The Spatial Analysis of the Ancient Funerary Landscape of the Sahara Fazzan - A Case Study of the Wadi ash-Shati, Libya

Kgosietsile Tshekiso (857764)

Supervisor: Dr Stefania Merlo

March 2016

A Report submitted to the Faculty of Science, University of the Witwatersrand, in Partial fulfillment of the Requirements for Masters in Geographic Information Systems (GIS) and Remote Sensing in the Faculty of Science

School of Geography, Archaeology and Environmental Sciences,

University of the Witwatersrand

Abstract

This study is an initial attempt to investigate the spatial arrangement of graves which are believed that they can shed new light on the mortuary behaviours of ancient societies. The aim of this study is to utilise Geographic Information System (GIS) and remote sensing to document and explore the funerary landscape of the Wadi ash-Shati, Libya using a comprehensive set of environmental variables that might have influenced the spatial distribution of Garamantian funerary monuments. In view of that argument, this study is motivated by these two objectives; documenting all the Garamantian funerary monuments and settlements visible in high resolution satellite imagery and investigating their spatial patterns in their topographic setting. Spatial patterns were achieved by plotting digitised graves data from remotely sensed imagery (accessed through Google Earth) and hand held Global Positioning System (GPS) data in a GIS environment in order to extract patterns and structure in the dataset. In order to better understand these patterns and structures, the following GIS approaches; slope, elevation, visibility, clustering, directional distribution analyses were utilised. The results of the GIS analyses showed that there was correlation between graves location, *qsurs* or settlements, wells and with the environmental variables (slope, elevation, and distance to water resources). On the basis of the results of this research, it can be concluded that environmental variables were major factor in the placement of graves, qsurs and wells. The placement of these site locations can be related to as an expression of the socio-political, economic, cultural and ideological characteristics of the Garamantian society that created the burials and organised the Wadi ash-Shati landscape.

The present study concluded that the Garamantian civilisation had established changes in the landscape that promoted the development of elaborate funerary monuments which peaked significantly during the time when aridity became immense in the study region. However additional research is necessary to provide more conclusive results and interpretations of this study, as such results from the analyses carried out should not be viewed as absolute, but as a stepping ladder for future investigation in the Wadi ash-Shati region.

Keywords: GIS, Remote sensing, Funerary Landscape, Wadi ash-Shati, Libya, Spatial Analysis, Garamantian, Google Earth, Global Positioning System (GPS), Environmental Variables

Acknowledgements

I would like to thank my supervisor, Dr. Stefania Merlo, for suggesting this topic to me and for her assistance in providing additional data needed for thisreport. Additionally, her positive feedback and advice have been invaluable for this study to materialize. I also wish to thankthe other members of my committee, Professor Jasper Knight, Professor Danny Simatele and Dr Elhadi Adam for their edits and suggestions.

A great deal of thanks is also owed to Mr Lokwalo ‘Tsankane’ Thabeng for his constant encouragement and support. He also ensured I did not get too stressed when things were not going as expected. All of my colleagues in the masters graduate program have been very supportive providing their opinions and insights regarding my report work, and in particular I would like to express my gratitude to Simbarashe ‘Chipinge Express’ Jombo, Mpho ‘Vhembe’ Gegana and Mcendisi ‘Mc^2’ Siteleki.

‘Le ka moso betsho’

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Chapter 1-Introduction and Project Background

1.1 Introduction

The purpose of this study is to investigate the ancient funerary landscape of the Wadi ash-Shati, Libya, using Geographic Information System (GIS) and remote sensing. As argued by Conolly and Lake (2006) GIS is dynamic and able of integrating various types of data into one database, and it serves as a way of mapping site positions as well as representing and developing our understanding of site distribution and ancient land use.GIS also acts as a unique way to better understand and reconstruct palaeo-environments, which are dynamic and ever changing as the people who inhabited them (Lock and Stancic 1995). By employing GIS, researchers can then reconstruct and have an enhanced understanding of the palaeo-environments inhabited by prehistoric human populations (Nigro *et al.* 2003).

This study explored the spatial patterns of ancient graves and other archaeological features such as *qsurs* (castles), settlements and wells, in their regional geographical setting with reference to a number ofenvironmental parameters (i.e distance to aquatic sources, topographic position or elevation, slope and viewshed), which may have influenced their location. For this study to materialise, the following research questions were posed and served as the driving force to this investigation.

1.2 Research Questions

1. *What is the spatial patterning of the Garamantian funerary earthworks in the landscape of the Wadi ash-Shati region?*
2. *What are the possiblemeanings expressed in the layout of the cemeteries and settlements in the landscape?*

1.3 Aim and Objectives

The aim of the study was to use remote sensing and GIS to document and explore the funerary landscape of the Wadi ash-Shati. The potential applicability of remote sensing and GIS information to analyse the spatial distribution of Garamantian funerary monuments was explored as a possible way of understanding the socioeconomic and political structure of the ancient communities in the Wadi ash-Shati region. This aim was complemented by two objectives, the first one being to document all the Garamantian funerary monuments and settlements visible in high resolution satellite imagery in the study area, and the second to examine the spatial layout of the burials in their physiographic setting using spatial analysis.

1.4 Significance of the Study

The use of GIS to conduct spatial analysis in archaeology has become increasingly popular over the years (Ebert, 2004). Additionally, the application of satellite remote sensing in archaeological studies has grown tremendously, and nowadays ancient settlements are detected with high resolution remote sensing techniques globally (Alexakis *et al.*, 2011). However, the use of GIS and remote sensing to study funerary landscapes seems to have lagged behind, especially in the African continent. As such, this study is the first attempt at using the topographical positioning of burial grounds and settlements in order to understand their relationship to each other and in the landscape of the Sahara Fazzan region of Libya. This analysis has the potential of shedding light on how ancient communities related to the landscape in the Sahara Fazzan. It is thus hoped that this study will lead to a broader examination of funerary landscapes within the African context using GIS and remote sensing.

1.5 Report Overview

This report has been organized into seven chapters. Below is a brief discussion on how this report has been organised.

Chapter 1- Introduction and Project Background

The first part to this chapter serves as an introduction to the report work. It is then followed up by four sections. The first section tackles the research question, the second one outlines the aim and objectives of the study, and the third one discusses the significance of the study. The last part to this chapter has two sub-sections, with the first one giving the geographic location and the environmental setting of the study region. The second section outlines the historical background of the study area. Various cultural chronologies which occupied the region during ancient times are presented to give a sense of where the study area lies within the regional prehistory. It should be noted that the physical geography and environmental backdrop is given, with the credence that it has not changed for the last several hundreds of years, which is from around the mid-first millennium BC to the mid-first millennium AD. The main focal point to the cultural history of the study region will be central to the archaeological materials found within the Wadi ash-Shati study region.

Chapter 2 – Literature Review

This review chapter has been divided into two parts, being the applications of GIS and remote sensing in archaeology and the use of GIS to study ancient funerary landscapes. It was deemed fit to review the use of GIS in the investigation of funerary landscapes and GIS and remote sensing in archaeology separately because the latter application is general and it was also incorporating remote sensing. The review section on the applications of GIS and remote sensing in archaeology provides an overview of the different use of GIS and remote sensing in archaeological studies. The selected literature here presented represents the current state of GIS and remote sensing use in archaeological studies in other parts of the world such as Europe and America. The other section, GIS in funerary landscapes tackled the application of this technique in investigating the spatial arrangement of mortuary works in the landscape in relation to other archaeological features there.

Chapter 3-Methodology

An overview of the methodology is provided in this chapter. The chapter has been divided into two sections, each having sub-sections. The first section outlines where the data used in this study was acquired from. The sub-sections discusses other issues such as the digitisation processes of archaeological data in Google Earth program, and the merging the two datasets (the field surveyed hand held GPS data and the digitised ones) so that they are analysed together. A discussion of the processing of the topography data in order to carry out environmental analysis such as viewshed and slope follows. The second section to this chapter is dedicated to the discussion of the methods of spatial analysis used in the study.

Chapter 4-Results

This chapter presents the results from the analyses which were carried out in chapter 5, and provides interpretations to each one of them. In short, the result of the analyses will be used to quantify the influence of environmental parameters on sites selection. Each of the analysis results have been discussed separately.

Chapter 5- Discussions and Interpretations

Chapter 5 presents the discussion and explanation of the results from the analyses carried out. The results have been combined and summarised with the view of answering the research questions and achieving the aim and objectives stated in this report.

Chapter 6-Conclusion and Recommendations

This chapter provides a summary of the research carried out in this report. The summary provides an overview of what the research entailed and its achievement are also highlighted. A number of the problems encountered during the study are also discussedand the potential of the methodologies for future application.

2. Project Background

2.1 Introduction

The purpose of this section is to introduce the study area, its environmental settings and the associated archaeological features which will be central to this study. To begin, an overview of the physical geography on the Wadi ash-Shati area is presented, with a focal point on the micro context of the study region for this research. The environmental backdrop is given, with the credence that the arid phase relevant to this study commenced between ~3700 and 3600 BC and it remained unchanged for the last five thousand of years (Cremaschi and Zerboni, 2009; Clarke *et al.* 2016). Following this discussion, the cultural history of the study region is also reviewed. The main discussion will be centred on the archaeological remains found within the Wadi ash-Shati study region.

2.1.1 Physical Geography

Wadi ash-Shati is a topographic depression located in the northern part of the Sahara Fazzan, and it is about 160 km long and 80 km wide. As shown in figure 1, the enclosed drainage basin stretches from east to west, between the southern edges of the al-Qarqaf Arch to the north and the Ramlat Zellaf to the south (Merlo *et al.*, 2013). Here, within the depression, the altitude drops to around 300 m from the surrounding topography of 800 m. The study area contains a number of distinct micro-geographical regions which present a contrasting diversity of topography, geology, soils and vegetation that in different combinations produce escarpments, hill outcrops, depressions, gullies, rivers or streams, oases and sand dunes. The sand dunes are mostly found to the south of the study area (Merlo *et al.*, 2013).

The area is cut by gullies formed probably during the wetter phases in the Pleistocene periods which cascades from the numerous carboniferous outcrops, mounds and spurs found mostly in the northern and north eastern side towards the ancient villages of Brak and Ashkida. These escarpments and hill outcrops are where clusters of archaeological sites, or to be more specific graves, are being identified. It is also possible to assume that the water discharded by the relic rivers was feeding the Wadi ash-Shati depression. Merlo *et al.* (2013) indicated that human population has from ancient until present days exploited both the numerous artesian springs, and the shallow ground water which can easily be reached by means of dug wells. The shallow water table has also led to numerous oases to be dispersed in the study area, which has attracted vegetations such as date palms, the *hatiya*, grassland dominated by fodder, tamarisks and some acacia species. To the south of the study area, there are sand dunes of the Ramlat Zellaf and the Ubari Sand Sea (Merlo *et al.*, 2013).

In summary to this discussion, it is postulated that the current geographic and environmental conditions are in essence the same as during the period in discussion, which is around the mid-first millennium BC. However, much more work needs to be done before a clearer appraisal can be concluded. The environmental conditions will be discussed below.

2.1.2 Environmental Setting

The general environmental setting of the Wadi ash-Shati in the Sahara Fezzan region will be discussed in this section. The terrestrial and lacustrine record for the period between ~4800 and 4300 BC, shows that the zonesofthe northern hemisphere in which the study area falls under had high stands in the lake levels. This means that the areas enjoyed periods of wetter and cooler conditions, and also based on that, there were numerous water bodies formed during those wetter conditions.

Some of the water bodies which are believed to have been formed during that period are a group of oases in the central part of the Sahara Fazzan basin (van Heekeren and Jawad 1966). The basins in the Sahara desert formed in the early and late Paleozoic to Mesozoic (300–65 Ma) tectonic phases (Turk *et al.*1980). The one in the study area is bowl shaped and to the south of the al-Qarqaf Arch plateau are the sand dunes of the Ramlat Zellaf and the Ubari Sand Sea. The sedimentary basins of the Murzuq and al-Hamada al-Hamra, are found to the south and north of the al-Qarqaf Arch respectively (Merlo *et al.* 2013). The other study which supported the notionthat there once existed a massive water body in the study area is by Castelli *et al.* (2005), when they postulated that the analysis of an ASTER satellite image coupled with the MAO elevation model, have revealed dark-brown massive organic alluvial clay found around Fewet, Barkat and particularly near Ghat. They argued that this might have been an overbank deposit originating in an alluvial plain or swamps.

White and Mattingly (2006) also in their study revealed that a lake once existed which supported lush aquatic plants, and their argument is based from pollen analysis recovered from lake deposits. Their analysis of botanical remains from their excavations indicated that a variety of high-grade cereals (wheat, barley, millet and sorghum) and other crops (date palms, vines, olives, cotton, vegetables and pulses) were cultivated during the discussed period. Also rock art found in the region by archaeologists, which is portraying water dependent creatures, such as elephants, rhinos and the massive bubalus bovine (Barnett and Mattingly, 2003) strengthen this argument.

However, towards the 6th millennium BP the North-African Holocene climatic conditions were broken up by several transitory dry spells, eventually leading to the termination of the wet phase (Clarke *et al.* 2016). This was due to the sudden drop in the amount of the African monsoon, which led to the present desert conditions (Cremaschi and Zerboni, 2009; Clarke *et al.* 2016). The present dry and arid conditions in the Sahara region is indicated by decreased tree ring width or the dendroclimatology of *C. dupreziana*, which is inferred as a sub-centennial period of harsh droughts which occurred between ~3700 and 3600 BC (Clarke *et al.* 2016). Clarke *et al.* (2016) also highlighted that the preservation of organic matter (sheep and goats droppings) in rock shelters as pens for sheep and goats is evidence that there was minimal bacterial activity due to increased aridity in the area.

