factor in rocky areas and saturated soils with a gradient of more than 12 %.¹⁴⁶

¹⁴² Syr/Nor (2008), p. 24.

¹⁴³ Syr/Nor (2009), p. 128.

¹⁴⁴ Al Ayyash (2012).

¹⁴⁵ Mamdouh (2007).

¹⁴⁶ Miller, (1994).

Figure 5.9 shows a calculation in GIS of the amount of runoff in the main catchment area of each site in the northern Palmyrene hinterland. The map is based on a rough calculation of the runoff factor based on steepness, multiplied with the total amount of precipitation.¹⁴⁷ Detailed information of size, general steepness and average precipitation for each site is presented in the table in the appendix. Even though the map is based on rough calculations, and one must conduct hydrological analysis on ground in order to get the real impression, it gives a good impression of what 200 (and less) mm of precipitation actually amounts to in terms of water. Many of the sites have tens and hundreds of millions of litres of water in runoff. The largest catchment area has more than a billion litres in runoff. Knowing that an Olympic swimming pool contains 2.5 million litres,¹⁴⁸ the lack of water is in many ways not the main concern of the region. Knowing that only 5 - 10 % of the precipitation in most cases ends up as runoff, the amount of water left in the fields and hillsides for infiltration and evaporation is enormous.

There is a widespread distribution of amount of runoff for the sites throughout the northern Palmyrene hinterland. There seem to be few sites with more than 100 mill litres of water in runoff at Jebel Chaar, Jebel Merah and Jebel abu Rigmen. Besides the expected pattern of huge amounts of runoff water in the large wadis in general, there seems to be an increased amount of runoff water in general at Jebel Bilaas compared with Jebel Chaar, and the North/western steppe even has quite many sites that have more than 500 mill litres in runoff water.

This is shown in detail in the chart in Figure 5.10. About 37 % of the sites at Jebel Chaar have 5 – 20 mill litres of runoff water, while about 25 % have 1 – 5 and 23 % have 20 – 100 mill. In comparison, 40 % of the sites at Jebel Bilaas have 20 – 100 mill litres of runoff water, and 27 % of the sites have more than 100 mill litres of runoff water. There is a notable exception of catchment areas with more than 500 mill of runoff water at Jebel Chaar, while 10 % of the sites at Jebel Bilaas have this amount.¹⁴⁹ It is interesting to see how similar the amount of water is distributed in Jebel Bilaas and Jebel Abyad. This is not because the conditions are the

¹⁴⁷ The calculation based on the size of the catchment area, total amount of precipitation within the catchment area, and the average slope in the catchment area. The runoff factor is modest and rough based on the mentioned studies. They should be investigated in detail in order to give the best result for each site: Catchments areas with more than 15% gradient = 12.5% runoff efficiency, 10- 15 % gradient = 10% runoff , 5 – 10% gradient = 5% runoff, < 5% gradient = 2.5% runoff. The runoff factor for the steepest parts are probably much higher than the modest factor used in this calculation.

¹⁴⁸ <http://www.livestrong.com/article/350103-measurements-for-an-olympic-size-swimming-pool/> (01/05-2017)

¹⁴⁹ Some of catchment areas must be studied in more detail, since the shape of the distinct valleys makes it hard to calculate in GIS.

same. There is much more precipitation in Jebel Bilaas. Jebel Abyad has steeper terrain, and There seems to be an increase in the amount of runoff water in the sites towards the northern parts of the plateau of Jebel Bilaas. This tendency is evident towards the North/western steppe. As seen in the chart (Figure 5.9), 35 % of the sites in the slopes towards the north/western steppe receives more than 500 mill litres of runoff water, and more than 25 % of the sites receives 100 – 500 mill litres.

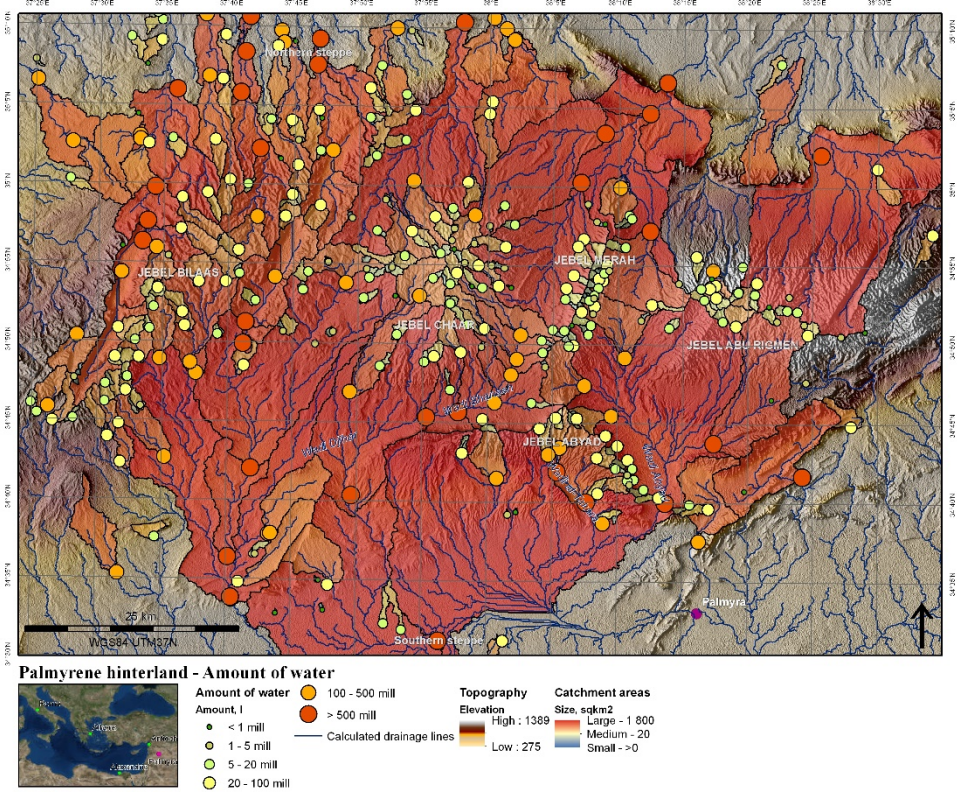


Figure 5.9: Showing the calculated amount of water for each site in the northern Palmyrene hinterland. The map is made by this study using GIS analysis.

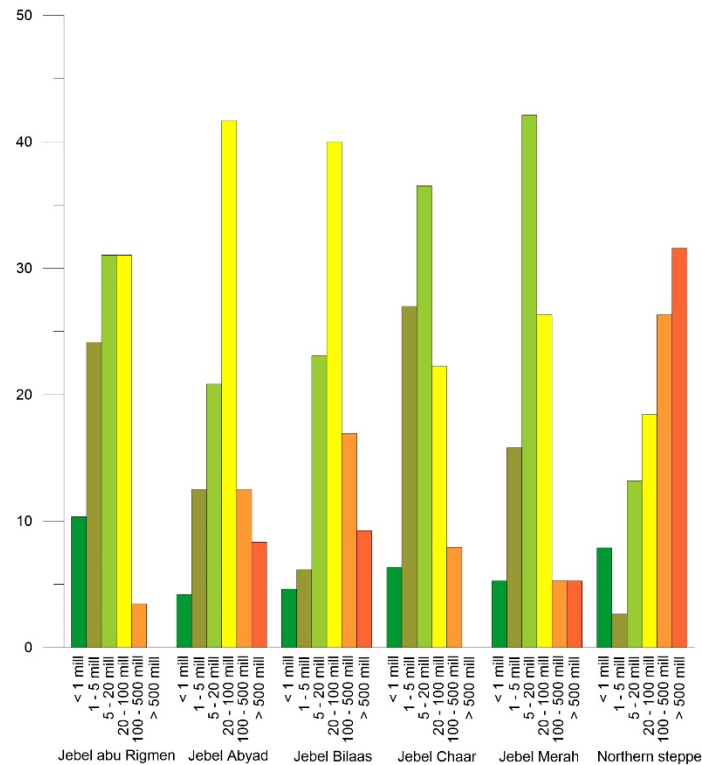


Figure 5.10: Showing chart of distribution of amount of water of the sites in each area. The chart is made by this study based on GIS-analysis. The colours of the bars reflect the amount of water, and are the same colours used in the map in Figure 5.9: Green is little (< 1 million litres) – Red is very much (> 500 million litres)

5.1.2 Methods

As illustrated in the diagram in Figure 5.1, there are three ways in which water is made useful for human activity (*methods*). One is through *water resources*, a second is *flood fields* and a third is *soil moisturizing*. These three methods represent different basis of existence and means of production. *Water resources* are in this context defined natural or artificially bodies of water as springs, wells and cisterns (including dams). *Flood fields* are in this context defined as artificial ways of directing and trapping water into fields in order to make it more fertile. *Soil moisturizing* involves the nature's own ability to moisture the soil through precipitation or the flow of wadis.

Water resources and *flood field*-systems can be connected to *water management*-systems. This is illustrated in the diagram in Figure 5.1. *Water management*-systems can have to purposes. It can improve the catchment of water, or it can distribute the water from the *water resource*.

In the following sections these methods will be reviewed in detail. The main scope is to present the information available and with the help of GIS, analyse how the methods were used by the different sites of the northern Palmyrene hinterland.

5.1.2.1 *Water resources*

Water resources concerns the three main ways of accessing bodies of water in the northern Palmyrene hinterland: springs, wells and cisterns. Cisterns receive water from the surface, wells receive infiltrated water from the wadi flow that has been trapped in a subsurface fault, and springs receive water from the aquifer which is forced up to the surface due to elevation in the terrain. This is illustrated with lines in the diagram in Figure 5.1. Of the 1875 water resources listed in the dataset, 17 are springs, 267 are wells, 743 are cisterns (in addition to 58 dams), and 818 are potential water resources located by this study are described as “wrs” (short for water resource).¹⁵⁰ This means that cisterns are by far the most numerous water resource in the northern Palmyrene hinterland.

In the following sections a comprehensive overview of *water resources* will be presented. This includes information on how the *water resources* were developed, how they functioned and how they were distributed in the northern Palmyrene hinterland. This is interesting in order to discuss what type of *water resources* that was important in the hinterland, and what effort that was put into accessing water.

Springs are the outlet of *ground water* that is forced to the surface through cracks and fractures in the geological layers. This means that springs are stable *water resources* that are not affected by yearly or seasonal variation in precipitation. The water of springs may also be easily accessible since the water is pressurised, and might flow from the *water resources* without the need of human effort. The Syr/Nor-survey have documented several springs with outlets that are quite developed by humans. Some openings are cut out in rock and reinforced with stones,¹⁵¹ some springs have artificially rock-cut ponds at the surface for collecting water,¹⁵² some springs might have aqueducts to lead the water away.¹⁵³

¹⁵⁰ They will be treated as cistern in the following analysis. This might create some errors, but the main impression is probably right.

¹⁵¹ Shalalah (Quechél): Syr/Nor (2008), p. 28.

¹⁵² Akerem: Syr/Nor (2009), p. 15-16.

¹⁵³ Shalalah (Quechél): Syr/Nor (2008), p. 29; Akerem: Syr/Nor (2009), p. 14.



Figure 5.11: Photo of spring with pond for collecting water at Akerem taken by Jørgen Christian Meyer while investigating the site with the Syr/Nor-survey in 2009. ©Meyer.

(<http://www.hist.uib.no/antikk/dias/Palmyrena/Akarem/Springarea/Data/page.htm?7,0> 08/05-2017).

There are some drawbacks with springs. Since they exist based on very specific geological conditions, the position is fixed. The function of a site must adapt to the position of the springs, not the other way around. The second drawback is that there are very few springs in the northern Palmyrene hinterland. Less than 1% of all the located water resources are springs, which makes springs statistically insignificant as water resource in the area. On the other hand, the great value of a spring must have given the sites close to springs some prominence.

As seen in the map in Figure 5.12, 10 of the 17 documented springs have been located at the eastern edge of Jebel Abyad. Seven of these are documented with certainty by the Syr/Nor-survey, two at Akerem and five at Shalalah (Quéchel).¹⁵⁴ These springs must have been important for the settlement at Shalalah (Quéchel) and the sites around Akerem. The other springs at Jebel Abyad are documented in the Russian Maps. While one is located some hundred meters south of the springs located by the Syr/Nor-survey at Akerem, the two others are located at Bir al-Dnejn and Majouf, between Akerem and Shalalah (Quéchel). The spring at Bir al-Dnejn is not investigated by the Syr/Nor-survey due to rough terrain.¹⁵⁵ The spring documented in the Russian Maps at Majouf is probably what has been defined as a well by the Syr/Nor-survey, called Well 324.¹⁵⁶

¹⁵⁴ Akerem: Syr/Nor (2009), p. 7-17; Shalalah: Syr/Nor (2009), p. 24-39.