The present desert conditions, which are characterised by subtropical, hot and arid climate are typical of the Saharan regional Transitional Zone. Based on the above discussed climatic condition of hyper aridity, environmental and societal change became quite clear as the inhabitants of the Sahara Fazzan region were in need of particular adaptive approaches in order for them to survive (Cremaschi and di Lernia 1998; Brooks *et al.* 2005; Merlo *et al.* 2013; Clarke *et al.* 2016). One of the drastic changes brought by this aridity was some major population shift in which people left desert locales for areas with more consistent water sources. Also there were widespread cultural disruptions, which ushered in new complex urban society, intensification of agricultural production, increasing social stratification, complex networks for trade in exotic items, and technological sophistication (including metallurgy) (Clarke *et al.* 2016).

To conclude this discussion, it should be highlighted that some of these adaptive strategies will later form some of the fundamental arguments on the spatial distribution of the funerary monuments in the area under investigation here. This is because it is evident that there are some links between climatic, environmental and societal changes found in the Sahara Fezzan region especially during the ushering of the hyper aridity phase between ~4300 BC and ~3200 BC.

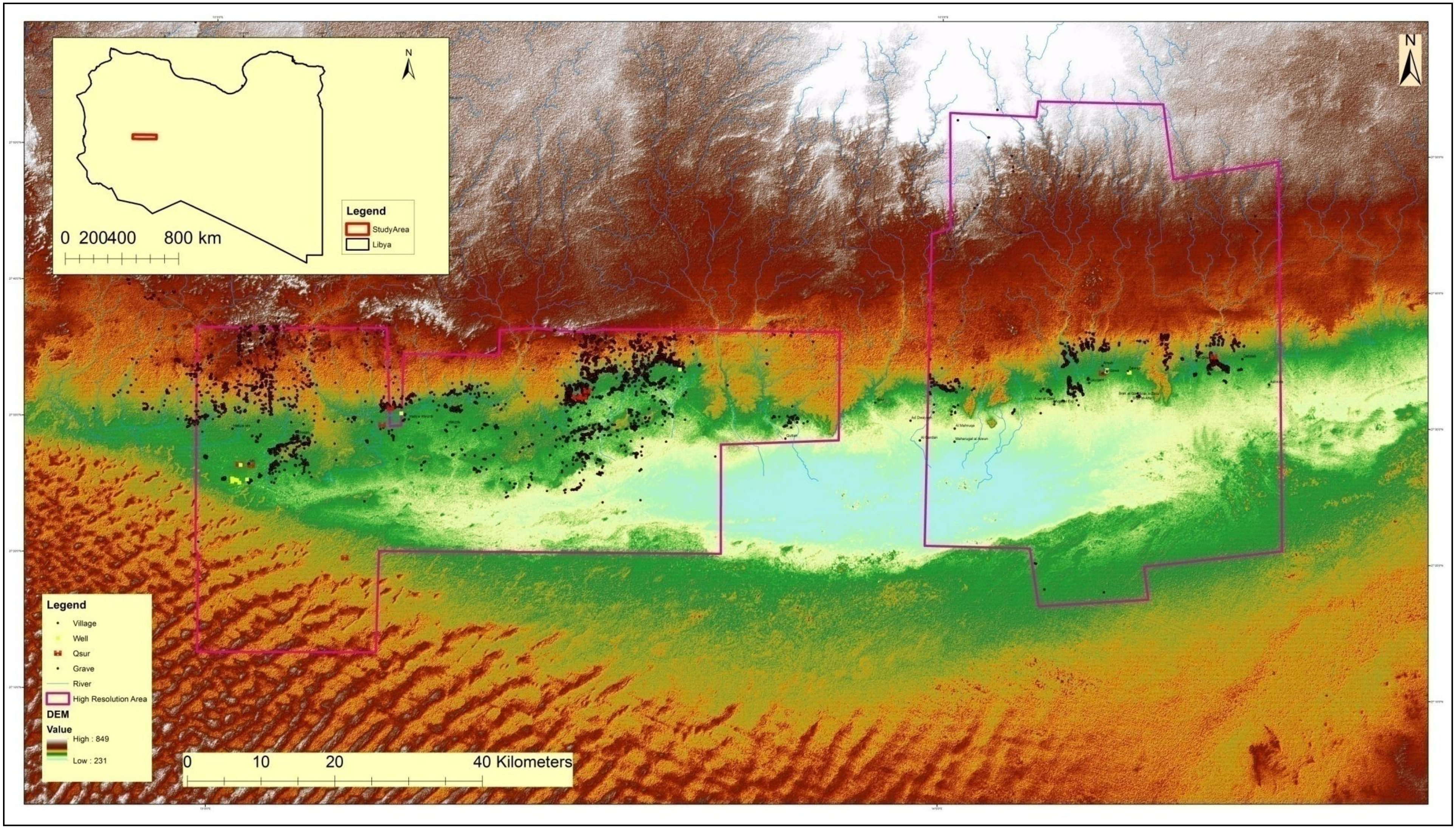

Figure 1. Study area in relation to contemporary places, with the purple colour indicating areas with high resolution satellite imagery in Google Earth. DEM Source: ASTER GDEM

2.1.3 Historical Background

The study area is believed to have been occupied by Late Pastoral-Neolithic societies, from around the mid-first millennium BC to the mid-first millennium AD (Mattingly and Sterry, 2013). In the first or mid-first millennium BC the area was occupied by a sedentary society, the Garamantes, marking a significant turning point in the Fazzan, The Garamantian society was already occupying other areas in the study region such as Jarma in the Wadi al-Aiial, 700 km south of modern day Tripoli and 170 km west of Sabha (Mattingly and Sterry, 2013) and likely spread its influence in the Wadi ash-Shati region possibly at the turn between the first millennium BC and the first millennium AD. The first or mid-first millennium BC period witnessed a radical change in subsistence strategies of the previous pastoral groups. The Garamantes society unlike the Late Pastoral-Neolithic society were living permanently around the oases and exploiting the water and pasture resources in a region turning into an arid and hyper-arid landscape which was a different and new forms of adaptation (Mori et al., 2013). This is testified by the numerous archaeological sites and necropoles recorded in the study area (Merlo *et al.*, 2013).

The study area is also strategically placed at the crossroads of several ancient trade routes between the northern edge of the Sahara and the southern Mediterranean coast (Di Lernia 2001; Liverani 2006; Mattingly *et al.*2007; Mercuri *et al.* 2009; Merlo *et al.* 2013; Mori *et al.* 2013). The emergence of the Garamantes society in the Sahara Fazzan region was involved in trade by utilisation of these trans-Saharan caravan routes. The influence of the trans-Saharan commercial routes became evident in the funerary practices and settlement patterns. The mortuary works during the Late Pastoral and Garamantian periods saw the location of burial grounds along the periphery of known and repetitively used road networks which were most of the time along river systems. The graves were used as land markers to delineate territories and social boundaries, and this was practiced during the Late Pastoral-Neolithic period and became widespread during the Garamantian civilisation period (Mori *et al.* 2013).

These graves, which are found in large clusters and in isolation in the study region, are varying in their structure. This is believed to be reflecting differing chronological periods. Mattingly and Edwards (2003) argued that most of them belong to the pre-Islamic Saharan period, but there are some belonging to the Roman and Islamic periods. Mattingly (2007) argued that most of the graves structures widespread in the study area are the cairns or tumuli which have been associated with the Garamantian period. Also there are some isolated small mounds of stones which are associated with the nomadic people or pastoralists. The other types of grave structures found in the study area are the mausoleums which were constructed using ashlar masonry and following the Mediterranean architectural traditions. These ones are dated to the Roman period. These graves are present in the Wadi al-Ajat and have not been so far been recorded in the Wadi ash-Shati. Based on these arguments, it is perhaps worth noting that due to their typical and recognizable morphology, the majority of the graves in the study area can be classified as Garamantian, since Pastoral ones are extremely different. This argument is based on personal communication from Dr Merlo who carried out the field work in the study area. The pastoral graves occur in a limited number of cases, therefore not significantly affecting the analyses herein carried out. In fact Pastoral graves are commonly found dispersed or as individual mounds whereas the Garamantian ones are clustered usually in a designated cemetery (Mori *et al.* 2013). The area under study is characterised primarily by clustered graves, thus most probably ascribable to the Garamantian period.

It can be concluded that the study of this region yielded a number of important archaeological features such as graves, castles or *qsurs* and wells, and therefore a more comprehensive study which will combine graves typology and the graves excavation material is needed. It is believed that this will envision us in constructing a full history of the region and informing this archaeological discourse.

2.1.4Chapter Summary

The purpose of this chapter was to introduce the research, covering the aim and objectives of the study, the research questions which are driving this investigation, the importance of the research, and how the whole study has been structured. In addition to that, an outline of the study area was provided, together with its associated geographical context and archaeological features being investigated. The overview of geographical and historical variations within the Wadi ash-Shati region of the larger Sahara Fazzan area has highlighted the challenges encountered by the historic societies who once inhabitated the study region. It serves to emphasize the many restrictions to the foundation, growth of settlements and struggle to survive of the human population during ancient times, in a harsh and very restrictive environment. This is because their subsistence which was dependent on agro-pastoralism together with settlements could only be sustained in certain prolific regions and locations where certain environmental variables permitted that.

Chapter 2 – Literature Review

2.1 Introduction

This chapter tackles the commonly well-known applications of remote sensing and GIS for detecting archaeological features in the landscape from remotely sensed imagery, and eventually spatial analysis of them using GIS tools. A summary of previous studies that have utilised GIS and remote sensing in investigating archaeological features is presented in the first part, followed by the one looking specifically at the investigation of ancient funerary monuments and archaeological features in relation to environmental variables in the whole world, as there are none for the present study region. The sections in this chapter have a common goal, which is to show that the environment is not the only influence on human deeds, but the landscape can also be culturally shaped. This is because the review on the applications of these technologies, remote sensing and GIS have demonstrated that they been used to map cultural and social ideals onto the environment, which makes the latter an important influence on human behaviour. This idea has been explored below.

2.2 GIS and Remote Sensing in Archaeology

Archaeology as a discipline can be counted amongst the earliest disciplines to use remote sensing in scientific investigations (Sever and Irwin, 2003). This started in the 1920s in Northern Europe, immediately after the First World War, which was inadequate at the start and then increasingly becoming common. This ushered in new methods of aerial photography for the detection of archaeological sites which were to some extent buried or totally buried, or in any case not visible from the ground (Orlando and Villa, 2011). Sever and Irwin (2003) argued that Corona imagery were the foremost satellite images used in archaeological investigations, which were produced by an espionage satellite operating from 1960 to 1972, and in 1996 they were declassified and the scientific commune were able to access them.

Since that period, declassified Cold War era satellite photos have been utilised in archaeological studies as a low cost source of photography, especially in regions where coverage is limited by traditional aerial photography. Hampton (1974) and Jones (1979) argued that the applications of remote sensing in archaeology can be grouped into three categories: predictive modelling, site detection, and intrasite mapping. Predictive modelling of archaeological sites attempts to connect site location with modern environmental zones, and site detection applications involve identifying unknown sites or features in remotely sensed data in areas where they are not known. The features are located through regularly shaped anomalies in the imagery, such as topographic variations, soil marks, or vegetation marks. Intrasite mapping involves the mapping of features within a known site using remotely sensed data. Often these are subsurface features that are otherwise invisible in ground observations. These are primarily visible as soil or vegetation marks caused by the underlying archaeological resources (Hampton 1974; Jones, 1979).

This study utilised the combination of intrasite and site detection applications to digitise the graves locations in IKONOS or other high resolution imagery (accessed through Google Earth). The graves are distinguished by their black dot or yellow dot in the middle of a black circle usually measuring approximately 1.5-3 metres. The graves with the yellow dot in the middle of the circle are because over the years they have been robbed of their upper stones and as such sand has accumulated in the void left by stones (Merlo *et al.,* 2013).

Archaeological data acquired by means of remote sensing techniques may be subsequently integrated into GIS, where it can be modelled against other environmental variables such as topography, hydrology and soil. This method of modelling archaeological data against topography or environmental variables was implemented in this study, where digitised grave locations were analysed against their topographic locations in a GIS environment. An example of where such study was carried out by Lowenberg (2010) who used GIS applications in Västmanland, Sweden, where environmental variables (elevation, aspect and slope) were investigated to see if they have any influence in the location of funerary monuments. The trend which was identified was that elevated grounds were preferred for burial grounds.

Another different application of GIS, but still combining topographical and archaeological data, is the work of Romano and Schoenbrun (1993) and Romano and Tolba (1994). They used GIS as a tool to study the ancient Roman city of Corinth. The project also utilized pre-existing data, such as topographic maps and aerial photographs from the Greek Geodetic service. Romano and Tolba (1994) integrated digital remotely sensed images from SPOT and LANDSAT satellites in order to supplement the pre-existing and newly acquired topographic data. This was done to create a more robust database of the archaeological site. Another example of study which combined remote sensing, GIS, and Global Positioning System (GPS) was by Sever and Irwin

(2003). Their study was to understand how the Maya society interacted with their environment, and to demonstrate the value of NASA remote sensing technology for detecting unrecorded archaeological features. Through the use of remote sensing, ancient Maya features such as sites, roadways, canals, and water reservoirs were detected and verified through ground reconnaissance. Their results shed new light on the adaptation of the ancient Maya to their environment (Sever and Irwin 2003). Another paper regarding the Maya civilization and its methodology much similar to the one used in this investigation to record the archaeological features in terms of point pattern is by Bevan *et al.* (2013). Their paper was looking at understanding settlement patterning of housemounds around the Late Classic Maya settlement landscape at Baking Pot, Belize, and then investigating the wider propositions of this outlining in the central Maya lowlands. Using a well-known concept of nearest neighbour distances, Bevan *et al.* (2013) found out that mounds are found in clusters, with gaps between them, and a probable buffer zone towards the periphery of the whole polity. This analysis according to Bevan *et al.* (2013) goes back to the question long established in the spatial analysis of archaeological features, which is to which degree can site spacing inform us about competition over resources, subsistence catchments and territoriality? In their findings, Bevan *et al.* (2013) asserted that families in their study area tended to keep their dwellings apart from one another, at a minimum spacing of at least 40-50 m. Each Late/Terminal Classic household have the right to use an area covering at least 500-600 m2 in their immediate surroundings, and this presented a model of micro-territoriality. Also the houses in the study area tended to align themselves generally parallel to the course of the Belize River, and this perhaps was done to improve drainage even in mainly flat places such as Baking Pot (Bevan *et al.* 2013).