¹⁵⁵ Syr/Nor (2009), p. 20.

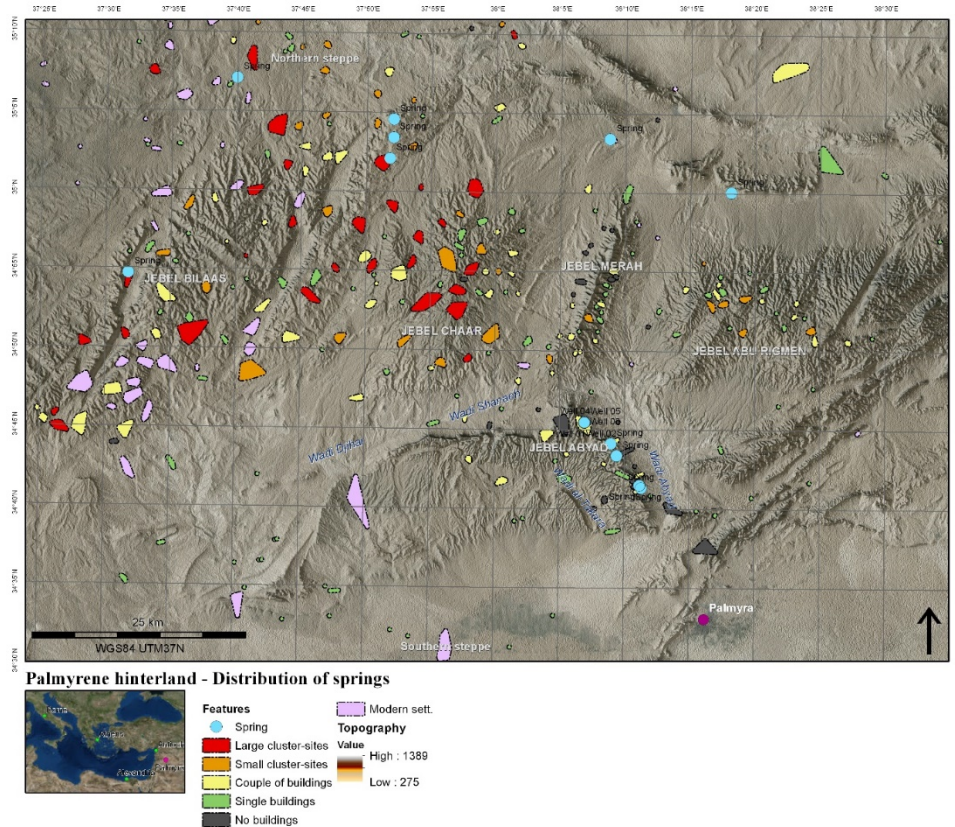
¹⁵⁶ Syr/Nor (2009), p. 24.

The other springs, all documented in the Russian Maps, are located on the northern side of the mountain range. The easternmost spring is located far north of Jebel abu Rigmen, and seems to be isolated. Further west, north of Jebel Merah, a spring is located by a quite isolated *modern settlement* called JC547. Far to the west of JC547, by the outlet of the eastern distinct valley of Jebel Bilaas, there are three springs quite close together. Especially the southernmost of these are interesting since it is located quite close to the Large cluster-site Marzouga, investigated by Schlumberger. While the spring at Marzouga is not mentioned by Schlumberger, it may have had impact on the development of that site. Going further west, towards the North/western steppe, another spring is documented in the Russian maps. It is not directly connected to any site, but is less than 3 km away from the *large cluster-site* RusRuin28, documented in the Russian maps. The last spring documented in the Russian maps is located close to the *large cluster-site* TST02, which was located in satellite imagery by this study in the western valley at Jebel Bilaas.

That the largest sites at Jebel Abyad, and several of the *large cluster-sites* at Jebel Bilaas contains springs, seems to confirm that springs give their sites prominence.

Looking back at the Tectonic map in Figure 5.2, it is apparent that all the springs at Jebel Abyad are located in areas with Paleogene source rock. As is the spring north of Jebel Abu Rigmen. The Paleogene source rock seems to be a favourable for springs. The other springs are located in areas with Cretaceous source rock. Looking at the roughness map, the three springs by Marzouga (north/west of Jebel Chaar) are located in quite rough terrain, while the spring at JC547 (north of Jebel Merah) and the spring at RusRuin28 (North/western steppe) are located in smoother areas. Knowing that the Russian maps probably defined the mentioned well (Well 324) at Majouf wrongly as spring, the springs documented in smooth areas should be investigated for being wells, since the conditions are favourable for wells.¹⁵⁷

¹⁵⁷ The catchment areas are gentle and large, which means that much surface water can infiltrate into the potential subsurface channels in the area.



Figur 5.12: Map showing how the springs are distributed in the northern Palmyrene hinterland. The map is made by this study.

The second type of *water resource* is wells. Wells are basically holes dug in the loose sediments of the surface into a reservoir of the subsurface channel system. Since the reservoir receives water through the quite slow process of infiltration, wells are quite stable water resources, and not very influenced by sudden variations in precipitation. The Syr/Nor-survey have investigated 35 wells in detail. Many of the documented wells are quite destroyed, and appears as filled craters. Some wells were reinforced with stones, and some openings were cut into rock, reinforced with stones.¹⁵⁸ Some of the investigated wells are used today, and have openings, reinforced with concrete and covered with metal lids.¹⁵⁹ The openings were often solid built in order to prevent surface water from flowing into the wells, filling the wells with gravel and bad water.¹⁶⁰

¹⁵⁸ Shanaeh: Syr/Nor (2008), p. 67; Khaled al-Ali: Syr/Nor (2008), p. 115; Khabar: Syr/Nor (2008), p. 89-90.

¹⁵⁹ Jazal: Syr/Nor (2008), p. 60, Syr/Nor (2009), p. 80; Khabar: Syr/Nor (2008), p. 89-90; Valley 369: Syr/Nor (2009), p. 69.

¹⁶⁰ A well at the Akerem site is described as receiving surface water, which is considered to be bad by the Syr/Nor-Survey (Syr/Nor (2009), p. 15).



Figure 5.13: Photo of reinforced well Khaled al-Ali taken by Jørgen Christian Meyer while investigating the site with the Syr/Nor-survey in 2008. ©Meyer. (<http://www.hist.uib.no/antikk/dias/Palmyrena/Khalilalali/Well1/Data/page.htm?0,008/05-2017>).

Besides the 35 wells documented by the Syr/Nor-survey, 232 wells are documented in the Maps. Most of these are used in the present and it is uncertain if they existed in the Roman era. Without the access of modern digging equipment, one of the challenges in the Roman era was to be able to dig deep enough in order to reach the subsurface reservoir. The deepest of the wells measured by the Syr/Nor-survey is 20 m deep.¹⁶¹ There are documented historical wells as deep as 40 m in other areas,¹⁶² but it is hard to say if the people of the Roman era were able to reach all the reservoirs indicated in Maps. Even if they could, we do not know if they did.

In any case, due to the stability of water resource, a well, like a spring, would probably have given the sites in its surroundings some prominence. There are, however, certain drawbacks concerning wells. As with springs, the location of wells is based on a certain geological factors, and is therefore fixed. Compared with springs, there are far more wells,¹⁶³ which makes the location and function of a site slightly less dependent on the location of one single well.

¹⁶¹ Well 1 at Khaled al-Ali: Syr/Nor (2008), p. 115. The total depth was measured on five wells, being 5, 5.7, 9, 9.7 and 20 m deep.

¹⁶² Braemer et alii (2010-2011), p. 97.

¹⁶³ If many of the wells documented in the Maps existed in Roman times.

The map in Figure 5.14 shows the results of a GIS analysis of the number of wells located within 1 km from a site (coloured circles), on top of a layer indicating density of all wells.¹⁶⁴ This indicates how important wells were for certain sites. Included in the map is calculated major flow lines, the main flow of the wadi. It is worth noting that most wells are located close to one of these. Looking at the density of wells in general (the background layer in the map) there is an evident density of wells at the western parts of Jebel Bilaas and towards the North/western steppe. There is also some density of wells in the areas north of Jebel Merah, in Wadi Shanaeh and Wadi Djihar, in the Jazal plain at Jebel Abyad and at the southern steppe. In addition the eastern edge of Jebel Abyad and Wadi Abyad have an increased density of wells. There is a notable lack of wells at the central plateau of Jebel Bilaas, at Jebel Merah and Jebel abu Rigmen. Compared with those areas, it is a notable existence of wells at Jebel Chaar.

Looking at the sites that are close to wells, 66 % of the sites at the North/western steppe are close to wells. This strongly indicates that wells were important in the development of the North/western steppe. While only a few of the sites at western side of Jebel Bilaas are close to documented wells, wells seem to be important to many of the sites in Wadi Shanaeh and at the eastern edge of Jebel Abyad.

The existence of wells at Jebel Chaar may be of importance for understanding the development of the area. There are 14 documented wells at Jebel Chaar. They are located close to nine sites. This is 22 % of the 64 sites documented in the area. However, it is interesting to see that five of the sites located close to wells are Large cluster-sites.¹⁶⁵ Including the mentioned spring at the Large cluster-site Marzouga, 37.5% of the 16 Large cluster-sites at Jebel Chaar are close to subsurface *water resources*.

¹⁶⁴ Many of the wells documented in the Maps are not close to any evident historical remain.

¹⁶⁵ JC03, JC13, JC14, Kheurbet Abou Douhour and Kheurbet Farouâne.

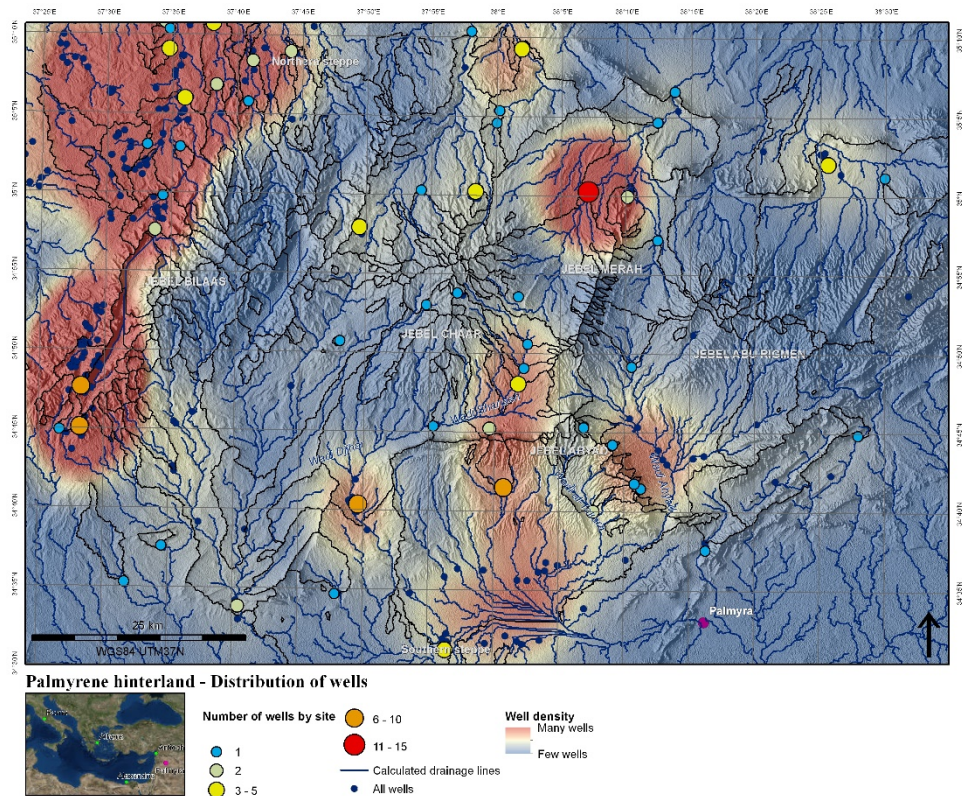


Figure 5.14: Map showing distribution of wells in the northern Palmyrene hinterland. The map is made by this study based on GIS-analysis.