In conclusion to this discussion, the development and application of GIS and remote sensing technologies in archaeology has had a significant impact on how geo-spatial analysis is carried out in the discipline. GIS applications have provided archaeologists with an array of tools for conducting spatial analysis and modelling or recreating ancient landscapes as demonstrated in the few case studies discussed above, which help in the presentation of data. Remote sensing applications have been in helping with the detection of cultural features.

2.3 GIS Applications in the Study of Funerary Landscapes

The development and application of GIS technology in archaeological studies has had a significant impact on a number of sectors of the discipline. It has been utilised in data management. This is because of its capabilities of providing a large-scale spatial database in which a rich variety of data can be stored and accessed with relative ease (Conolly and Lake 2006; Chapman 2006). Beyond data management, GIS technology has provided archaeologists with a range of tools for conducting spatial analysis and with a platform for the creation of visual representations of data which assist in its presentation (Conolly and Lake 2006). This has assisted in answering research questions that are fundamental to the understanding of past civilisations. GIS has been employed in a range of archaeological studies including investigating funerary landscapes. The aim of studying funerary landscapes was to discern the rationale behind the positioning and development of funeral monuments (Chapman 2006).

These analyses have helped in providing insights on how past human communities may have perceived their landscape. Llobera (2001) stressed that the questions which can be answered by analyses concerning the assemblages of archaeological features in a landscape include but are not limited to: do they denote different varieties of interface among people or with the environment? How do they associate to paths and other landscape structures? And lastly, are the social meanings of material culture that amass through time in one location the same ones? One such analysis commonly used in archaeological studies to help explore such questions is visibility or viewshed analysis. Visibility analysis explores the relationships of visibility and intervisibility between particular archaeological locations in the landscape (Wheatley 2004). This intervisibility between sites is achievable when the sites are at a more or less the same height, and as such these archaeological monuments particularly graves were positioned in elevated topographies.

Llobera (2001) and Dederix (2014) argued that the prominence felt at a location can be as a result of influence of social and cultural forces, and address issues surrounding hierarchy, rank and significance of an archaeological feature, as such governing the location of settlements, monuments and sites. To add further into this discussion, Llobera (2001) discussed topographic prominence as a meaning of height disparity between an individual and his/her surroundings as held from the individual’s point of view (terrain altitude plus individual’s height) within a specific radius. Visibilty analysis thus has the potential to contribute towards understanding the way past communities interacted, thought about, and created their environment. One typical study where visibility analysis was carried out is by Lageras (2002). Intervisibility analysis was used to investigate the Bronze Age burial mounds in western Scania, Scandinavia. Lageras performed viewshed analysis on over 390 mound sites, and throughhis analysis he found out that mounds could have been used as territory boundary markers. Herschend (2009) and Lowenborg (2010) corroborate Lageras’ (2002) conclusion by arguing that depending on how the burials are situated in their surroundings, they could either act as territorial boundaries in the landscape or used to strengthen and demarcate the position of the settlement.

Another similar study to the previously discussed one in which the monuments were employed as cementing social power across the landscape but this one entailing the use of round barrows is in North Yorkshire during the Early and Middle Bronze Age though this started earlier in the Neolithic periods. Llobera (2007) noted that the North Yorkshire barrows were positioned so that they could be viewed over private pasture lands linked with minor social units. This visibility pattern appends a visual component to the idea that the arrangement of barrows was connected to social lineages. Based on this argument, it can be concluded that that would have emphasized the power and status of particular lineages over pasture lands in North Yorkshire (Llobera 2007).

Another study regarding visibility analysis in a funerary landscape is by Bongers *et al.,* (2012) in Lake Titicaca basin, Peru. Using viewshed analysis, their study formally tested the notion that the tombs were placed intentionally on higher grounds and their roles were for ancestral veneration, to perpetuate memory, delineate social ties and territories, and demarcate access to resources. Their conclusions agreed with the earlier notion mentioned, and as such the tombs were positioned in strategic locations, they exhibit a high degree of clustering and were built in highly visible areas that could be seen from sites of occupation and regions of economic importance such as Lake Umayo. Knapp and Ashmore (1999) argued that this is a form of conceptualized landscape, where space has been given meaning by how specific areas of the land are used for political, social or ritual practices. Llobera (2007) shared Knapp and Ashmore’s sentiments that visibility patterns created by cultural features in the landscape most of the time are related with social and symbolic aspects within past societies. The patterns exhibited by visibility patterns are often argued as being influential in the definition of territorial boundaries. Despite this view, Llobera argued that it is implausible, however, that given the current technological advances that archaeologists will ever be able to re-enact these patterns with any degree of precision. On the other hand, it is conceivable to guess to some certain extent when one has palaeo-environments and vegetation data where certain type of vegetation may have been distributed in a landscape. These locations can then be simulated to allow us to determine in which areas visibility may have been affected between monuments and their surroundings.

Despite that, it still remains challenging in landscape archaeology studies to integrate vegetation models in visibility analyses in GIS approaches. Llobera (2007) argued that one of the reasons for this hiccup is that a fitting resolution cannot be attained using traditional GIS data structures. However, this can be rectified by using three-dimensional (3D) information which is yet to be fully developed in commercial GIS. Another challenge facing viewshed analysis approaches in archaeology besides vegetation data is the effect of atmospheric conditions. This is important because during some certain periods of the day and the season variances, certain features become more prominent than others. Llobera (2003) argued that it is not fortunate that a large proportion of studies utilising the application of viewsheds do not address these restrictions. He hinted that it is the lack of better algorithms which is ultimately responsible for setting the limits for further interpretations in viewshed analysis studies.

In summary to this discussion, it has been observed that a landscape can be both the medium and the outcome of human mind and agency in the environment. From this perspective, the selection of locations and spatial relations of burials and other archaeological features, for an example, settlements should be considered as an expression of the norms and values of a certain community or individuals. The location of a cemetery in a landscape is planned, as its function is not only as a place for the hygienic disposal of the dead. It is a sacred landscape, a transitional space between life and death, to which the society or community relates (Tilley 1994). GIS has thus availed potential means to examine spatial and statistical relationships of archaeological features in their landscape, and deriving meanings and interpretations from the analyses.

2.4 Chapter Summary

In this chapter, the applications of GIS and remote sensing as heuristic tools for appraising the past communities' cultural behaviours in archaeological investigations have been discussed. These tools have conveyed the importance of applying both the environmental and socio-cultural factors to better understand prehistoric spiritual belief, subsistence and settlement patterns in the Wadi ash-Shati region. The following chapter will discuss the data sources and methods used in the analysis of the spatial arrangement of the archaeological features in the funerary landscape of the Wadi ash-Shati region.

Chapter 3-Methodology

3.1 Introduction

This chapter presents a summary of the datasets and methods used in this study. These datasets were chosen for use in this study for their effectiveness in discerning cultural patterning in the ancient Wadi ash-Shati funerary landscape. A total of two data sets were used in this study which are: archaeological data and topographic data.

3.2 Data Sources and Preparation Methods

Below is the brief discussion of data acquisition and pre-processing.

3.2.1 Archaeological Site Data

Archaeological features are commonly incomplete and the ones (graves, wells, *qsurs* or settlements etc) investigated in this study area unfortunately fit this description. Some have been affected by modern land use while others have fallen, or have been looted and partially destroyed, leaving behind their incomplete foundations. Merlo *et al.* (2013) corroborate this statement that in the early 1970s, quite a number of modernisation policies in the agriculture, roads and urban areas sector were implemented by the Libyan government which destroyed archaeological features in the study region. Therefore, it should be noted that the data used in this study will not reflect a complete picture of the historic communities, this is because sites visible through remote sensing imagery does not permit us to see small scale archaeological features such as temporary camps, pottery sherds and lithics, which are also vital in shedding light into the way of life of past communities. .

Part of the archaeological data used in the study was provided by Dr Stefania Merlo, who conducted ground reconnaissance work in the Wadi ash Shati in 2007 and 2008 (Mattingly *et al.* 2007, Merlo *et al.* 2008 and 2013). The data includes the position and brief description of graves, *qsur* (fortified castles), wells, ancient and modern villages in the form of shapefiles (fig 2). In addition to the data acquired from the 2007-2008 field work, additional sites (mainly graves) were digitised using high resolution satellite imagery acquired through a Digital Globe grant and later available through Google Earth. This was aimed at covering larger areas within the study region that were not surveyed because of time limitation. The total number of graves recorded during the 2007 and 2008 filed work and digitised by Dr. Merlo was 11,516. Digitisation of other remaining graves was carried out onscreen manually by means of locating place marks (points) representing the location of each burial. Through this process, a total of 5, 548 graves were digitised. The final total combination of 17,064 graves was used for this investigation, which came from Google Earth sources. The other archaeological features used in this study were 11 *qsurs*, 18 wells and 32 villages. Before digitisation could begin, the study area was sub-divided into grids measuring 350*400 metres each. The grids are found in the View tab in Google Earth program. The graves were distinguishable as a black dot or a yellow dot in the middle of a black circle, usually measuring approximately 1.5-3m (Merlo *et al.* 2013).   The datasets were then combined with the ground collected data. It should be noted that some portions of the study area were not thoroughly digitised from Google Earth program, and this is due to the fact that the image resolution which covered those areas was too low to distinguish the features to be traces for thus study. This can lead to the presentation of bias and inaccurate information when analyses are conducted, as such care must be taken when working with this kind of data.

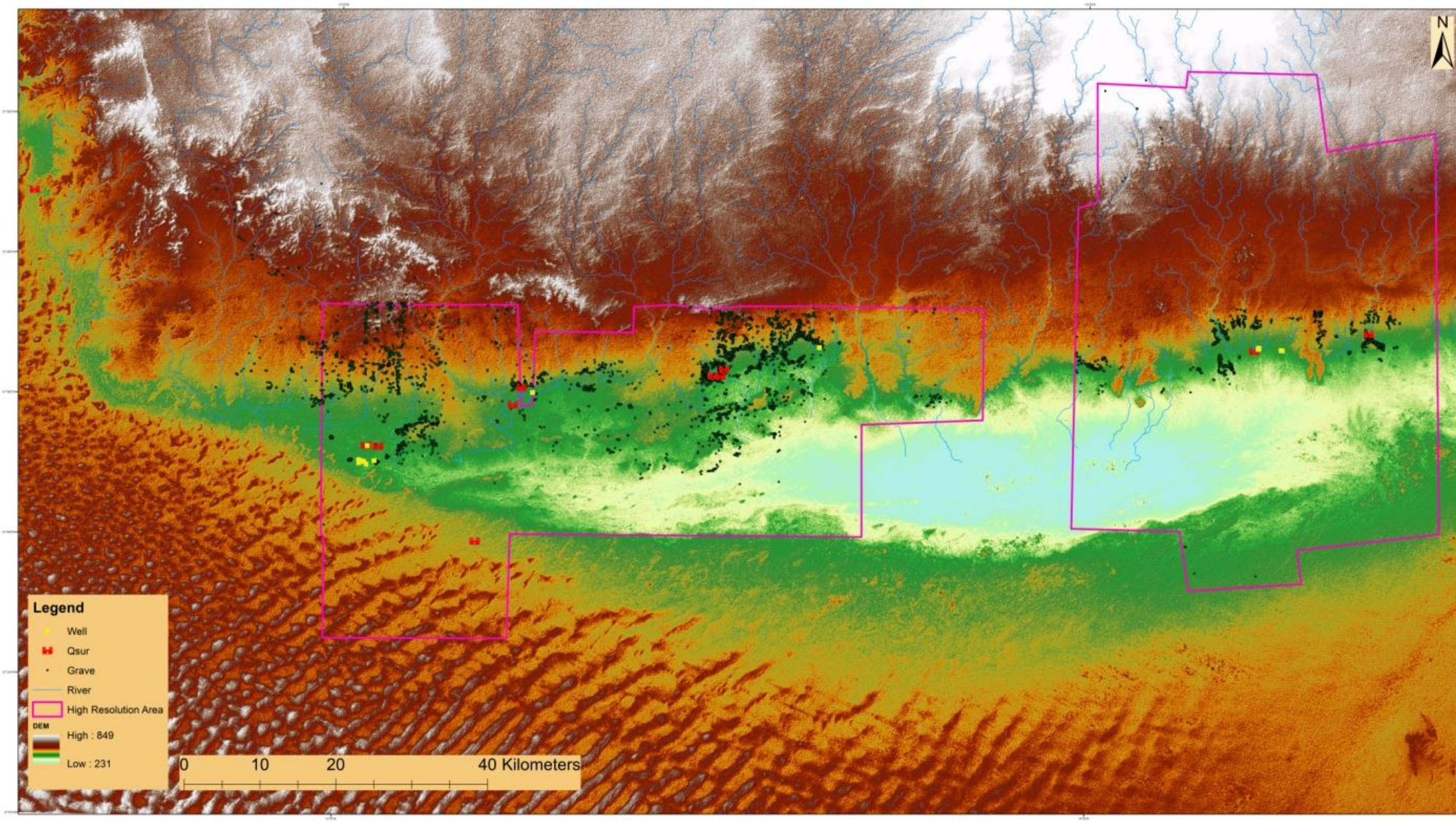

Figure 2.Archaeological features utilised in the study.DEM Source: ASTER GDEM

3.2.2 Environmental Data

Topography is known to influence archaeological patterning and site location (Binford 1978; Redman and Watson 1970; Stiner 1990), hence the need for these data in this study. Topographic data was supplied by raster, continuous field digital elevation models (DEM) acquired from USGS. These data was needed to identify elevation, slope and viewshed values of the Wadi ash-Shati region. The DEMs were produced using elevation data from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) with resolution of 30m. The original ASTER GDEM contained voids which have been attributed to radar shadowing and foreshortening effects. The regions are prevailing in the tropics and in extreme northern and southern latitudes (MicroImages 2009) especially in desert and mountainous areas. These voids were patched using the DEM obtained from the website, viewfinderpanoramas.org which was recommended by many scholars.