The third type of *water resources* in the northern Palmyrene hinterland is the cistern. A cistern is basically a hole in the ground in which *surface water* flows into. This makes the location of cisterns very flexible, which is probably the reason why most of the water resources in the hinterland are cisterns. A few of the cisterns documented by the Syr/Nor-survey are natural reservoirs in caves and depressions in rocks.¹⁶⁶ Other cisterns are parts of quite elaborated developed, with advanced water management systems. A typical cistern investigated by the Syr/Nor-survey in the northern Palmyrene hinterland is bottle shaped, dug into the ground, with a smaller reinforced opening.¹⁶⁷ With the small opening, the cistern can better prevent evaporation in the hot summertime. Of the cisterns measured by the Syr/Nor-survey, the depth to water level ranges between 2.8 and 5.6 m (excluding some very small cisterns).¹⁶⁸ There is little information about the actual size of the cisterns. An investigated cistern with a collapsed barrel vault, was 13 m long and 4 - 8 m wide, covered with plastered

¹⁶⁶ Like Cistern05 at Ras Al-Matna: Syr/Nor (2008), p. 50; Cistern 166 at Site 161: Syr/Nor (2011), p. 46.

¹⁶⁷ Meyer (2013), p. 173.

¹⁶⁸ See appended dataset for information on measured depth.

rocks, including an internal stair that probably was used for maintenance.¹⁶⁹ This seems to be one of the larger investigated cisterns in the northern Palmyrene hinterland. Braemer et alii described that soil covered cisterns normally could be up to 400 m³ large,¹⁷⁰ while vault covered cistern could be as large as 1700 m³.¹⁷¹ Top put size in perspective, the mentioned cistern with collapsed vault would have been about 400 m³ if it were 5 m in depth.

To endure the current of the water, and not collapse, the openings of the cisterns were in general quite reinforced. There are some variation in how the openings were made, some had square openings, some being several meters wide, while many openings where circular with opening being 0.5 – 1.5 m in diameter, reinforced as deep as 2.2 m with reinforced with plastered stones above the actual cistern.¹⁷²



Figure 5.15: Photo of cistern at Ras al-Matna taken by Jørgen Christian Meyer while investigating the site with the Syr/Nor-survey in 2008. ©Meyer. (<http://www.hist.uib.no/antikk/dias/Palmyrena/AlMatna/Cistern04/Data/page.htm?1,0> 08/05-2017).

There is located cisterns in all areas of the northern Palmyrene hinterland. The map in Figure 5.16 shows the number of cisterns per site (circle-symbols) and the density of all cisterns (background layer). Elaborated information about the distribution of cisterns are presented in the charts in Figure 5.17 and Figure 5.18. There can be a great difference in how many cisterns that are documented at each site, from zero to more than 20. Sites that contain 1 – 5 cisterns are distributed all over the area. Based on data at hand illustrated in the map in Figure 5.16, there seems to a general tendency that the amount cisterns per sites increases towards

¹⁶⁹ Cistern 202 at Site 202: Syr/Nor (2011), p. 62-64.

¹⁷⁰ 1 m³ = 1000 liters.

¹⁷¹ Braemer et alii (2010-2011), p. 95.

¹⁷² The deepest measured being Cistern 222 at Site 215: Syr/Nor (2011), p. 57.

west, and that Jebel abu Rigmen has in general fewer cisterns per site than Jebel Chaar and Jebel Bilaas. This is also the case of Jebel Abyad and Jebel Merah. This impression might change with a more thorough investigation of Jebel abu Rigmen. At Jebel Merah a majority of sites contain two or less cisterns. At Jebel Abyad, however, there are three sites that contains more than 10 cisterns.¹⁷³ Jebel abu Rigmen, Jebel Abyad and Jebel Merah contain more sites without documented cisterns than the other areas. Jebel Chaar and Jebel Bilaas have a range of sites that contains more than 10 cisterns, with several sites that might contain more than 20 cisterns. The North/western steppe, on the other hand, lacks sites with more than 10 cisterns, and is in that respect similar to Jebel abu Rigmen and Jebel Merah.

Looking at the distribution of number of cistern per site in relation to type of site in Figure 5.16, there is a general tendency that the smaller the site, the fewer the cisterns. *Large cluster-sites* have many cisterns, 45 % of the sites contain more than 10 cisterns. *Small cluster-sites* contain fewer cisterns in general, 22 % have between 10 – 15 cisterns and 45 % have between 5 – 10 cisterns. Couple-sites have a quite even distribution of sites that have between 0 – 10 cisterns.

¹⁷³ Ras al-Matna, Bir al-Arfa and Wadi al-Takara north.

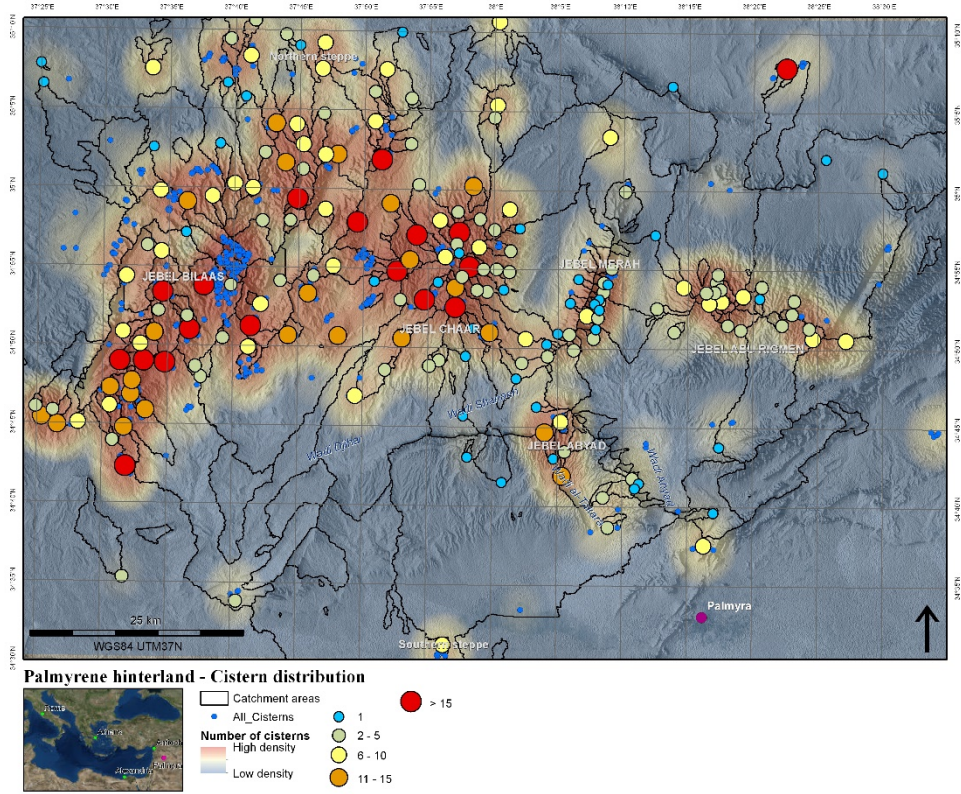


Figure 5.16: Map showing distribution of cisterns in the northern Palmyrene hinterland. The map is made by this study based on GIS-analysis.

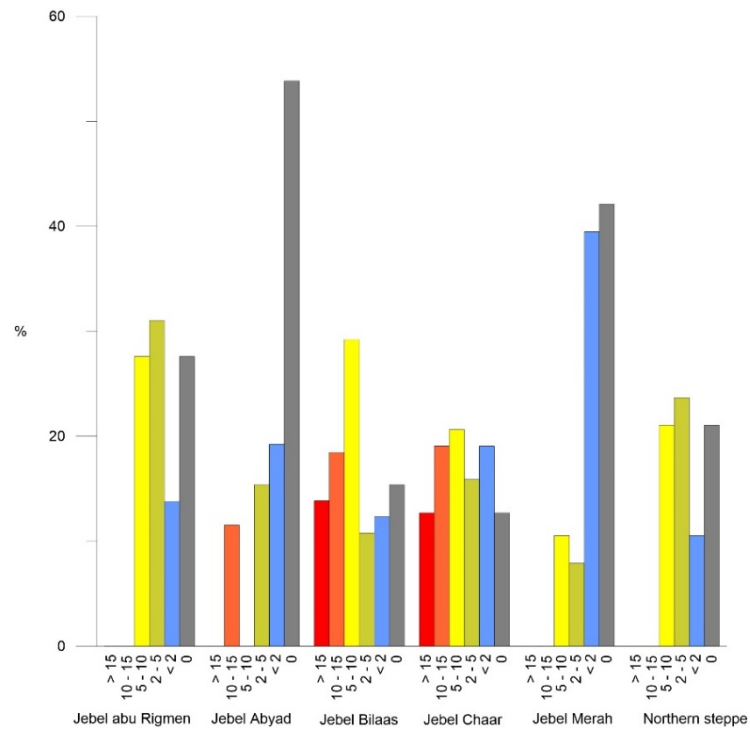


Figure 5.17: Chart showing distribution of number of cisterns per site in the areas of the northern Palmyrene hinterland. The chart is made by this study based on GIS-analysis.

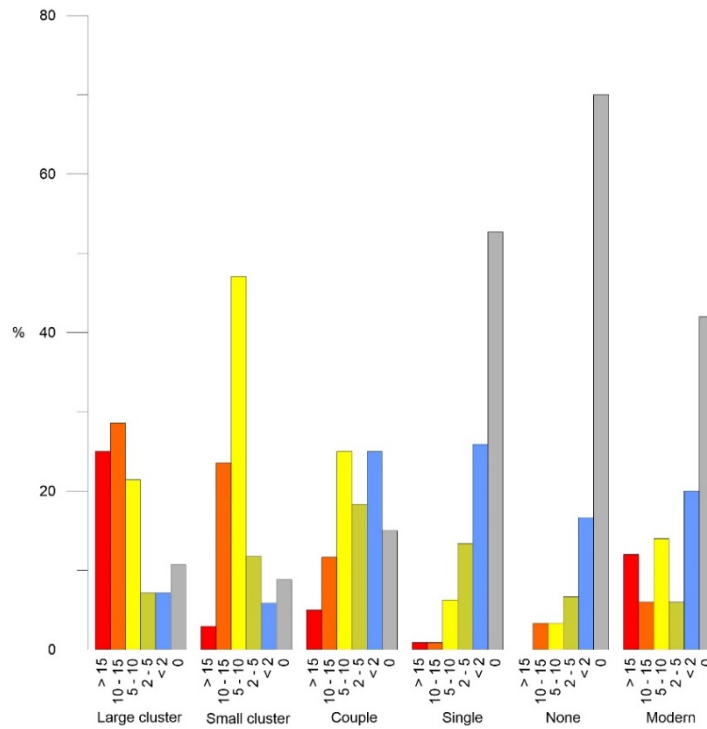


Figure 5.18: Chart showing distribution of number of cisterns per type of site in the northern Palmyrene hinterland. The chart is made by this study based on GIS-analysis.

5.1.2.2 Water management

Water resources and flood fields can be connected to systems of *water management*. *Water management* systems have in general two functions: The first is related to catchment of surface water, the second is related to distribution of the water from a *water resource*. Catchment of *surface water* involves improving how water is collected into cisterns and *flood field* areas. Distribution of water involves ways of diverting water from a *water resource* to households or *flood fields*. Systems of distributing water from one major water resource to other water resources have been documented in the Hauran. The information available on how *water management* systems were used in the northern Palmyrene hinterland is reviewed in the following sections. This includes looking at information provided by the surveys on how water management systems were developed, looking at the distribution of *water management* systems, including a large amount of catchment systems located by this study in satellite imagery, accompanied by analysis in GIS that provides information on how some of the *water management* systems worked in practice .

The first of the functions *water management* systems have is to improve the way *surface water* is collected. This is done in two ways: The first way is to filter the *surface water* in

order to prevent soil from coming into a cisterns, the second way is to maximize the amount of water that flows into a cistern or a *flood field*.

The method of filtering the water, as described by Braemer et alii, is done in order to prevent soil from entering the cistern, often called silt filter technique, uses structures to elevate the water, and by that separating it in from the soil.¹⁷⁴ How widespread this was in the northern Palmyrene hinterland is uncertain. At Site 035 in Jebel Merah, a wall in a wadi directs water into an elevated small dam in the installation called Cistern with small dam 063,¹⁷⁵ might have something to do with this.

Another catchment- method that does not involve maximizing the amount of water caught in a hillside, is to slow the water down with the help of small walls, in order to prevent the force of the water to destroy the *water resource*. The Syr/Nor-survey suggests that a system like this is located above the mentioned cistern with collapsed barrel roof, Cistern 202 at Site 202 in Jebel Merah.¹⁷⁶

The method of maximizing the amount of water that flows into a cistern or *flood fields* seems to be quite widespread in the northern Palmyrene hinterland. Of the 105 cisterns investigated by the Syr/Nor-survey, 75 of them, distributed in 18 sites, contain some kind of catch-arms or channels made to maximize the amount of water flowing into the cistern. Eight of the catchment systems contain some kind of channel, either small rock cut channels close to the opening of the cistern,¹⁷⁷ or long channels, sometimes reinforced by rocks,¹⁷⁸ or being part of large catch-arms systems.¹⁷⁹

In most cases the method of maximizing the catchment of water is by using catch-arms. Catch arms can be only a few meters long, up to several hundred meters long. The longest catch-arm measured by the Syr/Nor-survey is 343 m long,¹⁸⁰ and a many of the catch arms are more than hundred meters long. They are often built by large rocks and mud, and in some cases made tight with plaster. In many cases two catch arms goes diagonally to each direction up a hillside, creating an arrow that directs the water into a cistern. In some cases the catchment

¹⁷⁴ Braemer et alii (2010-2011), p. 104-105.