This is the source which was recommended from the USGS web page. After the ASTER GDEM tiles were downloaded, they were mosaicked together in ArcGIS program. This was done in order to provide a continuous extent of digital data from which all elevation derived GIS analyses could be carry out. The new merged ASTER GDEM was in the geographic coordinate system WGS84 which uses decimal degrees as the basic map unit. In order to simplify spatial calculations the data was re-projected to the projected coordinate system WGS84 UTM 33N so that the basic map unit can be in meters, which will make some spatial analyses such as cluster analysis easier.

3.3 Methods of Analysis

3.3.1 Introduction

In this section, a number of spatial analyses and exploratory spatial data analysis (ESDA) methods used in this research to understand the archaeological features spatial pattern of the study region are discussed. The software which was used to carry out the analyses was ESRI ArcGIS 10.2. This chapter starts first by attempting to quantify the archaeological features presented in this study using spatial statistics in ArcGIS program tools, and the first two analysis methods are more statistical. The identification of the patterns is crucial for this study as it will help in determining where and how features are distributed in the landscape. Eventually, this analysis will be used to recognize patterns and anomalies in the data which can steer to new research ideas, hypothesis and questions. This is followed by ESDA, which have been used here to better understand the distribution of graves within the study region and to identify patterns in terms of the relationship of graves and landscape features of relevance to environmental and phenomenological models. The details of each method will be discussed in this chapter.

3.3.2 Cluster and Outlier Analysis (Anselin Local Moran's I)

The clustering tool is an inferential statistic method, and this means that the outcomes of the analysis are inferred within the perspective of a null hypothesis. The null hypothesis for this study states that "there is no spatial clustering of the graves in the funerary landscape of the Wadi ash-Shati region". The null hypothesis can be rejected if the absolute value of the Z score is large and the p-value is very small. In this study, cluster and outlier analysis (Anselin Local Moran's I) was used to determine if graves were randomly distributed on the landscape or show a pattern of either clustering or dispersal. Also Anselin's Local Moran's *I*, was used to establish if there were any spatial outliers in the graves distributions and what these outliers may suggest about the socio-cultural organisation at Wadi ash-Shati region.

The analysis was carried out in ArcGIS 10.2 using a set of weighted features (graves), using inverse distance squared, with the Euclidian distance, and a ROW for standardization. The interpretation of this analysis is that a positive value shows that the feature is surrounded by features of similar attributes. Therefore there is clustering, and a negative value shows that the feature is bordered by features with dissimilar values. This makes such a feature an outlier. Not only clustering, but also views of these graves from particular points, ie the *qsur* and or the villages around them, may be of relevance to past human societies travelling through the region prehistorically. Therefore, viewshed analysis which is discussed below was also carried out.

3.3.3 Directional Distribution

In order to investigate the spatial distribution of the archaeological features (graves, *qsur* and wells) in relation to their landscape, the mean centre, median centre and directional distribution of the study area data were calculated in ArcGIS 10.3. This was done in order to define the central tendency and visualize the directional trend of the mentioned archaeological features found within the Wadi ash-Shati study area. These three calculations were conducted for each archaeological features stated previously in this discussion. Esri (2009) stated that the mean centre works by identifying the geographic central position of a set of features by averaging the x and y values for all the points in the dataset. The formula for this is given as below;

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \quad , \quad \bar{Y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

where x_i and y_i represent the coordinates for feature *i*, and *n* denotes the total number of features being investigated(Esri 2009).

On the other side, the median centre functions by looking at the location that minimizes the Euclidean distance from it to all other features investigated in the dataset (Esri 2009). The formula for this calculation is as presented below;

$$d_i^t = \sqrt{(X_i - X^t)^2 + (Y_i - Y^t)^2}$$

It works by that each single step *(t)* in the algorithm, a candidate Median Center is found (X^t, Y^t) and then developed until it corresponds to the location that minimizes the Euclidean Distance *d* to all features *(i)* in the dataset (Esri 2009).

The third and last calculation which was carried out in this analysis is the directional distribution-Standard Deviational Ellipse. This method calculates the standard deviation of the x and y coordinates from the mean centre which seeks to define the axes of the ellipse (Esri 2009). The calculation is carried out following this formula below;

$$SDE_x = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{X})^2}{n}}$$

$$SDE_y = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \bar{Y})^2}{n}}$$

Where x_i and y_i represent the coordinates for feature *i*,*{X and Y}* standing for the mean centre for the features, and *n* denoting the total number of features being investigated (Esri 2009).

3.3.4 Viewshed Analysis

Viewshed analysis is a process of computing visibility in GIS. This is done in order to examine what can be observed from a given location. This analysis allows the relationship (in terms of visibility) of these graves to themselves and archaeological sites (wells, settlements or *qsur* and graves) to be evaluated. Viewshed is of great significance to how past human communities related to and interpreted their landscape.

This viewshed is not without limitations because atmospheric conditions and eyesight of the past cannot be transposed onto present landscapes. Also it should be noted that the analysis cannot compensate for vegetation that may have been located along the ridges of the sand dunes. Currently, based on satellite imagery and Google Earth, the area appears barren from any plant life in the Wadi ash-Shati region. However there might be some shrubs, bushes and grass all with approximate heights of less than 100 cm. This viewshed assumed that the present position of the dune was the same at the time the area was inhabitated during the Garamantian civilisation period. Although this may or may not have been the case, the analysis was conducted to investigate how the past human communities saw their funerary landscape.

3.3.5 Elevation Analysis

Another variable which is of great importance to this study is elevation, which is also tied into the environmental variables of slope and aspect. Dualistic settlement pattern in which settlements are found at lower elevations and burial grounds are found at higher elevations can be inferred from this study hence the importance of this variable. The elevation data which was derived from the 30m ASTER GDEM was categorized into six classes. The categorised classes were done mainly looking at the fact that from a visual perspective, the natural outline of the study area topographical features like the depression and sand dunes were clearly outlined. In other words, the six categorisation classes were following the natural breaks of the topography of the study area.

3.3.6 Slope Analysis

It is common knowledge that the slope of the ground has much influence in site selection in several ways. This also depends on the land use for that specific site, as for an example the slope for a settlement is usually desirably flat for practical reasons, and areas with low slopes are commonly chosen. The reason for that is that steeper slopes in an up direction require more energy per unit of horizontal distance than a flat surface. For this study, it is assumed that high slopes were chosen for graves locations, and this can perhaps be attributed to ritual purposes. The slope percentage was calculated and classified into four categories being; 0-2% (flat areas), 2-4 % (low slope), 4-6% (moderate slope), and 6-14% (steep slope).Here, these classes were categorized using natural breaks which are based on natural groupings inherent in the dataThe lower values for the slope indicate flatter terrain and higher ones shows that the terrain is steeper. The slope was calculated in ArcGIS using Slope tool which calculated the maximum rate of change between each cell and its neighbours.

3.3.7 Distance to Water Sources

Distance to water sources such as rivers or wells just like slope also contribute to site selection. Locating settlements in close proximity to water sources is important to those living in more arid regions like in the Sahara Fazzan region in which the study area is situated. This is because it should be minimal for people to travel to their water sources and also not located much closer so as to reduce contamination of the water. For this study, the distance to rivers was calculated using Euclidian distances of layered 100 meter buffers whereby they (rivers) were buffered. Since no data on the hydrology of this region of Libya is available in digital format, the river system was extracted from the 30m ASTER GDEM of the study area, using the ArcGIS Hydrology tools. This automated method for delineating rivers from the DEM followed a series of steps. As follows:

1. The first step was to load the then fill the sinks in the DEM
2. The second step was then to specify the direction of flow the rivers will take from every cell in the raster. In other words, direction of flow is the one which decides the decisive destination of water flowing across the land surface.
3. The third step was to calculate where the watershed will accumulate flow (streams or rivers).
4. The final step was to define the stream network, which states out some conditions that pixels that have a specified value draining into them should be kept. This was done in the raster calculator.

For this study, only the pixels in the landscape which have a flow accumulation > 100 (the pixels that have more than 100 pixels draining into them) were kept. This was done to reduce the size of the resulting polylines and speed up data processing. After extracting, the network was exported as KML format to Google Earth to correct the river systems because there were several areas on the DEM where rivers were placed in low lying areas such as depressions and also following sand dunes outlines. The correction was done by manually removing the river lines which did not match the ones found in the study area in Google Earth.

3.4Chapter Summary

In this chapter the principal techniques for data collection which were employed at Wadi ash-Shati region were summarised. Also the steps taken to transform and import the data obtained from the various sources into ArcGIS for analysis have been provided. The section was sub-divided into two more sub-sections with the first one presenting the archaeological data sources, and the second sub-section discussing the environmental data sources used in this study. The data sources of errors, challenges in obtaining the data and their limitations were also presented for each phenomenon. Importantly, the data employed in this study especially the archaeological one is not complete, but it is the best existing and steady at this period. It should be noted that the issues identified with each data have been addressed in such a way that make the dataset as vigorous as feasible given the conditions. This information discussed in this chapter is critical to build up suitable spatial analysis methods required for this study

The goal of the second section was to initiate the spatial analysis methods that have been used in manipulating the archaeological and environmental data in this investigation. The discussed spatial analysis techniques which will be performed on the environmental variables have been derived from the DEM of the study region. The six main spatial analyses tools (viewshed, elevation, slope, buffering of rivers, directional distribution and cluster analyses) steps that have been used to analyze these data have also been discussed. The use of these analyses to examine graves distributions were helpful in understanding the spatial structuring of archaeological features, identification of discrete activity areas, and lastly to social structure of past societies in relation to topography and resource availability.

Chapter 5-Results

The results of each of the analyses carried out will be presented and, where appropriate, maps will be used to discuss spatial patterns. Any patterns identified in this process will be used in defining spatial organisation within the cemetery that may explain the socioeconomic structure of the Garamantian civilisation

5.1 Cluster Analysis

Results of cluster analysis performed on the graves distribution from the study region are presented in this chapter.

5.1.1 Results

The graves distributions were analyzed using the Anselin Local Moran's I tool in ArcGIS to determine where clusters occur within these distributions. It is worth noting that this analysis was executed twice, firstly on more isolated graves (thought to be belonging to the Pastoralism period) and on the clustered ones (Garamantian era). This was done to find out if the two showed any different pattern when isolated by their specific periods. However the isolated ones' pattern was not convincing as there were only a few of them. This might be attributed to biasness when picking up the isolated graves from the digitised points as this was only done visually without any other concrete evidence such as field records. As such, it was deemed not to include the results of the isolated or clustered graves in this report, but to group together the two graves periods and run the analysis. Specifications for each test were as follows; OID was chosen for the input field, Euclidean distance as the distance method, ROW standardization was selected in order to take into account sampling biases or aggregation of data, and lastly a distance threshold of 500m was used for all graves points. The results of this spatial statistic generated a shapefile output in ArcGIS that identified if graves points were components of clusters of higher values (HH) or lower values (LL). In addition to that, this analysis also identified spatial outliers as either higher values bordered by lower values (HL) or lower values bordered by higher values (LH).This analysis was executed out in order to investigate the spatial characteristics of graves distribution in order to have a glimpse of the mortuary work during the Garamantian civilisation period. Also cluster analysis was executed on the two graves datasets (from the 2007-2008 fieldwork and the Google Earth digitised ones) separately to see if there is any difference in their results. It was found out that the outcomes were much more similar despite the fact that the data was captured using different methods. This is perhaps it is because the physical examination of the distribution of the two graves dataset looks the same with minor differences. As a result of that, only a combination of the two datasets results will be discussed for this investigation. The results indicate that there is clustering of graves but not randomly distributed (fig 3).The connotation of these results demonstrates a level of social organisation occurred during the period in study which will be discussed below.

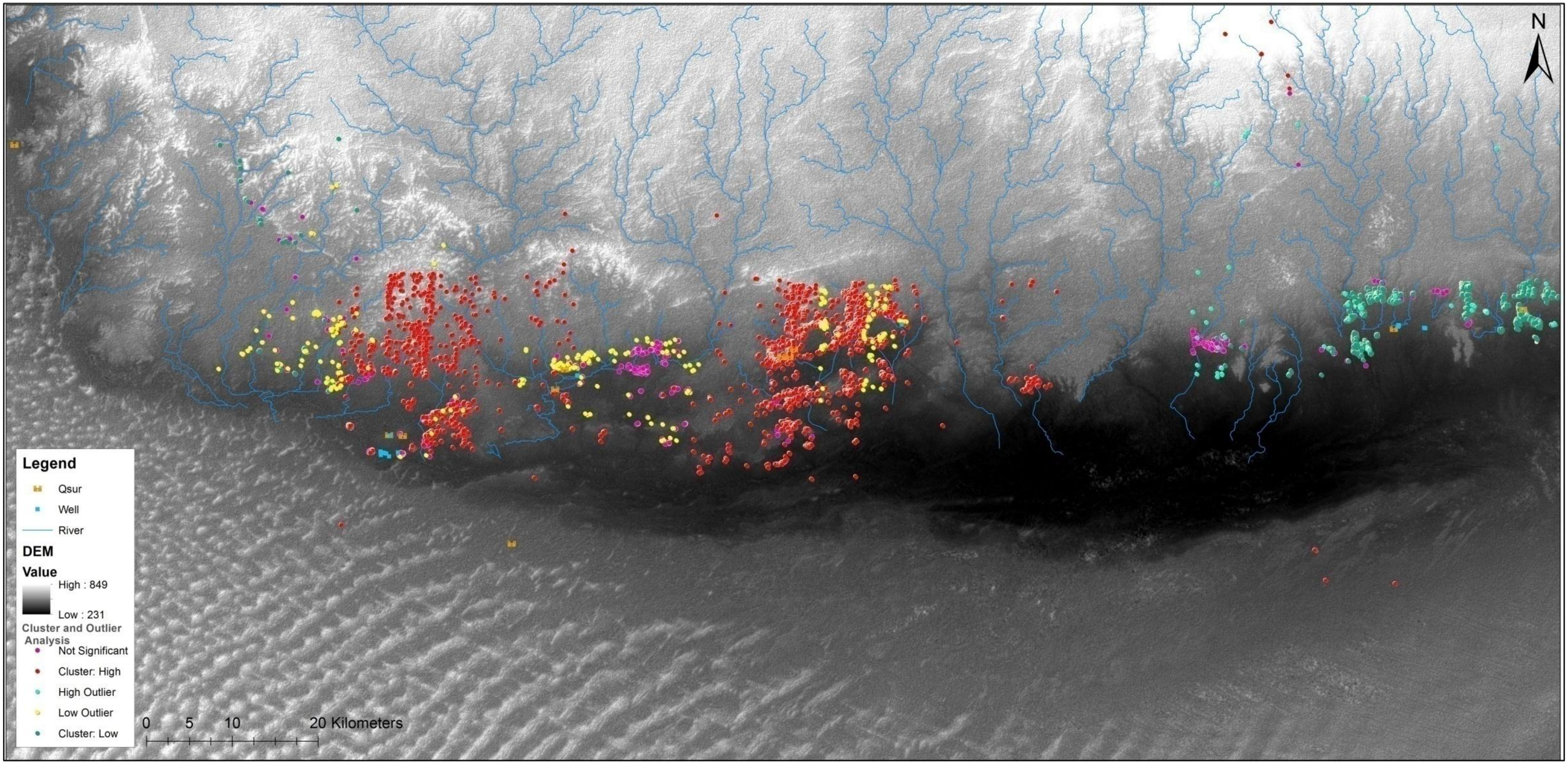

Figure 3. Cluster analysis results.DEM Source: ASTER GDEM

5.2 Graves Directional Distribution

5.2.1 Results

Spatial dispersion of the graves was essential for this study in order to see what the relationship between the graves and the landscape is. The results for the mean centre, median centre and directional distribution calculations are presented in figure 4. The mean centre and median centre for the graves are located closely to each other, and are located close to the western portion of the study area. This is the area where there is a high concentration of the graves. The directional distribution shows a more pronounced east-west directional trend, which extends 130 kilometres from both directions. However this trend for *qsurs* is a little bit different as the mean and median centres are not close to one another, there is a distance difference of 14 kilometres between them. Conversely the directional distribution is much the same as that of the graves. This is because the east-west directional trend has been maintained, which measure 137 kilometres. Also this east-west directional drift is noticeable in the wells analysis, which spans over a distance of 157 kilometres. The distance between the median and mean centre is 43 kilometres, which is similar to the *qsurs* ones in terms of the closeness of the two measurements.

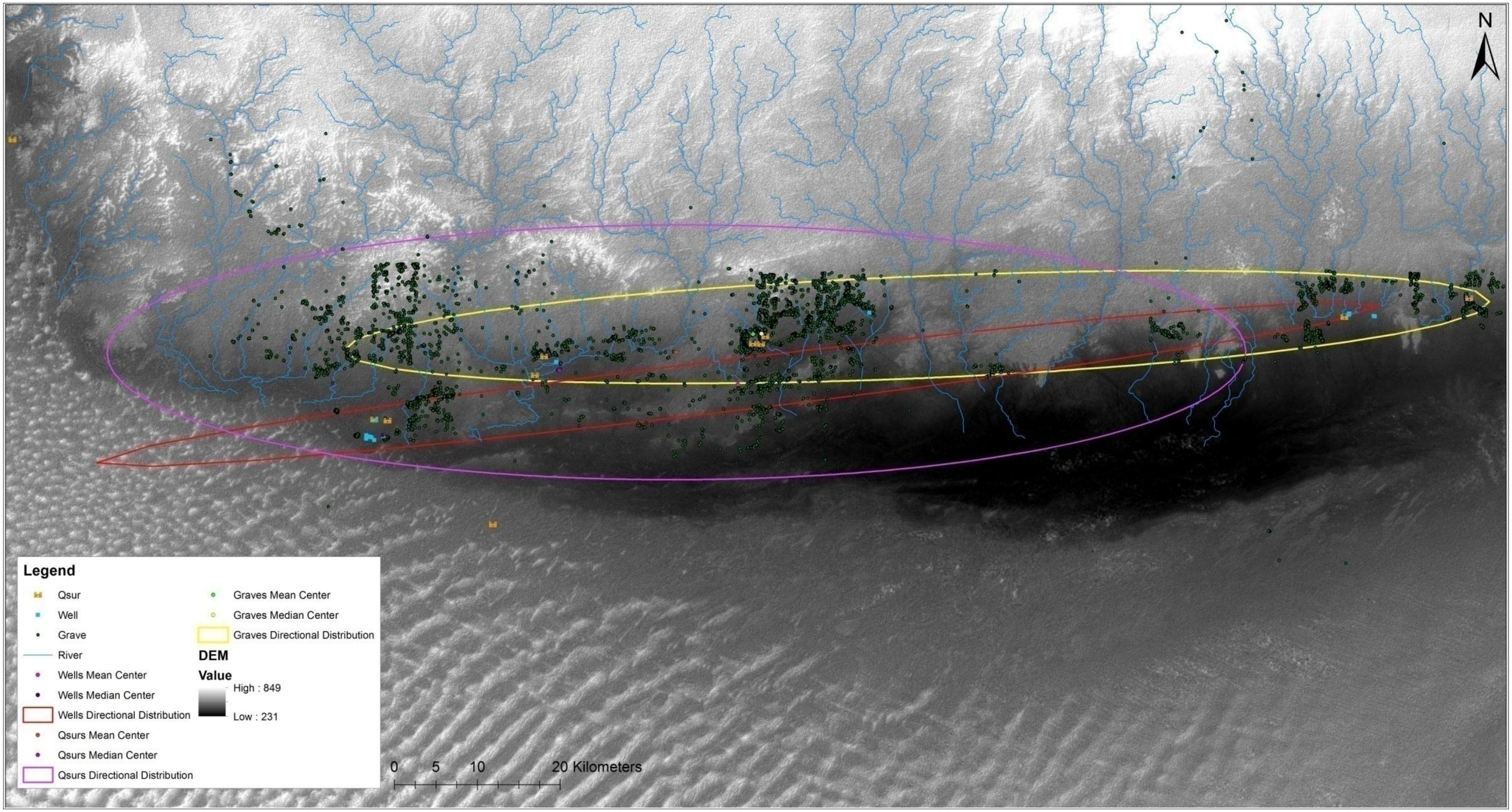

Figure 4. Archaeological features distribution summary results. DEM Source: ASTER GDEM

5.3 Viewshed

5.3.1 Visual Prominence Analysis

This analysis was undertaken to test for evidence of visual prominence as a determinant in *qsur* location selection. For each *qsur* point location, 5 random points were plotted around it and then viewshed from those individual points was generated (fig 5). The 5 random points were chosen without any measurements being taken and also with the believe that they will be representative enough. This was needed in order to make them as random as possible. In total, 55 points were plotted in Google Earth then converted to shapefile format in ESRI ArcMap software and then processed using the conversion tool. The viewshed analysis for these random points was from each individual point to the *qsur* itself, and it was then created using the viewshed analysis tool in Spatial Analyst, and this resulted in the cells from the input raster that can be seen from the random points. This analysis works by giving each cell that can be seen from an observer point a value of 1. The cells which cannot see the observer point are given a value of 0 (Esri 2009). However for this analysis, the cells with values of zero were changed and given no colour and the ones given 1 were assigned a desired colour. This was done by clicking on the viewshed analysis results in the layers tab, and changing colour in the symbology window in the properties tab. The output raster results were then masked to the study area location to compute the area of visual prominence of the total landscape area. It should be highlighted that the offset used during the calculation of these viewsheds from individual random points were the same as the ones for cumulative viewsheds, as the observer points were given a maximum of 1.70 m which was assumed to be of the average height of a person.

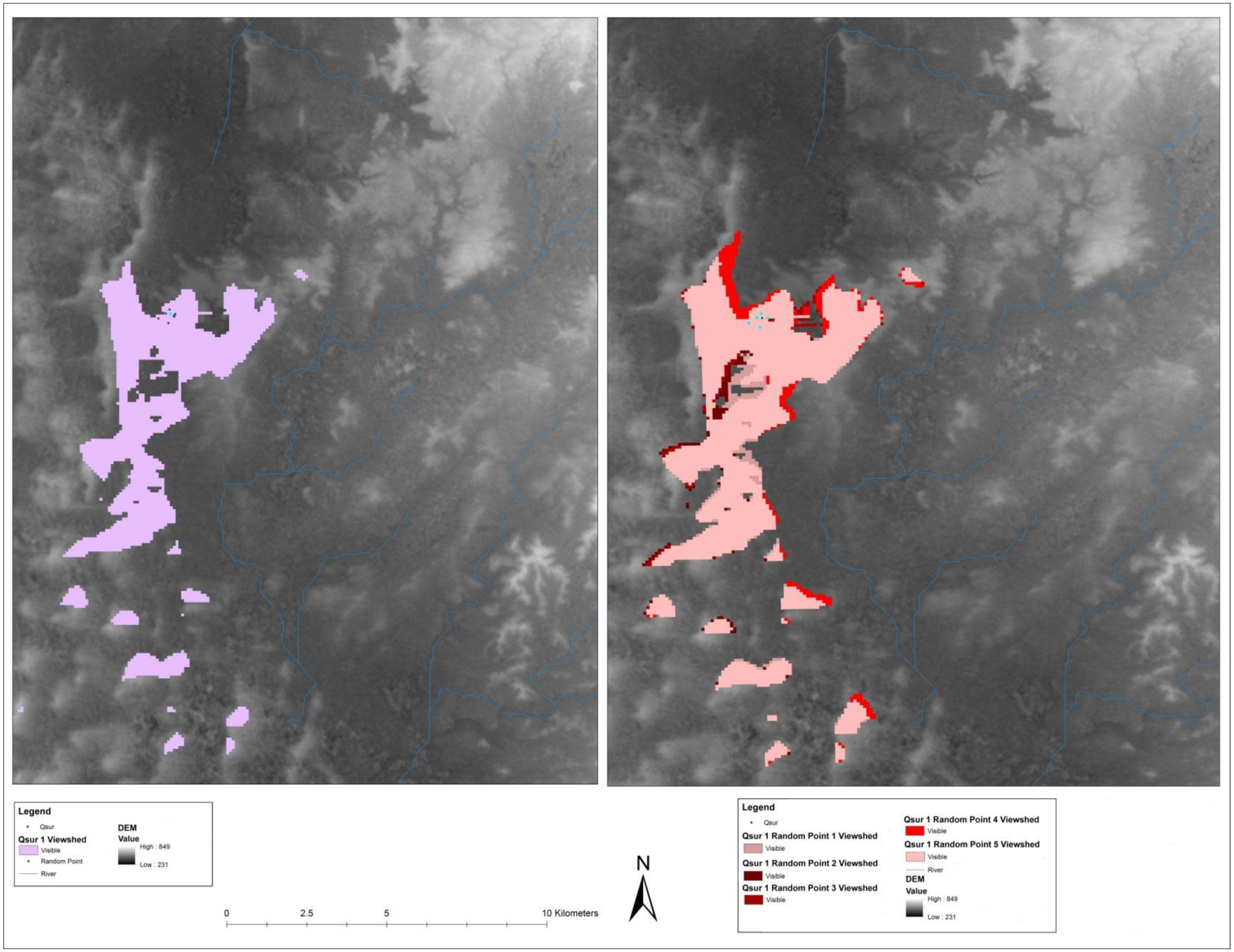

Figure 5. Comparative viewsheds from Qsur 1: binary viewshed (left) and random multiple viewshed from 5 viewer points (right side)..DEM Source: ASTER GDEM

5.3.2 Cumulative Viewshed Analysis

Individual viewsheds were created from each of the 11 *qsurs* (fig 6), and then a Cumulative Viewshed Analysis which is the sum of a set of individual viewshed maps was created (fig 7). This was done by adding together each *qsur* location viewshed raster results in the raster calculator in ESRI ArcMap. This approach was used to show the areas which are most visibly prominent within the individual cell from the *qsur* sites. Results of viewshed analysis performed on the graves distribution from the study region are presented in this discussion below.