¹⁷⁵ Syr/Nor (2011), p. 18.

¹⁷⁶ Syr/Nor (2011), p. 62-64.

¹⁷⁷ See: System 3 at Tweihina: Syr/Nor (2008), p. 14; Cistern 439 at Wadi al-Takara north: Syr/Nor (2009), p. 55; Cistern 202 at Site 202: Syr/Nor (2011), p. 62-64; Cistern 166 at Site 161: Syr/Nor (2011), p. 46; Cistern 383 at Al-Koullah: Syr/Nor (2009), p. 38.

¹⁷⁸ Like Cistern 381 at Al-Koullah: Syr/Nor (2009), p. 38; Cistern 220 at Site 215: Syr/Nor (2011), p. 57

¹⁷⁹ Like System 1 at Tweihina: Syr/Nor (2008), p. 14.

¹⁸⁰ Cistern 528 at Bir al-Arfa: Syr/Nor (2009), p. 92.

system is more elaborated, as with System 427 at Al-Koullah,¹⁸¹ where long catch arms encircle a whole hill, including two shorter catch arms that creates an arrow in the middle of the circle.



Figure 5.19: Photo of Catch-arm system 427 at Al-Koullah in Jebel Abyad taken by Jørgen Christian Meyer while investigating the site with the Syr/Nor-survey in 2009. ©Meyer.
(<http://www.hist.uib.no/antikk/dias/Palmyrena/AlKoullah/Catcharm427/Data/page.htm?2,0> 08/05-2017).

Catch-arms made it possible to catch water in quite gentle slopes.¹⁸² With the low amount of precipitation in mind, one would expect that catch arms were used to catch water as much water as possible. This is, however, often not the case. As discussed, the main runoff of most of the sites in the northern Palmyrene hinterland receives several million litres of water each year. Knowing that precipitation often is intense, the force of the main flow must be quite large. The Syr/Nor-survey described that cisterns close to wadis at Jebel Abyad would be buried if they were not maintained.¹⁸³ Catch arms would be destroyed if they were in the main wadis. Looking at the catch arms documented by the Syr/Nor-survey in detail, most of the catch arms do not seem to catch the main flow of water, but rather avoiding it. This is evident with the mentioned catch-arm system (System 427) at Al-Koullah in Figure 5.20, where much effort have been put into building catch arms that catches water from the flanking hillsides, while avoiding the main flow, which is calculated to be 94 mill litres a year.¹⁸⁴ The

¹⁸¹ Syr/Nor (2009), p. 40.

¹⁸² Syr/Nor (2009), p. 128.

¹⁸³ Syr/Nor (2009), p. 35.

¹⁸⁴ With 10% runoff efficiency.

pattern is the same at Bir al-Arfa (see Figure 5.21) further north at Jebel Abyad, Site 298 and Site 304 (see Figure 5.30) at Jebel Merah, and most other sites where there are catch arms.

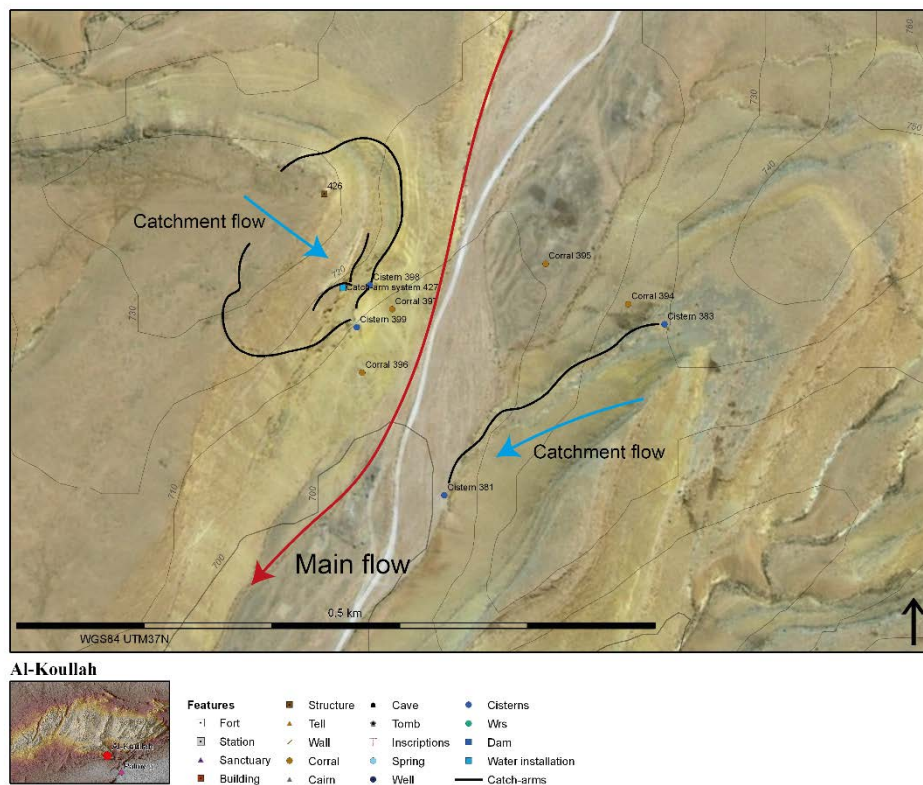


Figure 5.20: Map showing how catch-arms are located compared to the main flow of the site Al-Koullah. The map is made by this study based on GIS-analysis.

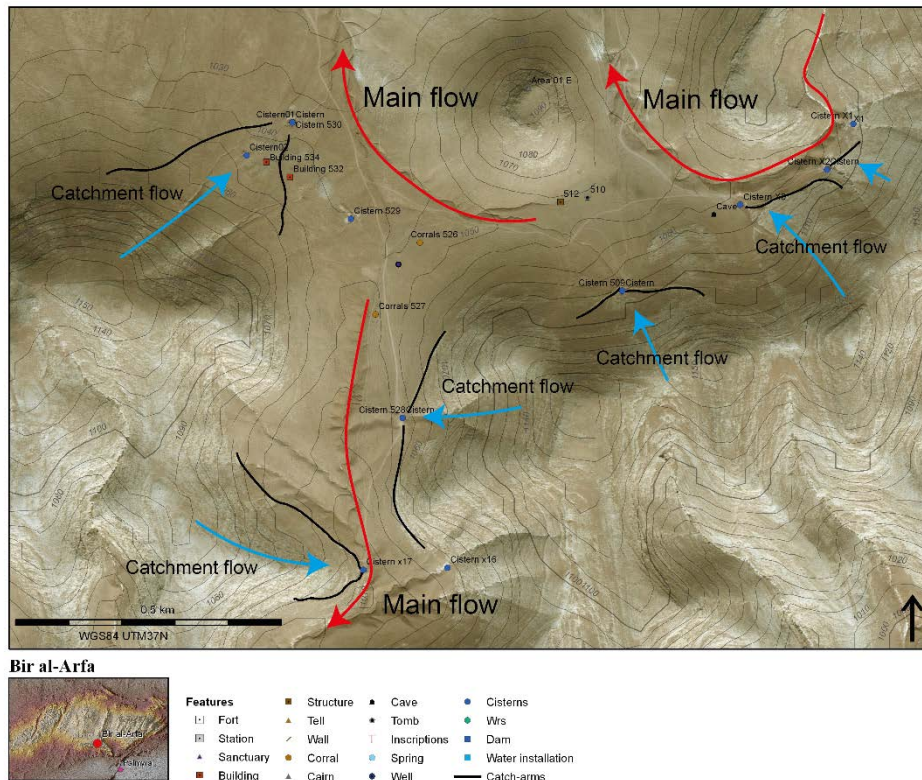


Figure 5.21: Map showing how catch-arms are located compared to the main flow of the site Bir al-Arfa. The map is made by this study based on GIS-analysis.

All of the documented *water resources* have been investigated by this study in satellite imagery, in order to reveal potential water management systems. This has resulted in the discovery of more than 300 potential catch-arms at 56 sites distributed in all parts of northern Palmyrene hinterland. As seen in Figure 5.22, this means that the use of catch arms can be attributed to the whole hinterland. There are seemingly no difference in distribution between the areas of the hinterland, or between type of sites. There is however an increased density of catch arms at Jebel Merah, where most of the sites have catch-arms, while there is a notably absence of documented catch-arms at the North/western steppe. This difference may be due to the fact that Jebel Merah has been investigated in detail on ground, while the North/western steppe only have been investigated in satellite imagery.

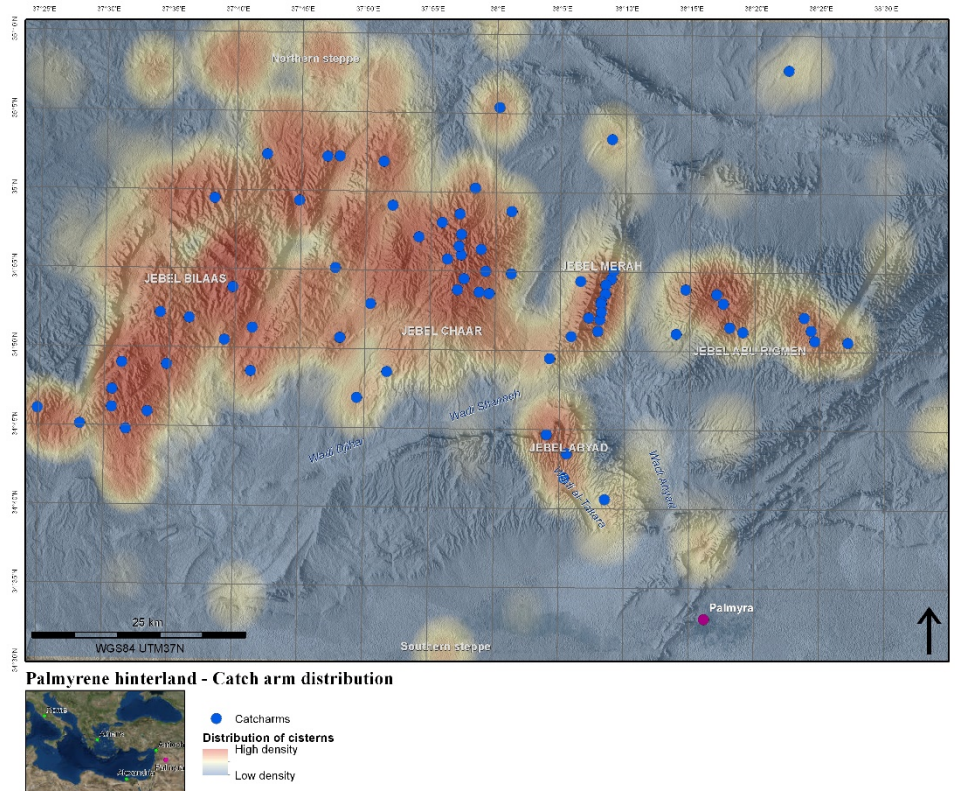
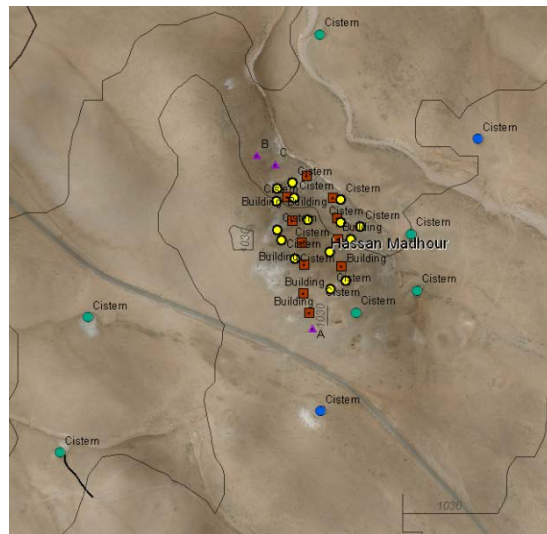


Figure 5.22: Map showing distribution of catch-arms in the northern Palmyrene hinterland. The map is made by this study.