5.3.3 Results

The above figure shows areas visibility in relation to *qsur* features and archaeological features (graves and wells) in the Wadi ash-Shati study area. Much of the lowest latitude of the depression together with the areas south eastern in the sand dunes area, and in the upper locations of the *qsurs* is not directly visible from all the *qsurs* (fig 4 and 5). The upper areas which are not visible from the *qsurs* have river systems running through them, but the vegetation may have been visible above them. The rivers and wells features are small and unobtrusive and would not be visible from significant distances. However, vegetation could have created more lush vegetation around them, thereby creating a landscape difference which would have been visible from greater distance. The large majority of the graves are located south-west of the study area. These graves are most strongly correlated with visible areas, with almost all of them located where they can be seen from the *qsurs.* A significant amount of the western portion of the Wadi ash-Shati study area is not visible from the *qsur* 1 located in the western side (see the above figure 4 and 5), this area is in the margins of the sand dunes. Most archaeological features of interest (graves) are not located in this part of the study area, but in the south-eastern portion closer to the middle of the study area and towards the eastern areas. Minimal amount of the viewsheds areas are seen in the southern, south-eastern, or western areas of land especially in the upper left areas. These areas are likely where there were resources exploited by the community were minimal.

According to the viewshed analysis results, the areas in the depression have ancient aquatic bodies such as rivers and wells. The area also perhaps would have provided good pastures because of the moisture contents it could retain when compared to sand dunes prone areas. In this situation, community members could have laid claims to positions almost entirely having these resources. The areas which are at minimal coverage of the viewshed comprised entirely of sand dunes, and it is likely that they are without any or limited resources to be exploited by the community.

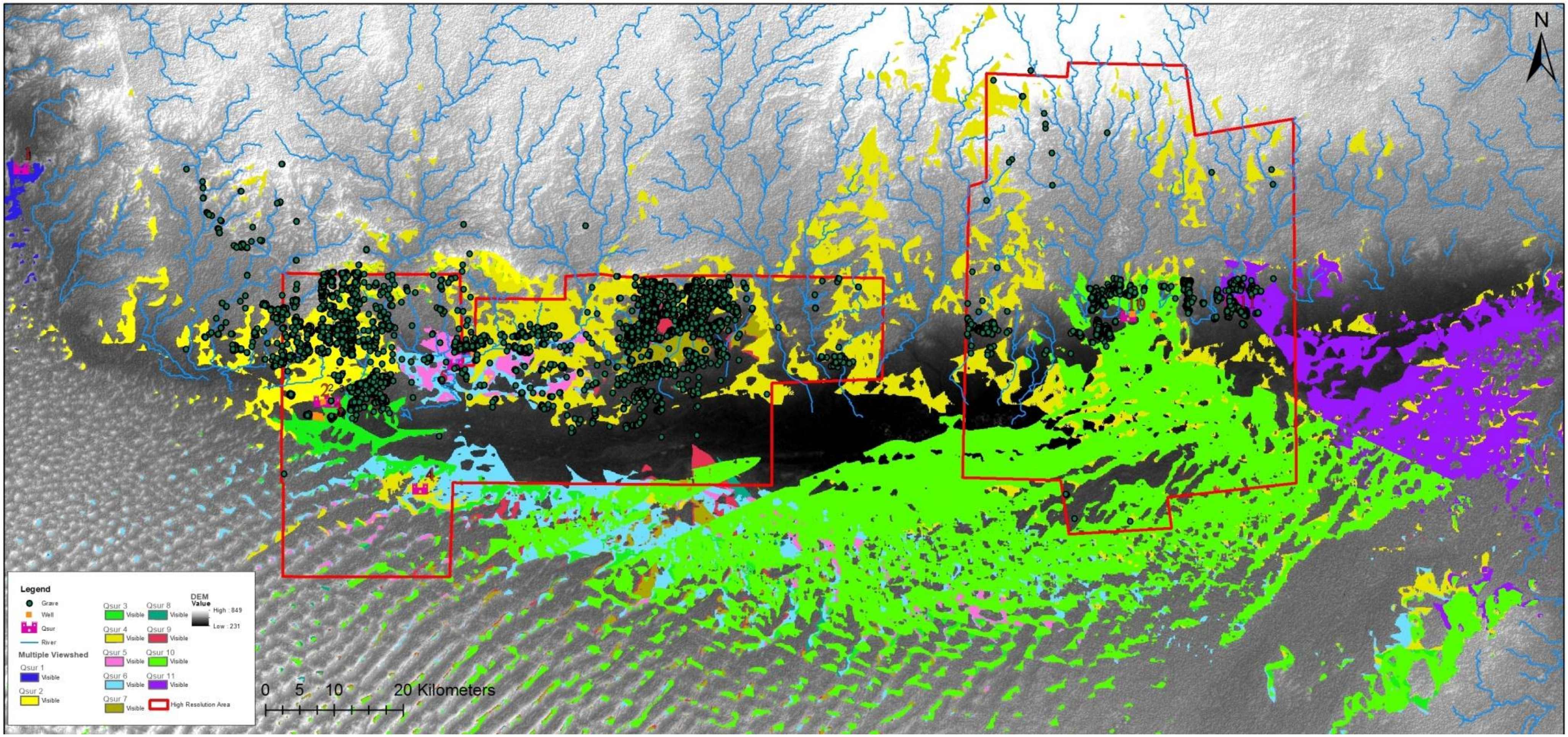

Figure 6. Multiple viewshed results from the 11 qsur location.DEM Source: ASTER GDEM

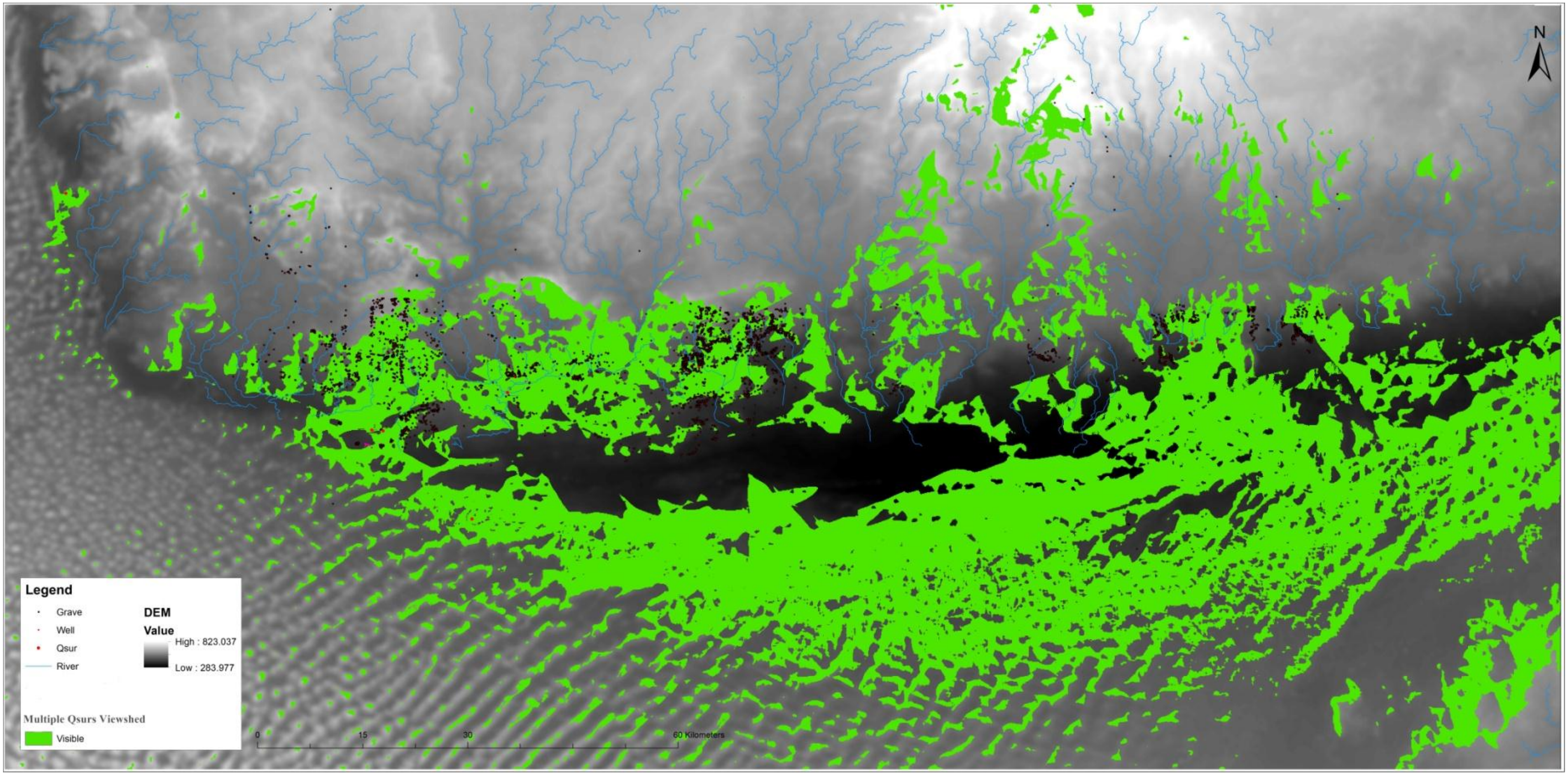

Figure 7. Cumulative viewshed of the 11 qsurs. DEM Source: ASTER GDEM

5.4 Elevation

The results of elevation model together with the discussion like those of the cluster analysis from the study region are also presented in this chapter.

5.4.1 Results

The elevation layer shows a map of the study area with elevation which has been categorised into 6 breaks which range from 283 m to 823 m (fig 8).It should be noted that this categorisation has been explained in the methods of analysis part. The lowest elevations values are central around the Shati depression, which according to Merlo *et al.* (2013) is one of the few regions in the inner parts of Libya where groundwater has been known to be abundant and shallow (refer back to figure 1 and 2 for the DEM). The highest elevations values, on the other side, are situated further north around hills (fig 9).

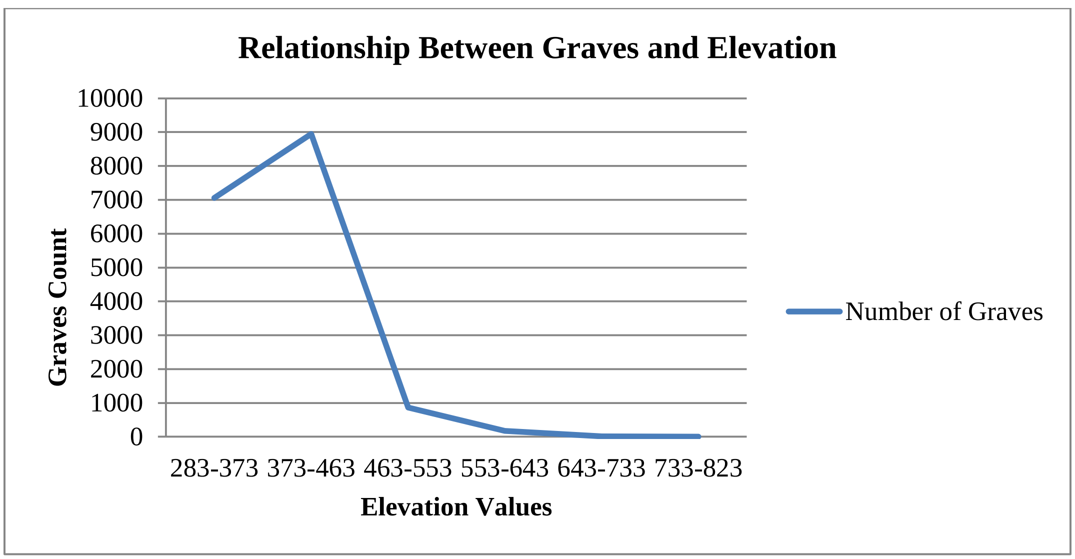

Figure 8. The relationship between the graves and elevation

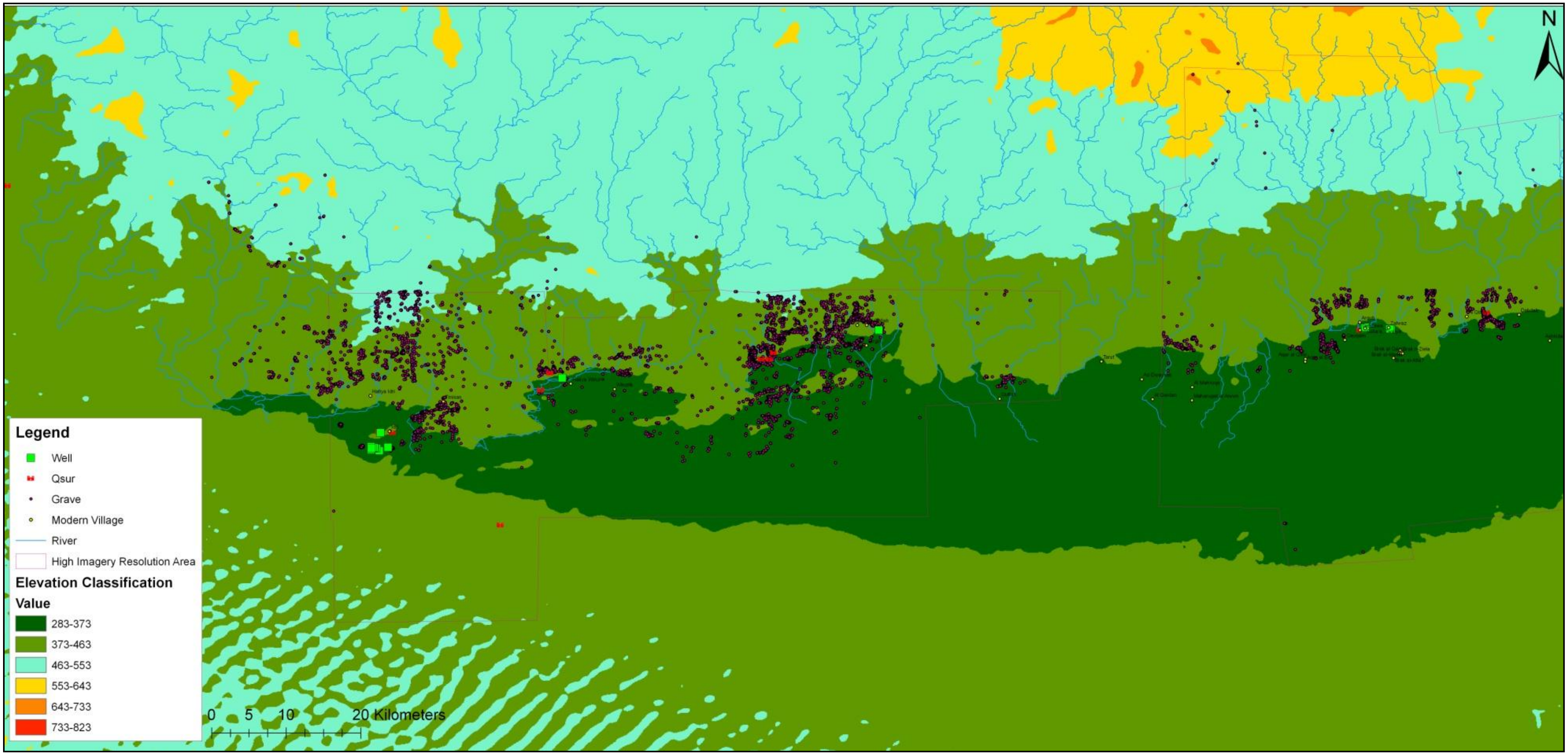

Figure 9. Classified elevation analysis outputs results. DEM Source: ASTER GDEM

5.5 Slope

Just like the elevation analysis results above, the results for the slope of the study region is also presented in this below.