The majority (60 %) of the cisterns documented by Syr/Nor-survey at Jebel Abyad and Jebel Merah contains catch-arms. This study has located catch-arms at 37 % of the sites in Jebel Chaar, using satellite imagery. Still, none of the possible 56 cisterns documented by Schlumberger at Jebel Chaar are described as having catch-arms. Schlumberger only documented cisterns graphically, and clearly didn't pay much attention to *water resources*. This might explain why no catch-arms are described. On the other hand, the majority of the catch-arms located in satellite imagery are situated some distance from the cluster of buildings. As shown from the *large cluster-site*, Hassan Madhour, in Figure 5.23, the located catch-arms are outside the centre of buildings, while the possible cisterns documented by Schlumberger are very numeral and located very densely distributed among the buildings. This does not contradict that the cisterns still had some form of catchment systems, for instance short channels in order to direct water into the cisterns, or perhaps they didn't need any *water management system* in order to catch of water. The distribution is, however, peculiar, since such large amount of cisterns, densely distributed in the middle of a cluster of buildings, can't be compared to any of the sites documented at Jebel Abyad and Jebel Merah.

Braemer et alii describes roof-top catchment systems, which were used in other dry areas.¹⁸⁵ This is simply a method of catching the precipitation that falls on the roof of a building, and directing it through pipes into a tank or cistern. Knowing that many of the buildings in the settlements of Jebel Chaar are large, an effective roof-top catchment system could catch several hundred thousand litres a year. A building in Jebel Chaar, measuring 50 x 50 m, would normally receive about 450 000 litres of water from precipitation a year. There are no sources of such systems in the northern Palmyrene hinterland, but there are also few roofs to investigate. It would therefore be intriguing to ask why there could not be such systems.



Figur 5.23: Outcrop of map, showing the location of documented catch arms at the Large cluster-site Hassan Madhour, in relation to the cisterns plotted by Schlumberger. The catch-arm is the black line in the south/western corner. The cisterns plotted by Schlumberger are highlighted as yellow dots. (Background imagery is Bing maps).

The second function of *water management* systems is to distribute water from *water resources* to other *water resources*, *flood fields* or households.¹⁸⁶ There is two fundamental ways of doing this: In channels on the surface, called aqueducts, or in channels beneath the surface, often called foggaras or qanats.¹⁸⁷

Aqueducts are mainly on-surface, rock constructed channels, that lead water in gentle slope into the area of usage. At the Shalalah (Quéchel) and Akerem sites the Syr/Nor-survey discovered traces of small aqueducts that might have derived water from springs into fields. At Akerem a watertight room,¹⁸⁸ described as a reservoir or bath, implies that water was

¹⁸⁵ Braemer et alii (2010-2011), p. 101.

¹⁸⁶ Meyer (2013), p. 172.

¹⁸⁷ The name might differ from region to region. The function is in any case basically what is described here.

¹⁸⁸ Syr/Nor (2009), p. 9.

derived from the spring area.¹⁸⁹ The function is uncertain, and one might suggest that the room might have been fed with precipitation, like what was suggested in the case of the watertight structure at Village 539. The Syr/Nor-survey also documented a large aqueduct at Acadama towards the North/western steppe, a site originally investigated by Poidebard & Mouterde.



Figure 5.24: Photo of aqueduct at Akerem in Jebel Abyad taken by Jørgen Christian Meyer while investigating the site with the Syr/Nor-survey in 2009. ©Meyer. (<http://www.hist.uib.no/antikk/dias/Palmyrena/Akarem/Aqueduct/Data/page.htm?7,008/05-2017>).

Foggaras or qanats are gentle sloped, horizontal subsurface channels, that derives water from an aquifer, the water bearing strata or a major Water resource, into other Water resources or other areas of usage like serving households or Flooding fields.¹⁹⁰ The foggaras/qanats are recognisable on the ground due to distinct vertical access shafts along the channel that were used for digging and maintaining the channels (see image in Figure 5.25).

In the Hauran, further west in Syria, ancient villages can be up to one km from a *water source*, receiving water through subsurface channels into the settlement.¹⁹¹ The most advanced qanat-systems are several km long (the longest 19.5 km), feeding more than 20 villages with water.¹⁹²

¹⁸⁹ Syr/Nor (2009), p. 17.

¹⁹⁰ Braemer et alii (2010-2011), p. 101.

¹⁹¹ Braemer et alii (2010-2011), p. 104.

¹⁹² Braemer et alii (2010-2011), p. 107.

There are few evidence of advanced foggara/qanat-systems in the northern Palmyrene hinterland.¹⁹³ Poidebard and Mouterde investigated Acadama (Qdeym), which was an important fort/station (measuring 87 x 87 m) at the plain north of Jebel Merah.¹⁹⁴ According to Poidebard, he spotted 11 *water resources* (puits) from the air, all in a cluster except two.¹⁹⁵ According to Poidebard, many of these *water resources* were part of a foggara/qanat system.¹⁹⁶ The site have been visited by the Syr/Nor-survey, which located large aqueduct and foggara systems and at the site.¹⁹⁷



Figure 5.25: Photo of Foggara-system Acadama in North/eastern steppe, taken by Jørgen Christian Meyer. ©Meyer. (<http://www.hist.uib.no/antikk/dias/Syria/Academa/Data/page.htm?13,0> 08/05-2017).

5.1.2.3 Flood field

The second of the *methods* listed in the diagram in 5.1 is *flood field*.¹⁹⁸ This involved the technique of flooding an area, field or garden,¹⁹⁹ with water in order to improve the condition for growth of vegetation, plants and trees.²⁰⁰ In some areas this occurs naturally, like in flat

¹⁹³ Meyer (2013), p. 173.

¹⁹⁴ Mouterde & Poidebard (1945), p. 109.

¹⁹⁵ Mouterde & Poidebard (1945), p. 109.

¹⁹⁶ Mouterde & Poidebard (1945), p. 111.

¹⁹⁷ See: <http://www.hist.uib.no/antikk/dias/Syria/Academa/Data/page.htm?1,0> 08/05-2017.

¹⁹⁸ What differs flood field technique from irrigation, is that it does not involve the same kind of controlled distribution of water at given intervals.

¹⁹⁹ As Meyer points out, one must also include watering of small gardens, not only large scale fields: Meyer (2013), p. 174.

²⁰⁰ Lightfoot 1997; Braemer et alii 2010-2011: 98-101.

areas of the wadis, or by large natural dams, or possible around the outlet of springs. The methods concerned here is the artificial ones, developed by humans.

There are two basic ways of directing water into a field. One way is to direct water from a *water resource* through aqueducts or underground channels. Another way is to redirect *surface water*.²⁰¹ The field might just be quite flat naturally or artificially enclosed, in order to prevent the water from flowing away.

There are some examples of directing water from a water resource into a field in the northern Palmyrene hinterland. Of Shalalah (Quéchel) in Jebel Abyad, Musil describes "...a green meadow irrigated by the spring of al-Wešel..."²⁰² The spring of al-Wešel is probably the site Shalalah. It was investigated by the Syr/Nor-survey, who discovered traces of an aqueduct not far from five springs of the site.²⁰³ As mentioned, an aqueduct is also found at Akerem at Jebel Abyad in the hills beneath springs. Besides possibly serving a house with water, there is located a large structure enclosing an area of about 12 000 m² at the sites that might get water from the spring area (see Figure 5.26).²⁰⁴

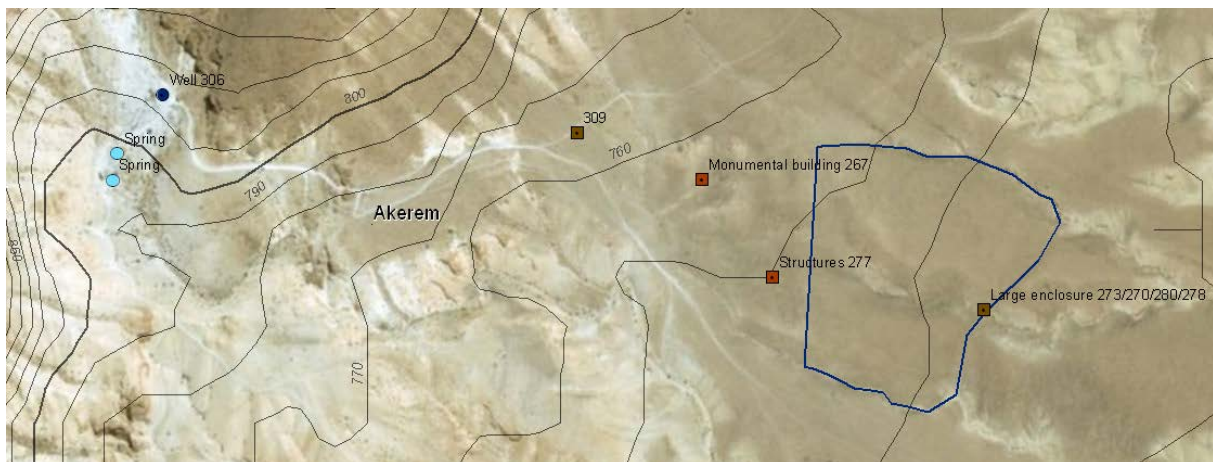


Figure 5.26: Outcrop of map showing the location of the large enclosure in relation to springs. The map is made by this study. (Background imagery is Bing maps).

Of examples of directing surface water into fields, there are enclosures similar to that of Akerem discovered in satellite imagery several places in Jebel Bilaas. Contrary to Akerem, they are not located close to springs, and most probably entrapped surface water. As seen in

²⁰¹ Read more in: Braemer et alii 2010-2011: 103-107; Newson 2000: 88-95; Oleson 2007; Lavento et alii 2004; Lavento 2010.

²⁰² Musil (1928), p. 148-149; Syr/Nor (2008), p. 24, 29.

²⁰³ Syr/Nor (2008), p. 29.

²⁰⁴ Syr/Nor (2009), p. 14.

Figure 5.27. a modern enclosure measuring about 86 000 m² is located at JB49,²⁰⁵ at TST16 there is a potential enclosure measuring about 60 000 m².²⁰⁶ There is also a large enclosure by a fort at GerRuin12 measuring about 33 000 m², in an area with several potential field enclosures.²⁰⁷



Figure 5.27: Outcrop of maps show enclosures located in satellite imagery: JB49 (to the left), TST16 (in the middle) and GerRuin12 (to the right).

Besides large enclosures, there are several examples of small enclosures of garden size that were used to trap surface water. Gardens like these were probably quite common, and functioned as a supplement of grain and vegetables to the households. This system is called horticulture. The Syr/Nor-survey mentions modern gardens at Wadi al-Takara north,²⁰⁸ at Jazal,²⁰⁹ and that several corrals might have been gardens, for instance Corral 396 at Al-Koullah.²¹⁰ As seen in Figure 5.27, at JR14 in Jebel abu Rigmen there is a small garden enclosure measuring about 700 m²,²¹¹ and at RusRuin05 in Jebel Bilaas, four garden size enclosures are visible in satellite imagery, measuring about 2800, 3300, 1500 and 1000 m².²¹²

²⁰⁵ Located by the Syr/Nor-Survey in satellite imagery

²⁰⁶ Located by this study in satellite imagery.

²⁰⁷ Located in satellite imagery by this study by a site documented in the German maps.

²⁰⁸ Syr/Nor (2009), p. 46.

²⁰⁹ Syr/Nor (2008), p. 60.

²¹⁰ Syr/Nor (2009), p. 129.

²¹¹ Located by the Syr/Nor-Survey in satellite imagery

²¹² Located in satellite imagery by this study by a site documented in the Russian maps.



Figure 5.27: Outcrop of maps show potential garden enclosures located in satellite imagery: JR14 (to the left) and RusRuin05 (to the right).

There are also some examples installations, like catch-arms, walls or dams built to divert *surface water* from a wadi into a field area. As can be seen in Figure 5.28, at Site 089 in Jebel Merah, there are several walls that redirect water from the wadis, seemingly to flood the areas beside the wadis.²¹³ At Jebel Bilaas there is a large area visible in satellite imagery with what seems to be large modern flood field system. The water system is 8 x 5.5 km in size, and include at least 128 dams/walls and cisterns visible in satellite imagery. The area include the historical sites JB28,²¹⁴ Hirbet el-Bilas,²¹⁵ GerRuin05, Querbet el-Bilaas and GerTell05,²¹⁶ and TST20.²¹⁷

²¹³ Syr/Nor (2011), p. 34. See Meyer (2013), p. 174 for discussion: Further reading: Gilbertson, Hunt 1996; Haiman 1995; Lavento 2010; Barker 2002. Meyer is quite certain that the walls have function of flood fields: Meyer (2013), p. 174.

²¹⁴ Located by Syr/Nor-Survey in satellite imagery.

²¹⁵ Located by Mouterde & Poidebard.

²¹⁶ Documented in the German Maps.

²¹⁷ Located by this study in Satellite imagery.

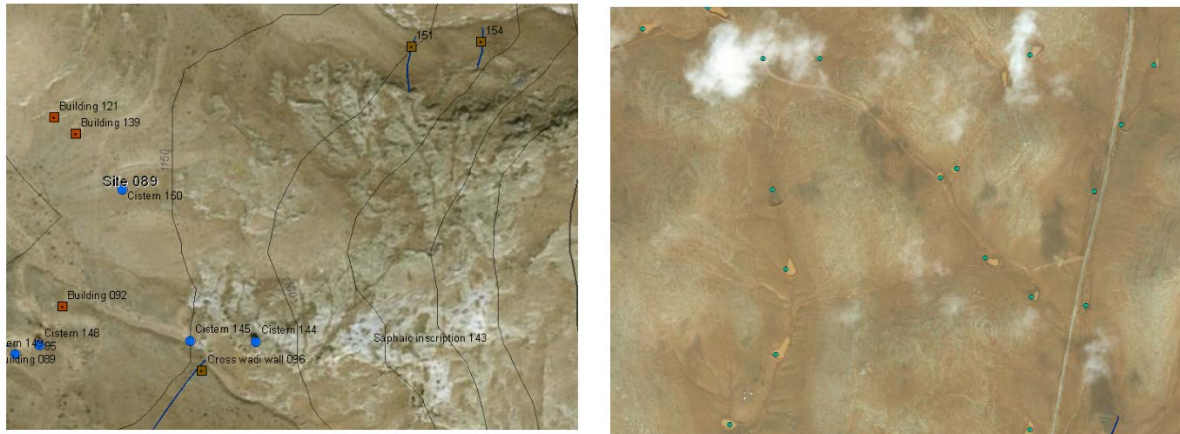


Figure 5.28: Outcrop of maps showing examples of flood field systems at Site 089 (to the right) and Querbet el-Bilaas (to the left).

There are documented several walls in the northern Palmyrene hinterland. In many cases the function of the walls are diffuse, but they may have something to do with flood management. According to the Syr/Nor-survey the walls might have to do with preventing soil from flowing away,²¹⁸ as Musil describes,²¹⁹ or securing the area from heavy flooding in the rain season.²²⁰ The Syr/Nor-survey have investigated some quite large walls on ground (See Figure 5.29). At Wadi al-Takara north in Jebel Abyad, there is traces of a wall 38 m long, 3 m thick,²²¹ located close to, but not near the main wadi flow. It is suggested that the wall is situated for the purpose of stopping excel water that has flooded over the banks of the wadi, when the flowrate is high, in order to moisture the soil above the wall.²²² Another example is the wall at the site Wadi al-Takara wall, also in Jebel Abyad. It is somewhat similar situated as the wall at Wadi al-Takara north, between two quite large wadis, and might have been used to stop excel flood water. This wall is however much longer, 170 m, but is also less solid than the wall at Wadi al-Takara north.²²³ Another wall was investigated at Site 232 in Jebel Merah. It is almost 200 m long, and is located beside a quite large wadi, not directly connected to it. One might suggest that the function of this wall also is to stop excel flood water.²²⁴

²¹⁸ Syr/Nor (2009), p. 45.

²¹⁹ Musil (1928), p. 134.

²²⁰ Syr/Nor (2009), p. 51.

²²¹ Syr/Nor (2009), p. 50-51.

²²² Meyer (2016), p. 91.

²²³ Syr/Nor (2009), p. 45.

²²⁴ Syr/Nor (2011), p. 100.

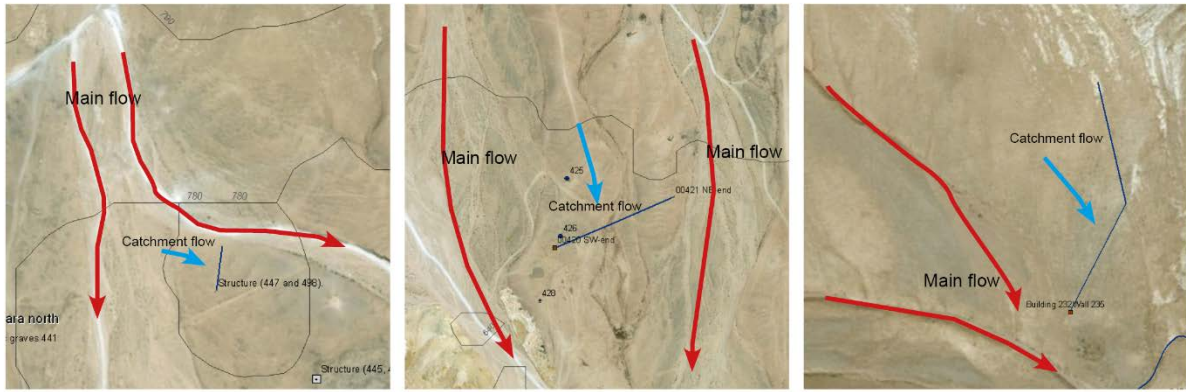


Figure 5.29: Showing the location of walls in relation to main flow of wadis: Wadi al Takara north (to the left), Wadi al Takara north (in the middle) and Site 232 (to the right). The maps are made by this study.

This method of trapping excel water from wadi flow may explain the peculiar location of several of catch-arms at Jebel Merah. As seen at site 304 in Figure 5.30, the catch-arms of the cisterns are headed straight to the sides, away from the main wadi flow. Whether this is to catch water from the flanking hillsides, silt-filter excel flood water from the wadi flow before it enters the cisterns, and/or moisture the earth in addition to collecting water into the cistern is uncertain.

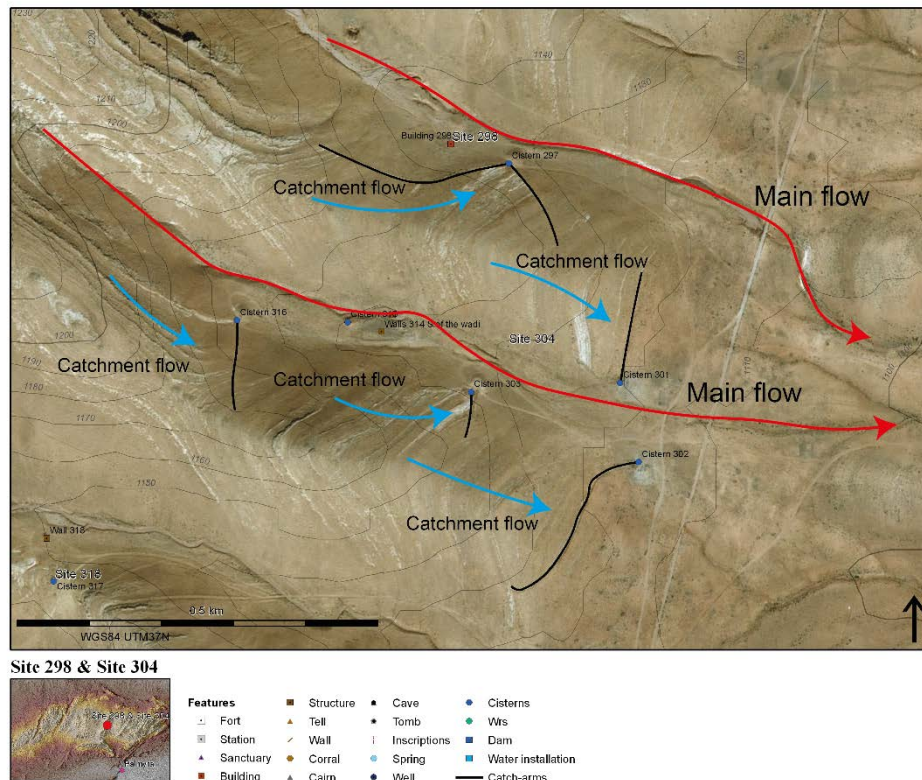


Figure 5.30: Map showing how catch-arms are located compared to the main flow of the site Site 298 and Site 304. The map is made by this study based on GIS-analysis.

5.1.2.4 Soil moisturizing

The last of the Methods in the diagram in Figure 5.1 is *soil moisturizing*. *Soil moisturizing* is in this study defined as the nature's own ability make water an area without the aid of artificial water management, in order to make it fertile. One way is through the infiltration of precipitation. Another way of natural soil moisturizing is in the run of wadis after a rain shower and the flooding of areas around small ponds.²²⁵ Today, grass roots just beneath the surface covers the ground in several areas of the northern Palmyrene hinterland.²²⁶ The soil is in general said to be of good quality.²²⁷ As described, there are several examples of areas where vegetation and trees grew freely, especially before the deforestation in the middle of the 20th century. As Meyer points out, with vegetation and trees, the microclimate would have

²²⁵ Syr/Nor (2008), p. 122.

²²⁶ Jebel Chaar: Syr/Nor (2009), p. 107; Jebel Abyad: Syr/Nor (2009), p. 27.

²²⁷ Meyer (2013), p. 173.

been very different. Dew and humidity caught by the grass and trees would have made the condition far into the dry period.²²⁸

5.1.3 Function

As illustrated in the diagram in Figure 5.1, water is the basis of three types of *functions* in the northern Palmyrene hinterland. One is *Human and animal consumption*, a second function is *pastoralism*, and a third function is *agriculture*. In the following sections, what we can say with certainty of these functions, will be discussed.

Human/animal consumption concerns in this context the direct use of water from *water resources*, like drinking, cooking, bathing and production. This is in contrast to indirect use, like watering a field for the purpose of livestock grazing or growing foodstuff.

Water must have been of great concern in the northern Palmyrene hinterland. Even though there are good reasons for discussing how productive the hinterland might have been, water can't have been taken for granted. Since several months a year often were completely dry, and several years could be with reduced precipitation, securing access to water must have been of essence in order to cover the basic needs of human existence.

Besides typical household activities, like drinking, cooking and washing, one can assume that water was in the making of products like cheese and yogurt, as suggested by Meyer.²²⁹ These products could have been part of an economy. Access of water could also have been a commodity, sold to seasonal travellers and nomads entering the mountains with its colder climate in the summertime.²³⁰ One might suggest that this was covered by the tax on grazing rights described in the Palmyra tariff,²³¹ aimed at animals entering the territory.

The large amount of *water resources* clearly show that effort was put into making water usable, but there is only a few sources that relates directly to how the water was used. Among these are the mentioned watertight room at Akerem, which may have been used at a bath.²³² The Syr/Nor-survey found traces of ropes and buckets by several of the wells and cisterns, used for lifting water up from the *water resources*. These findings do not provide detailed information of what the water was used for, but is one of the few sources that relate to the activity around the water resources. Ropes and buckets are documented at Shalalah

²²⁸ Meyer (2013), p. 172.

²²⁹ Meyer (2013), p. 175.

²³⁰ Meyer (2016), p. 93.

²³¹ Meyer (2016), p. 92.

²³² Syr/Nor (2009), p. 9.

(Quéchel),²³³ Ras al-Matna,²³⁴ and Bir al-Arfa in Jebel Abyad,²³⁵ Cisterns - Jebel Merah West in Jebel Merah,²³⁶ at Khabar,²³⁷ and Khaled al-Ali north of Jebel Merah.²³⁸

A type of finding that relates more directly to what the water was used for, is troughs. Troughs are vessels that were filled with water from a *water resource* in order to provide drink for animals. They are documented at Akerem,²³⁹ Al-Koullah,²⁴⁰ Wadi al-Takara north,²⁴¹ Tweihina,²⁴² Shalala (Quéchel),²⁴³ Bir al-Arfa,²⁴⁴ and Ras al-Matna in Jebel Abyad,²⁴⁵ Site 089, Site 304,²⁴⁶ and Site 291 in Jebel Merah,²⁴⁷ in addition to Khabar north of Jebel Merah.²⁴⁸ This must have been an important part of the process of breeding and herding animals, especially in the dry summer months, and is therefore strictly a part of the *pastoralism*-category.²⁴⁹ Seeing the water resources in relation to pastoralism might explain the function of sites like the mentioned al-Koullah and Ras al-Matna, that have elaborated water management systems, but no evident buildings. Much effort must have been put into building systems like these, and it seems to make most sense to see them in relation to a economical activity, like breeding of horses or camels, or herding of sheep and goats.

As seen in the diagram in Figure 5.1, the basis of *pastoralism* may to a small extent have been *flood fields*, but it mainly concerns areas of where the soil has been naturally moisturized. If *pastoralism* in the hinterland was closely connected to the economy of Palmyra, flocks of animals must have been a quite common site.