5.5.1 Results

According to the slope map layer, the grey areas in the layer correspond to low slope amounts, and the red ones areas to high slopes. The slope map of the study area has been categorised into 4 slope breaks which range from 0 to 14%, which can be noticed in the histogram given in figure 8. The histogram suggests maximum concentrations at 2-4% and it is gradually declining as the slope increases, with 6-14% recording the lowest volume of the graves (fig 10). From examining the slope map layer obtained from the 30m ASTER GDEM, it can be stated that the general tendency for the graves locations and other archaeological features (villages and *qsur* or settlement) under investigation here are on slopes ranging between 0° and 4°(fig 10 and 11). This is a slope which has been categorised as flat (0-2%) and low (2-4 %) areas. Also a close examination of the slope map reveals that few graves are located at a slope of 5-8 % (moderate slope). Based on these examinations, it seems like that mortuary practices and residential areas were occurring on more favourable levelled areas.

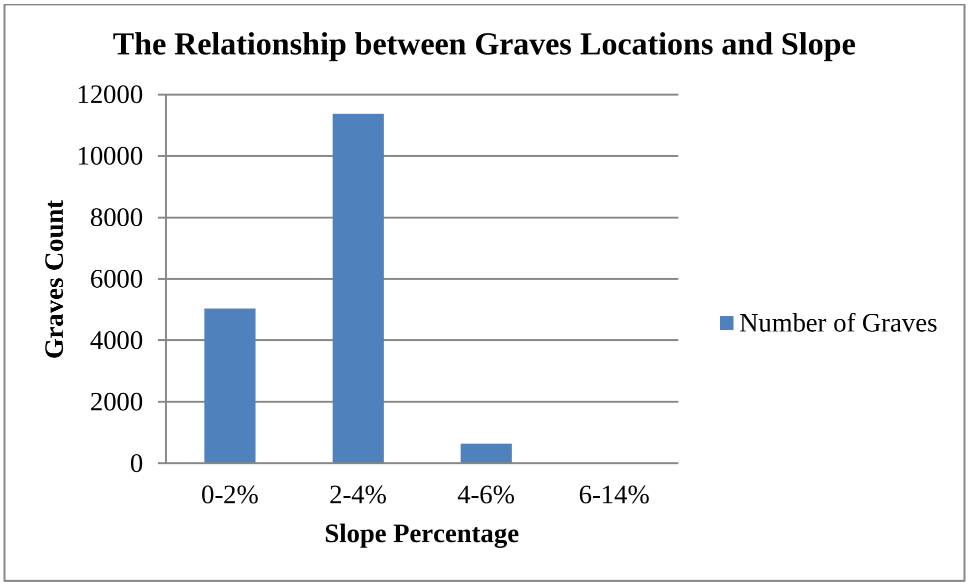

Figure 10. Graves's locations in relation to the study area's slope

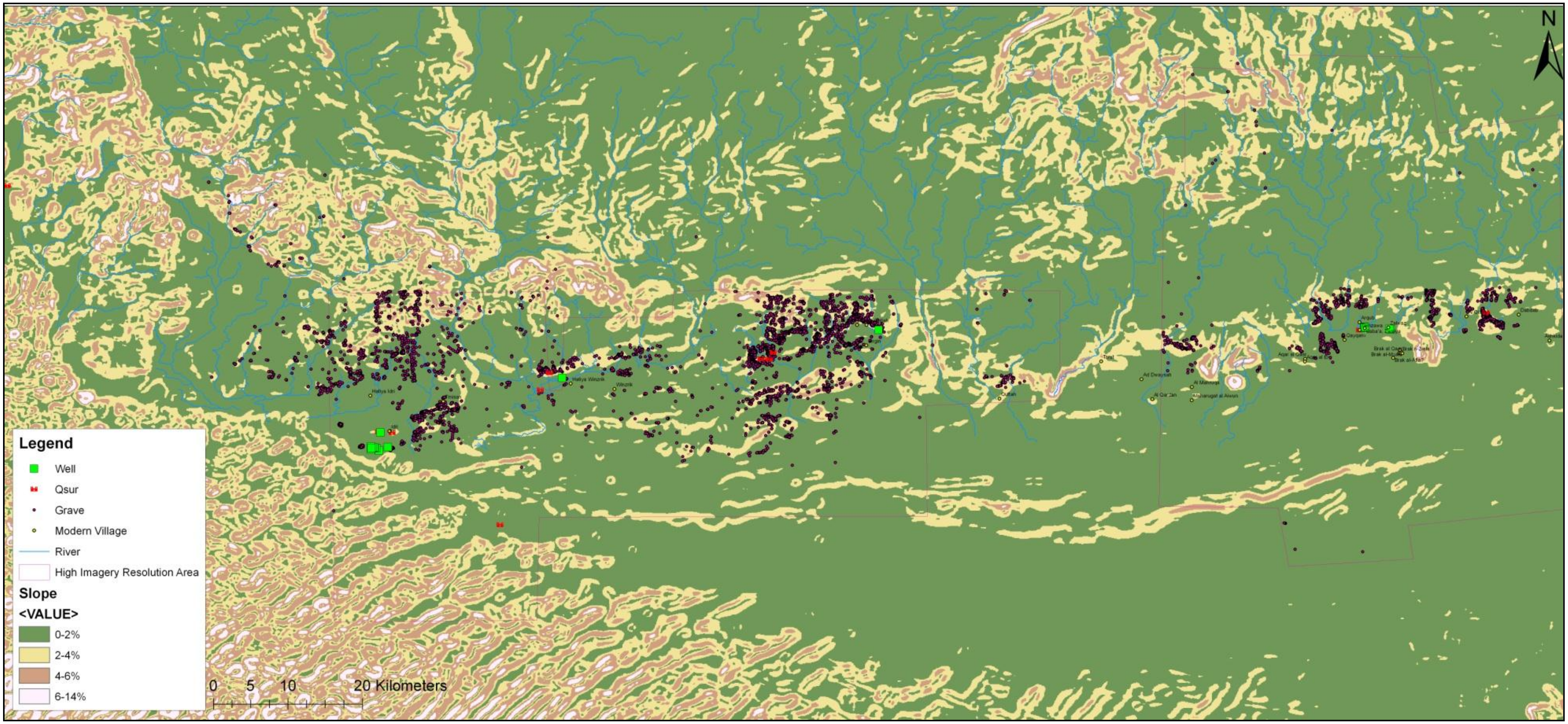

Figure 11. Study area slope in relation to archaeological features being investigated. DEM source: ASTER GDEM

5.6 Distance to Water Sources

Below are the results from the buffer zones created around the rivers in the study area, which is important to investigate so that and understanding of the distance between the river and graves is achieved. This understanding is needed so that we know if the river has any influence in choosing the grave location.

5.6.1 Results

The distance of graves to the water sources, to be more specific to rivers, was quantified by creating a buffer zone of 200 and 500m (fig 12).It should be highlighted that the buffer zones were created without any specific reason in mind but merely to look at some possible patterns of dispersion of the graves from the centre of a river valley. The results were then used to clip graves falling within each buffer zone. From the results, it shows that a maximum of 2806 graves is located within the 200 m buffer zone form the river, and for the 500 m one, it is 4023 graves. This makes sense because precautions had to be taken in case there was a flash flood which can destroy the graves, or that the graves placed some distance from the river so that they do not contaminate the water.

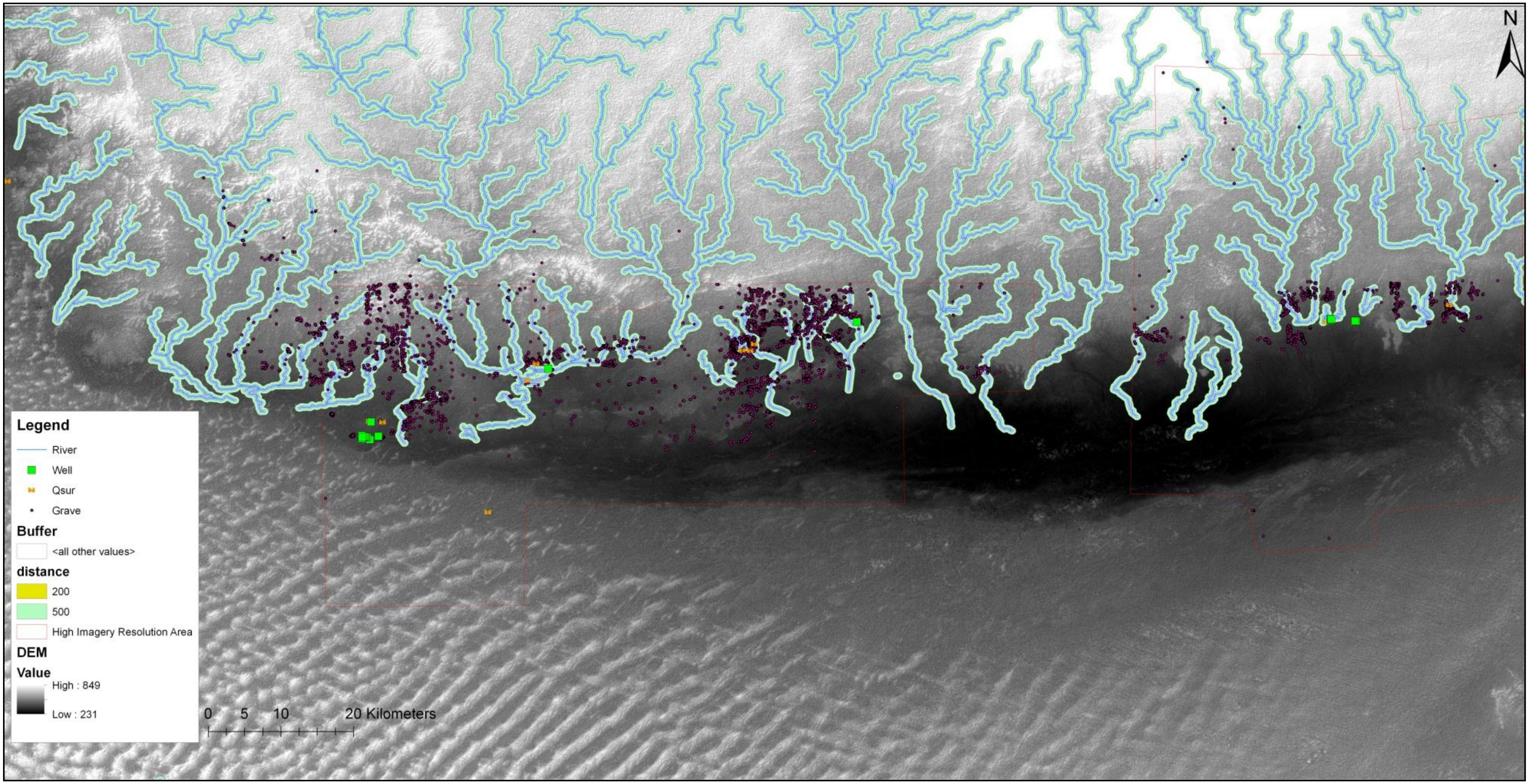

Figure 12. Buffer zone showing graves distance to rivers. Source ASTER GDEM

5.7 Chapter Summary

This chapter has spanned a considerable amount of analyses and their results discussed. The results imply that no single landscape variable can account for all volatility in positioning of archaeological features present in the archaeological dataset. However it is with a strong belief that the combination of these landscape variables results is appropriate for modelling prehistoric human behaviour. With this argument in mind, the next chapter will evaluate the patterns presented by the analyses carried out in this chapter, and to explore their suggestion on how the environment in the Wadi ash-Shati influenced the prehistoric humans' behaviour.

Chapter 6-Discussion and Interpretation

6.1 Introduction

The results presented in the previous chapter showed that there are possibilities to gain insight into the role and perceived nature of the Wadi ash-Shati funerary monuments in the ancient Sahara Fazzan funerary landscape. As such, the primary goal of this chapter is to interpret these results by considering the topography of the study area, the archaeological data and its cultural history. The evidence presented from the analyses carried out in this study, in some instances, supports either environmental or cultural models for the ancient settlement patterning. Subsequently, the results of each model will be appraised in order to assess the spatial patterns of the funerary monuments in the Shati. In carrying out that task, the discussion which follows below has been divided into three main groupings in order to help discuss the results based on the performed analyses.