There are, however, only a few findings that relates directly to how *pastoralism* was performed. The Syr/Nor-survey have documented ties for animals at Shalala (Quéchel) and Tweihina (Tahoun al-Masek) in Jebel Abyad.²⁵⁰ This may be remains of horse or camel

²³³ Syr/Nor (2008), p. 28, 29

²³⁴ Syr/Nor (2008), p. 49.

²³⁵ Syr/Nor (2008), p. 57.

²³⁶ Syr/Nor (2011), p. 52.

²³⁷ Syr/Nor (2008), p. 89.

²³⁸ Syr/Nor (2008), p. 115.

²³⁹ Syr/Nor (2009), p. 9.

²⁴⁰ Syr/Nor (2009), p. 39.

²⁴¹ Syr/Nor (2009), p. 52.

²⁴² Syr/Nor (2008), p. 15

²⁴³ Syr/Nor (2008), p. 28, 29.

²⁴⁴ Syr/Nor (2009), p. 92.

²⁴⁵ Syr/Nor (2008), p. 49, 50.

²⁴⁶ Syr/Nor (2011), p. 84.

²⁴⁷ Syr/Nor (2011), p. 89.

²⁴⁸ Syr/Nor (2008), p. 89

²⁴⁹ It is included in the *human/animal consumption*-category since it is so related to the *water resources*, which means that the *pastoralism*-category in this chapter mainly grazing.

²⁵⁰ Shalalah (Quéchel): Syr/Nor (2008), p. 29. Tweihina (Tahoun al-Masek): Syr/Nor (2008), p. 11.

breeding. There are also documented several advanced corrals that seems to have been used as animals pens, for instance corrals at Al-Koullah and Wadi al Takara south in Jebel Abyad,²⁵¹ Site 35 at Jebel Merah,²⁵² and at the Jebel Merah site at the northern side of Jebel Merah.²⁵³ Perhaps the most directly related finding to pastoral activity is traces of eggs from intestinal worms, probably from goat, in mudbricks at Khaled al-Ali, far to the north of Jebel Merah.²⁵⁴ Besides being one of the few direct source of pastoral activity in historical times, the mudbricks also contained pollen of domesticated barley. This may indicate that goats grazed and fertilized the barley fields after harvest, which means that pastoralism was actively used to improve agriculture.²⁵⁵ This technique has been studied by the ecologist Allan Savory under quite similar condition on the steppe in Zimbabwe. He showed that by having smaller packs of animals grazing, naturally fertilizing and harrowing the earth while constantly moving around like in a natural environment, the vegetation flourished.²⁵⁶ If pastoralism was widespread throughout the northern Palmyrene hinterland, the vegetation may have flourished even more because of that.

There are several accounts of recent Bedouins concerning the grazing abilities in the area. These accounts do not describe the conditions in the Roman era, but knowing that conditions probably was little better then, the accounts are of some value. Several areas are described as good grazing grounds, like Fasida and Khaled al-Ali far to the north of Jebel Merah,²⁵⁷ Wadi al-Takara South,²⁵⁸ Kshebar,²⁵⁹ Wadi al-Takara north,²⁶⁰ Tweihina (Tahoun al-Masek),²⁶¹ Shalala (Quéchel),²⁶² Ras al-Matna,²⁶³ and Bir al Arfa at Jebel Abyad,²⁶⁴ Al-Matna even include watch places for herding.²⁶⁵ In addition Bedouin camps have been observed at Site 073,²⁶⁶ Site 083,²⁶⁷ and at Site 208.²⁶⁸ The eastern side of Jebel Abyad is described as not

²⁵¹ Al Koullah: Syr/Nor (2009), p. 129; Wadi al Takara south: Syr/Nor (2009), p. 34.

²⁵² Syr/Nor (2011), p. 18.

²⁵³ Syr/Nor (2008), p. 100.

²⁵⁴ Meyer (2013), p. 274.

²⁵⁵ Meyer (2013), p. 272.

²⁵⁶ Savory, C. A. R. (1969). "Crisis in Rhodesia". *Oryx* 10: 25; See also Meyer (2016), p. 97.

²⁵⁷ Fasida: Syr/Nor (2008), p. 105; Khaled al-Ali: Syr/Nor (2008), p. 113.

²⁵⁸ Syr/Nor (2009), p. 30.

²⁵⁹ Syr/Nor (2008), p. 40.

²⁶⁰ Syr/Nor (2009), p. 46.

²⁶¹ Syr/Nor (2008), p. 10.

²⁶² Syr/Nor (2008), p. 24.

²⁶³ Syr/Nor (2008), p. 44.

²⁶⁴ Syr/Nor (2008), p. 124.

²⁶⁵ Syr/Nor (2008), p. 45.

²⁶⁶ Syr/Nor (2011), p.10.

²⁶⁷ Syr/Nor (2011), p.24.

²⁶⁸ Syr/Nor (2011), p.67.

very good grazing ground,²⁶⁹ but the Syr/Nor-survey discuss whether a valley close to Al-Mazraah at the eastern edge of Jebel Abyad was used for horse breeding.²⁷⁰

Agriculture is the third *function* of the southern Palmyrene hinterland. *Agriculture* concerns the growing of foodstuff. Crops are especially interesting because if wheat or barley was grown, the settlements in the hinterland could have been self-sufficient, and perhaps able to supply Palmyra with grain. If so, the settlements could also develop economical networks independent from Palmyra. The main type of grain was probably barley, since it generally needs less precipitation (200 mm), than wheat (250 mm).²⁷¹

As seen in the diagram in Figure 5.1, there are two fundamental ways in which agriculture may have been performed in the northern Palmyrene hinterland. Either the food was grown in naturally *moisturized soil* or it was grown in *flood fields*.

Concerning naturally *moisturized soil*, Musil observed dry-farming fields in the southern hills of Jebel Abyad,²⁷² and the Syr/Nor-survey observed traces of fields at Site 209 in Jebel Merah,²⁷³ and limited agriculture at Fasida far north of Jebel Merah.²⁷⁴ There are several examples Bedouins growing vegetables in the dry steppe,²⁷⁵ and in some areas of Wadi Abyad there have been grown wheat and barley in recent times.²⁷⁶ As part of the political actions in the 1950s, the central government started a “growing barley program” in an attempt to resettle Bedouins.²⁷⁷ Barley was grown at the Shalalah plain in the 1960s,²⁷⁸ and growing of barley have been attested for in the hills around the fort of Shanaeh and at Ras al-Matna in Jebel Abyad.²⁷⁹ This barley was however only meant for animal consumption,²⁸⁰ and Meyer do not think that dry-farming was a major function of the area.²⁸¹

With the help of *flood field* techniques, there are possibilities for more stable agriculture.²⁸² The Syr/Nor-survey also suggest that the mentioned cross-wadi walls at Site 089 in Jebel

²⁶⁹ Syr/Nor (2009), p. 27.

²⁷⁰ Syr/Nor (2009), p. 67.

²⁷¹ Meyer (2013), p. 271.

²⁷² Musil (1928), p. 147.

²⁷³ Syr/Nor (2011), p. 68.

²⁷⁴ Syr/Nor (2008), p. 105.

²⁷⁵ Beawes (1929), page 31.

²⁷⁶ Meyer (2013), p. 171.

²⁷⁷ Barley needs slightly less water than wheat: Meyer (2013), p. 171.

²⁷⁸ Syr/Nor (2009), p. 27.

²⁷⁹ Syr/Nor (2008), p. 63

²⁸⁰ Meyer (2013), p. 172.

²⁸¹ Meyer (2013), p. 172.

²⁸² Syr/Nor (2008), p. 122.

Merah,²⁸³ and the wall at the site Wadi al-Takara wall in Jebel Abyad was used for agriculture,²⁸⁴ which might mean that other mentioned walls also had an agricultural purpose. The Syr/Nor-survey also suggest that the mentioned large enclosure at Akerem in Jebel Abyad was used for agriculture, at least as a garden,²⁸⁵ which means that the other similar enclosures located in satellite imagery also may have been used for agriculture. When discussing how self sufficient the settlements were and if they were grain producers for Palmyra, only large fields with the potential of producing extensive amounts of barley are interesting, small gardens were only supplemental.

As with pastoralism, there are few historical sources that indicates how wide spread agriculture in the northern Palmyrene hinterland might have been.²⁸⁶ The most interesting source that specifically relates to growing of barley in the northern Palmyrene hinterland, is the mentioned mudbrick at Khaled al-Ali, that contain traces of eggs from intestinal of goat and pollen from domestic barley. It is hard to draw conclusions about how extensive the growth of barley was at Khaled al-Ali. It was, however, domestic, and was quite certainly not grown as dry-crop, but in the more steady environment of a flood field. Meyer compare the area around Khaled al-Ali, with areas like Jebel Chaar, which indicates that if barley was grown at Khaled al-Ali, it could just as well have been grown elsewhere in the northern Palmyrene hinterland.

Looking at the conditions at Khaled al-Ali in detail, based on the analysis performed in this study, the sites receives 188 mm precipitation a year (in average), has 12 °C as the highest temperature during the winter and is located in a an undulating terrain,²⁸⁷ the catchment area has an average gradient of 3%. This resembles areas like Jebel Chaar and Jebel Bilaas. In fact, Jebel Chaar and Jebel Bilaas have slightly more favourable conditions. On the other hand, there are certain aspects with Khaled al-Ali that are not so easily comparable. The site lays at the outlet of a huge catchment area (82 000 000 m²), which receives more than 15 billion litres of precipitation a year. Even if the runoff factor probably is quite low, the amount and force of the water that runs through the main wadi, is probably high. Another aspect is that the documented *water resources* of site are wells. If distribution systems from the wells were used to flood the field of barley, the conditions of the site can't be compared with many sites

²⁸³ Syr/Nor (2011), p. 114.

²⁸⁴ Syr/Nor (2009), p. 56.

²⁸⁵ Syr/Nor (2009), p. 18.

²⁸⁶ Syr/Nor (2009), p. 129.

²⁸⁷ As described by the Syr/Nor-survey: Syr/Nor (2008), p. 113.

at Jebel Chaar or Jebel Bilaas. It is notable that this context can be compared to the North/western steppe, where several sites have quite large catchment areas and 66 % are located close to wells. There are, however, no sources that indicates that the barley field was connected to either the main flow of the wadi, or to any of the wells. The flood field might have been related to the smooth hills around Khaled al-Ali, and therefore comparable to other areas in the northern Palmyrene hinterland.

Another source in the hinterland that is related to agriculture, is the many discoveries of grinding stones made by the Syr/Nor-survey. Grindings stones were used for grinding barley into flour (see photo in Figure 5.31). The barley may have been imported from other markets, not grown at the sites of the grinding stones, but the large amount of grindings stones may indicate that crops was common in the northern Palmyrene hinterland. Especially if the grinding stones are dated to the time after the trade routes of Palmyra broke down, the large amount of grinding stones would not make sense unless a large amount of grain was produced in some areas of the hinterland.

The Syr/Nor-survey found traces of grinding stones at Wadi al-Takara south,²⁸⁸ Wadi al-Takara wall,²⁸⁹ Wadi al-Takara north,²⁹⁰ Al-Mazraah,²⁹¹ Valley 369,²⁹² Jazal,²⁹³ Ras al-Matna,²⁹⁴ Bir al-Arfa,²⁹⁵ Shalalah,²⁹⁶ and Tweihina (Tahoun al-Masek) at Jebel Abyad.²⁹⁷ Tahoun even means grinding stone.²⁹⁸ Traces of grindings stones were also found at fort of Shanaeh,²⁹⁹ and at the Village 539 in the southern hills of Jebel Chaar.³⁰⁰ In addition traces of grinding stones were located at Site 073,³⁰¹ Site 035,³⁰² Site 079,³⁰³ Site 083,³⁰⁴ Site 089,³⁰⁵

²⁸⁸ Syr/Nor (2009), p. 31.

²⁸⁹ Syr/Nor (2009), p. 45.

²⁹⁰ Syr/Nor (2009), p. 60.

²⁹¹ Syr/Nor (2009), p. 67.

²⁹² Syr/Nor (2009), p. 70.

²⁹³ Syr/Nor (2009), p. 85.

²⁹⁴ Syr/Nor (2008), p. 46.

²⁹⁵ Syr/Nor (2009), p. 94.

²⁹⁶ Syr/Nor (2008), p. 27; Syr/Nor (2009), p. 75.

²⁹⁷ Syr/Nor (2008), p. 13.

²⁹⁸ Syr/Nor (2008), p. 16.

²⁹⁹ Syr/Nor (2008), p. 65.

³⁰⁰ Syr/Nor (2009), p. 112.

³⁰¹ Syr/Nor (2011), p. 12.

³⁰² Syr/Nor (2011), p. 19.

³⁰³ Syr/Nor (2011), p. 23.

³⁰⁴ Syr/Nor (2011), p. 27.

³⁰⁵ Syr/Nor (2011), p. 41.

Site 161,³⁰⁶ Site 172,³⁰⁷ Site 215,³⁰⁸ Site 222,³⁰⁹ Site 209,³¹⁰ Site 330,³¹¹ Site 318,³¹² Site 304,³¹³ Site 291,³¹⁴ Site 252,³¹⁵ Site 263,³¹⁶ and Site 232 at Jebel Merah,³¹⁷ and the mentioned Khaled al-Ali far to the north of Jebel Merah.³¹⁸



Figure 5.31: Photo taken by Jørgen Christian Meyer, showing example of the use of grinding stone similar to those used in the northern Palmyrene hinterland. ©Meyer

³⁰⁶ Syr/Nor (2011), p. 46.

³⁰⁷ Syr/Nor (2011), p. 50.

³⁰⁸ Syr/Nor (2011), p. 58.

³⁰⁹ Syr/Nor (2011), p. 61.

³¹⁰ Syr/Nor (2011), p. 72.

³¹¹ Syr/Nor (2011), p. 77.

³¹² Syr/Nor (2011), p. 81.

³¹³ Syr/Nor (2011), p. 84.

³¹⁴ Syr/Nor (2011), p. 88, 91.

³¹⁵ Syr/Nor (2011), p. 93.

³¹⁶ Syr/Nor (2011), p. 96.

³¹⁷ Syr/Nor (2011), p. 104.

³¹⁸ Syr/Nor (2008), p. 114.

6 Conclusion

This study has contributed to the field of research of the northern Palmyrene hinterland with detailed information about the sites and natural resources of the hinterland. It has shown that the content of the hinterland is even more comprehensive than earlier known, and, with detailed arguments, shown how the *200 mm-argument* fails to explain the natural resources of the hinterland. This study has shown that there are reasons for being optimistic concerning the productivity of the hinterland, and that the area that usually has been defined as relevant study area, probably should be extended westwards.

This study has emphasized the diversity of the northern Palmyrene hinterland, how different areas contain different type of sites, and how the sites within each area can be distributed differently. The analysis of different areas and different types of sites, has created a framework for understanding the hinterland, of which hypothesis can be made.

In the following sections a brief summary and discussion of the information provided in *Chapter 4 – Distribution of the sites*, and *Chapter 5 – The water system of the Palmyrene hinterland* will be performed. For last in this study comes a hypothetical discussion concerning what the distribution of sites can say about the function of the hinterland.

6.1 Jebel Chaar

Jebel Chaar is one of the areas in the northern Palmyrene hinterland with best natural conditions. It usually receives 190 mm precipitation a year, and the warmest temperature during the winter is 10 °C. The area contains a large amount of sites which are distributed quite evenly across the different types. There is a notably low amount of documented sites without buildings and modern settlements. Most of these sites are located 2 – 3 km distance from its nearest neighbour.

Spatially Jebel Chaar seems to have been divided into different areas based on density: a central, southern, eastern (south/east and north/east) and north-north/western part. Especially interesting are the eastern and north-north/western parts. To the east, there is a dominance of smaller sites (couple and single-sites) quite densely settled. While most of Jebel Chaar has quite gentle terrain, the north/eastern part has slightly steeper terrain. To the north-north/west, there is a dominance of large cluster sites, quite sparsely distributed (3 – 5 km).

Jebel Chaar seems to have a continuance of sites towards Jebel Bilaas in the west, North/western-steppe to the north/west and the fort of Shanaeh to the south/east. There is low

continuance towards Wadi Shanaeh and Wadi Djihar to the south, north/eastern steppe, and towards Jebel Merah in the east. It is interesting to note that the eastern areas that have no further connection to the east, are the areas that is dominated by smaller sites. One might suggest that this is the outer-boarder of an area that has an orientation to the west.

Springs are not important at Jebel Chaar, except possible for the large cluster site Marzouga far to the north/west. Wells are on the other documented in the Maps by nine sites, and are close to 37.5 % of the large cluster sites. While cisterns are the most important water resource at Jebel Chaar, the amount of large sites that are close to wells is worth noting. As seen in Figure 5.16-18, there seems to be a relation between size of the site and number of cisterns. Some sites seem to have huge amount of cisterns. These numbers are, however, somewhat uncertain, and should be revised.

There are no clear evidence that relates to function at Jebel Chaar. The natural conditions are however better than Khaled al-Ali, where traces of domestic barley was found, which strongly indicates that Jebel Chaar had the potential of growing barley.

6.2 Jebel Abyad

There are fewer sites at Jebel Abyad than Jebel Chaar. Their location seems to be quite related to the appearance of the valleys and the position of springs. For that reason, a distribution analysis is not as interesting. The largest sites at Jebel Abyad are *couple-sites*, which are much smaller than the largest sites at Jebel Chaar. On the other hand, the buildings of these sites are similar to those of Jebel Chaar. In difference from Jebel Chaar, Jebel Abyad has several developed sites without buildings. The natural conditions are not so good. The area receives 156 mm precipitation a year, which is 17 % less than the other mountain areas. The maximum temperature in the wettest month is 14 °C , 40 % higher than Jebel Chaar. The catchment areas are quite steep, which means that water moves fast, and less is left to moisturize the ground. There are some remains of possible flood field systems connected to the springs, and walls possible used for flooding fields in Wadi al-Takara, but one can argue that pastoralism was the economic base of the area. There are several remains of troughs, animal pens and ties of animals, in addition to several sites with developed water management systems and no buildings. One can suggest that these fits with pastoralism. Knowing that Jebel Abyad is the mountain closest to Palmyra, it is not unlikely it was part of the pastoralism discussed in the academic discourse.

6.3 Jebel Merah

Similar to Jebel Abyad, Jebel Merah is a steep mountain. There are, however, many things that are not similar to Jebel Abyad. Jebel Merah receives 190 mm precipitation a year, which is similar to Jebel Chaar, and the temperature is only slightly higher than Jebel Chaar. The density of the sites is very high, even higher than the sites at Jebel Chaar. Unlike Jebel Abyad, Jebel Merah contains *small cluster-sites*. Looking at the distribution of sites in detail, the southern part of the mountain is little less dense than the eastern mountain side. This area is also little less steep. It is in this part the *small cluster-sites* are located. Maybe this area has more favourable natural conditions. Several sites potential flood fields are located in the same area, and there are several remains of grinding stones, which is related to agriculture. There are also several remains of troughs and possible animal pens, which are related to pastoralism. It is not unlikely that there were a mixture of functions, but it is difficult to say if the agriculture was extensive. The area seem to have a continuance towards the fort of Shanaeh, not towards Jebel abu Rigmen in the east.

6.4 Jebel Bilaas

Jebel Bilaas are in many respects similar to Jebel Chaar. Jebel Bilaas contains a large amount of sites. The amount of different types of sites is interestingly similar. The climatic conditions are almost similar, as is the steepness of the terrain. There are, however, some differences. Jebel Chaar does not contain many *modern settlements*, while this is the most numerous type of site at Jebel Bilaas. Jebel Bilaas also contain several large forts, and large potential flood field enclosures are located in satellite imagery. Even though the steepness of the terrain is similar, the catchment areas are in general larger, which means that more water is involved for each site. There are good reasons to argue that Jebel Bilaas was as developed, if not more developed than Jebel Chaar.

There seems to be a continuance between the sites at Jebel Chaar and Jebel Bilaas. Jebel Bilaas also seems to be connected to the west and North/wester-steppe. In these areas there is documented a large amount of wells. However, unlike Jebel Chaar, no wells are located in the central areas of Jebel Bilaas.

6.5 Jebel abu Rigmen

The plateau of Jebel abu Rigmen has many similarities to Jebel Chaar. It has got the same amount of precipitation, almost the same temperature and the same undulating terrain. Still far fewer sites have been discovered. The reason for this may be lack of proper research. Still, one can suggest that the area has not developed in the same way as Jebel Chaar. No *large*

cluster-sites have been found, and the density of the sites is very high, like that of Jebel Merah. At the same time, the mountain is quite isolated from other areas in the hinterland. Jebel abu Rigmen is in that respect a little mystery.

6.6 North/western steppe

In terms of developed areas, the North/western steppe is very interesting. It contains a range of impressive sites, including several forts and *large cluster sites*. The natural conditions are better than most other areas of the hinterland. It receives more precipitation than any mountain (197 mm), and is only one degree warmer than Jebel Chaar in the wettest months. The steepness of the catchment areas are the same as Jebel Chaar, but they are much larger. A larger amount of water is involved. The North/western-steppe also differs from many areas of the hinterland by having a large amount wells. 66 % of the sites contain wells. In many respects, the North/western-steppe is a better version of the area around Khaled al-Ali, where proof of domestic barley has been found. There are many good reasons for arguing that the North/western-steppe might have been a prominent part of the northern Palmyrene hinterland. The pattern of sites in the North/western-steppe continues towards Jebel Bilaas and Jebel Chaar. In a way it seems logical to view these areas as one large area instead of three separate ones, and suggest that there is a tendency of orientation westwards, away from Palmyra, at least when considering where all the large sites in the northern Palmyrene hinterland are located.

6.7 Discussing what the distribution of sites can say about function.

As described in the *Chapter 2 - Research*, the academic discourse are concerned about property and function. Were the sites estates of wealthy men of Palmyra, or were the sites more independent, only trading with Palmyra.? Were the function of the sites pastoralism or agriculture?

It is peculiar that the different type of sites (*large cluster, small cluster, couple* and *single-sites* (with large buildings)) are seemingly so similar across the different areas. The large buildings at Jebel Abyad, resembles the large buildings at Jebel Merah, which can be compared to the large buildings documented by Schlumberger at Jebel Chaar. In other words, a *couple-site* seems to be quite similar whether it is located in Jebel Abyad or Jebel Chaar. Based on satellite imagery, there are no reasons to suggest that this do not apply for most of the sites in the northern Palmyrene hinterland. There seems to be some kind of systematic development of the sites. May this reflect a local style, the building-custom of the area,

necessity because of natural conditions, or does it reflect a centralized organized development, performed by wealthy men of Palmyra or the hinterland?

Another question is why the buildings of the sites, independent of number of buildings, in general are so large. Does this mean that wealthy men must have been involved in the development of most of the sites, or could such large buildings have been built by farmer-societies, without the help of a wealthy man? If so, why would they build so large buildings?

It is fair to suggest that the monumental buildings at the *couple-sites* at Jebel Abyad belonged to wealthy men. Can this be applied to the *couple-sites* in other areas as well, viewing the rather numerous *couple-sites* at Jebel Chaar as villas of wealthy men? Can this explain the majority of *couple* and *single-sites* at the eastern part of Jebel Chaar? This cannot be ruled out, but the monumental art and traces of banquet halls documented by Schlumberger in the *large cluster-sites* at Jebel Chaar,³¹⁹ show that they also must have housed wealthy people.

If the size of a site is a result of economic prosperity, does this mean that areas without *large cluster-sites* are less prosper? If so, one could suggest that Jebel abu Rigmen, on the basis of current knowledge, is less developed than Jebel Chaar. As mentioned, Jebel abu Rigmen share many of the natural conditions with Jebel Chaar. As it appears, it is far more isolated, and does not seem to be closely related to any other region. It can be intriguing to suggest that the sites at Jebel abu Rigmen were inhabited and developed for a shorter period of time, perhaps related to the changes of Palmyra following in the third century AD. Without proper dating, this will only be guesswork.

Concerning type of site related to function. It is fair to suggest that the function of the sites in Jebel Abyad probably was pastoralism, not extensive agriculture. The major sites at Jebel Abyad were *couple-sites*. If agriculture was widespread in the northern Palmyrene hinterland, this probably involved Jebel Chaar. Jebel Chaar contains several large sites. Are *large cluster-sites* somehow connected to agriculture, and may agriculture be the reason for their prosperity? If so, is the lack of *large cluster-sites* at Jebel Merah and Jebel abu Rigmen because they didn't deal with large extent agriculture? At least, can the size of the sites reflect how productive they were in terms of agriculture, which means that Jebel Merah might have performed limited, but not extensive agriculture?

³¹⁹ Meyer (2016), p. 86; Schlumberger on courtyards: p. 13-44, banquet halls: p. 101-106, cisterns: p. 10-11.

6.8 Concluding remarks

This study is based on a massive amount of data, and contributes with valuable information for further research. On the other hand, it is limited by the level of detail in the data material. It can't replace a pollen analysis at Jebel Chaar, a hydrological survey at Jebel Merah, or a proper excavation at Jebel abu Righmen. However, given the terrible political situation in present Syria, the data at hand is the data one have to work with. In that respect, a GIS-analysis is a great way of maximizing the knowledge.

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