6.2 The Wadi ash-Shati graves as territorial markers

In order for this study to assess whether and in what context the graves in the study area could have been utilised to demarcate the territory claimed by the Wadi ash-Shati inhabitants, several questions must be tackled first. The first question which should come to attention is whether the study area's past inhabitants fits the economic lifestyle of a culture that would require the control of resources as put forward by the Saxe/Goldstein hypothesis. This hypothesis states that the emergence of formal cemeteries during ancient times matches to the appearance of a common lineages which monopolise vital resources through inheritance (Morris 1991). The second and last question which is also important to this discussion concerns which restricted resources family lineages could have laid claim to, through the location of family graves.

As stated earlier on, in the introduction chapter it is believed that the Sahara Fazzan region of the study area of Wadi ash-Shati was occupied by pastoralists and agro-pastoralist societies consecutively. These two, somehow differing cultures or societies can be evidenced by the clustering results (fig 3). It has been out found that several graves formed statistically significant high value clusters in areas located in the left side or western ridges and plateaus, while in other far right portion of the study area the graves show statistically significant low value clusters but still in the same topographic locations. Based on this argument, it is plausible to interpret this as evidence of two different occupations or cultures with differing mortuary works and spatial land use within the same study region. In the area with high-high values, graves clusters were identified and it is plausible to argue that these graves clusters belong to the Garamantian period. The few or low clustering and isolated graves identified can be attributed to the Late or Final Pastoral period, which Mori *et al.,* (2013) investigated in their study in another Sahara Fazzan region of Wadi el-Ajal at Fewet site. They argued that this type of mortuary practice is associated with the Pastoral societies because during the Garamantian period, the whole village had a formal and single burial ground whereas the Pastoralist societies did not have a formal burial ground or cemetery. Based on their argument, this added a new dimension in the funerary practices and social organisation of another civilisation in the Sahara Fazzan area. However it should be noted that this argument is made without firm chronological evidence from excavated graves in this area.

The clustering results indicated that the majority of the graves are located in close proximity to each other. This affirms the notion by Mori *et al.,* (2013) that during the Garamantian period, the whole settlement was burying their dead at a common cemetery which perhaps indicated a common cultural or kinship affiliation. The existence of lineal claims of territory was plausible for that society based on their economic structure. The strategy which perhaps was employed to suit their economic structure was of a delayed return system resources which require long term procurement or processing were necessitated by some level of control put into action. The procurement of restricted resources over the long term is in a sense necessitated by the harsh environment of the region, which makes water and pasture resources extremely sparse.

The partitioning of the landscape with certain areas reserved for settlements, pasturing or agricultural activities and burials or cemeteries is also critical to the Saxe/Goldstein hypothesis. This means areas were strictly reserved for those activities for example such as burials of the dead at the cemetery areas. This point is supported by the viewshed and cluster analysis results, it is evident that the *qsur* or places for settlements were located on the margins of the graves clusters but with excellent panoramic or 360° views to their surroundings (fig 3). That on its own signifies that rather than settling within these graves clusters, the communities were selecting areas nearby, potentially with views of these places. This means as argued earlier in the viewshed discussion that there were some areas in the landscape designated for certain activities such as burials and settlement spaces. It is also plausible to argue that the cemetery areas were used to represent aspects of the funerary practices, including veneration of the dead and not used for general settlement.

The other question which was posed at the beginning of this discussion was in regard to the positioning of the graves as territorial markers and whether they were utilised as indirect symbols of resource claim through kinship descent from the dead relatives. It would also have been informative of this study to investigate if perhaps the graves could have represented social statues within the society or community through mortuary rituals such as grave goods, or whether these kind of behaviours were both present in the study area. However the latter behaviour is impossible for this study to prove because no excavation was carried out. The graves sites in the study area, which likely were the exclusive domain of the dead except during mortuary ritual feasts or the funerals of the dead, tend to be located between 400-500 m above ground level (fig 8 and 9). These heights are either on the edges or within highland regions with higher elevation values. Also on the other side, there are some of the graves located between 500-600 m on the landscape atop the surrounding ones. This by default means that the graves were overlooking other archaeological features such as the *qsur* or settlements, wells and the depression.

The views from the *qsur* to the graves are very extensive except for *qsur* 1 which is located on the upper western fringes of the study area. The current landscape which is believed prevailed or did not change much since the ancient Garamantian civilisation period would have afforded the graves, given their monumental structures, a clear view from the surrounding areas, and thus making them distinctive reminders of the existence of the ancestors and of a right of possession for their genealogy. Herschend (2009) corroborates this discussion by asserting that topographically prominent locations during ancient times were often seen as significant locations in the landscape, associated to hierarchy, visual and physical control. The notion that the graves were used as land markers is also confirmed by Mori *et al.*, (2013) that this practice was widespread within the pastoral communities to mark territories and social boundaries with dead relatives' graves. Perhaps it can be argued that this tradition was adopted during the Garamantian period where large cemeteries at the fringes of the oases, and isolated graves were used as ritual burial sites for the control of land around them (Mori *et al.*, 2013).

Control of land is believed to have occurred during the last phase of Pastoralism culture between 1500-1000/850 BC, when the environment progressively became more arid but exacerbated during the Late Garamantian period in 200-600 AD when aridity increased (Mori *et al.*, 2013). This period ushered in new social and economic organisations of the Garamantian communities, together with their adaptations to environmental restrictive dynamics and subsequently their land use patterns. The period in discussion here led to the widespread of fortified settlements such as the *qsur* in the study area, which were located in strategic areas for the exploitation of fertile areas and control of the trade routes. This is evident in the study area. This argument is also attested by Mori *et al.,* (2013) that villages such as Murzuq and in the Tanezzuft were established in order to secure the fertile areas and centralising the control of the commercial routes.

The fertile areas in the study region could have been portions of areas around the depression and flood plains, and these were exploited for pastures and rich nutritious alluvial soils. Also the water table was much closer at these areas (depressions), which made irrigation easier to achieve.It makes sense to argue that these were highly contested landscapes which were likely could have been marked by stationary symbols such as graves. Given the apparent relationship between the distribution of archaeological features mentioned in the previous chapters and the depression and river systems (fig 2), it seems likely that the most contested restricted resources would have been those aquatic sources mentioned. The results from the directional distribution of the archaeological features being investigated in this study substantiate this argument. This is because there does appear to be a strong relationship between the directional distribution of the graves and the natural environment, particularly looking towards the depression. The implication for this is that the graves were located on the margins of the depression which runs from the west-east direction, which is the same as the direction in which the graves are running (fig 4). Also this direction remained constant between the directional distribution of the *qsur* or settlements and the wells, though for the wells it is a little bit different because it is starting from the low areas of the study area. This makes sense because the water table as articulated by Merlo *et al*. (2013) is high in the study area including at the depression, and it is also in abundance because of the discharge from the river drainages.

It is also conceivable to argue the areas around the depression would have given the study area inhabitants an opportunity to access water for irrigation of their crops easier since the water table is very low around the depressions. The visibility results generated for this study indicate good visibility coverage from the *qsur* to the graves which include the areas covered by the depression and river systems. As such, control of those areas would be extremely important in such a way that their control will have been solidified through graves claim or family lineage in order to fit this particular case. The graves directional results show that they are located in the upper fringes of the depression are extensive and were perhaps utilised to strengthen the claim to this resourceful area (fig 4). Furthermore to this discussion, the presence of the wells in direct viewshed from the *qsur*, seem to indicate an interrelationship between the wells and the funerary beliefs of the graves owners (fig 6 and 7). The strength of this interrelationship is further sustained by the location of the graves, which as indicated earlier that they could have been used to lay claim to certain resources in the area

To further add on to this discussion, if the graves were utilised for the control of restricted resources as articulated in the Saxe/Goldstein hypothesis, then it is likely that the resource which would have been claimed was in close proximity to the grave. It is plausible also to argue that the natural water sources would have not been highly reliant as maybe they were seasonal, and other water sources or technologies such as the foggaras were imported from the Western Egyptian oases (Mori *et al.* 2013) as an adaptive method to this unfavourable environment. However due to the society's adaptation to the environmental restrictive dynamics, many villages in the study area were established during the first centuries AD when the region flourished due to this new irrigation technology (Merlo *et al.* 2013; Mori *et al.,* 2013). The environment was already in its hyperarid climatic phase by then (Mercuri *et al.* 2009). These villages in the Wadi ash-Shati and Murzuq regions grew significantly during the 4th-6th centuries AD to an extent of becoming trading and political centres (Mori *et al.* 2013). This was coupled together with the opening of new trans-Saharan caravan routes connecting the Mediterranean coast to the sub Saharan zones (Mercuri *et al.* 2009; Merlo *et al.*2013; Mori *et al.* 2013).

The influence of the consolidation of agricultural lands, water resources and newly established commercial routes became evident in the funerary practices and settlement patterns. The mortuary works during the Late Pastoral and Garamantian periods saw the location of burial grounds along the periphery of known and repetitively used road networks which were most of the time were along river systems (refer to fig 2 for better view of this). This made caravan movement by traders easier as they can easily water their animals. This practiced became widespread during the latter period as the population grew and environmental conditions also became unfavourable. The association of graves clusters with the road networks along the river systems which were used by these traders' caravans suggests that the graves were used to manage resources around them.

As such, the presence of graves clusters or not clustered shows the tendency of archaeological sites to be located in close proximity to restricted resources by that time such as water sources is expected because their primary importance was to lay claim to them (fig 3). The relationship identified between restricted resources and graves as such may, instead, have been guided by the society's spiritual ideology.

In summary to this discussion, it can be argued that the notion that the graves were placed intentionally on higher grounds and their roles were to define territorial boundaries, and demarcate access to restricted resources has been verified. The conclusions agreed with the earlier notion mentioned, and as such the graves were positioned in strategic locations, they exhibit a high degree of clustering and were built in highly visible areas that could be seen from sites of occupation and regions of economic importance such as the depression to the south east. In general, it is conceivable to argue that despite not having a firm chronological attribution of the graves, the graves were used as territory markers and the clustered ones can be affiliated to the Garamantian period mortuary practices, whereas the isolated ones to the earlier period of the Late Pastoralists. This argument is based primarily on the literature available on the Sahara Fazzan region, and it need to be verified perhaps through excavations.

6.3 Ideological Context of Graves Locations

The previous discussion was focused predominantly on the economic elucidation of the relationship between the graves positioning and their visual relationship within their environmental context. However it should be remembered that the places for the burials of the dead are experiences wrapped in past memories and emotions, which occur within cultural frameworks with historic and ideological significance specific tied to the societies that experienced them.

Based on the above arguments, another aspect to consider is the principles behind the positioning of the funerary monuments in their respective topography, and this is because it is anticipated that such actions were subjected to the actions and beliefs of the individuals or society at large. Even though ideology is challenging to verify form the archaeological record, the concept of ideology will be considered in this study. Viewshed analysis results provide some insights into the possible ideological connotation of the graves locations. From the results, it seems that there is some patterning amongst the archaeological features that certain topologies were reserved for different land use types, which also maximised their orientations to have clear views either to or from particular directions (fig 6 and 7). There are also intervisible relationships between the graves and the settlements or *qsur*.As shown in Fig. 6, much of the graves are visible from the qsurs. This suggests strong associations between *qsurs* locations and larger visible areas, with the latter being where the graves are located. This viewsheds of the area is interesting, because less of the viewsheds are seen in the far northern and south-western areas. Based on that, it is suggested as stated before that this view would have afforded the *qsur* dwellers visual access or given them rights to the natural resources (water bodies, pastures) through the graves of their kins which were visible from the *qsurs*. It is with high regard to these two aspects, site orientation and inter-site relationships that it is believed that they can help in investigating how ideology has been embedded in the ancient Wadi ash-Shati funerary landscape context.

From the elevation analysis results (fig 8 and 9), it has been observed that the majority if not all of the graves are situated on highly elevated topographies overlooking or on the edges of the depression, and the *qsur* and wells on the other side are located on low lying areas when compared to the graves locations and much closer to the depression. As noted in the previous discussion, this location places the graves in prominent locations which give them a commanding view over their surroundings which are plausible that they could have functioned as territorial markers. This also brings in the aspect of ideology as such locations relate directly to the ideological significance of such locations. Buikstra and Charles (1999) argued that ancient societies usually viewed elevated surfaces such as outcrops, hills or mountains to name a few as threshold zones between the earth and the sky, with the sky believed to be where the ancestral spirits are residing and overlooking their descendants. Tacon (1990), for example substantiate this argument by noting that burials located in prominent locations in the landscape around aquatic sources are regarded as areas of interface between earth and water. Also burials at such places increase the power of the location itself. This could be interpreted as symbolising the connection between the dead and the living. This connection seems significant for the study area, given the large number of graves situated in elevated surfaces and overlooking the *qsur* and the depression.

Another point worth of noting is that, the results of the elevation, slope and distance to rivers showed some similar trend. There are few graves locations situated closer to the river (fig 12) from the elevation results a considerable quantity of graves are located in the lowest elevation, 283-373m (fig 8 and 9). In general, the graves are mostly located between 283-373 and 373-463, with the latter recording the highest number. This can be attributed to the fact that travel to the graves for mortuary feasts such as ancestors veneration was usually undertaken by individuals on foot, travel undertaken in this way was largely limited to a lower elevation so as not to use high energy but the topography should be fair enough for the graves to have maximum visibility to their surroundings. The slope which is more preferred for the graves locations is from 2-4%. (fig 10 and 11) It conceivable to argue that the graves even though they were perhaps used to consolidate control on the aquatic sources, were not located in much close proximity to them to avoid contaminating the water. As a result of that, low slope (2-4%) was preferred for the easy reason that water can flow gently and easily without destroying the graves unlike other higher slopes (4-6% and 6-14%) or the flat one (0-2%) which can be prone to flooding because water will be not flowing faster.

To summarise this discussion, the need for control on aquatic resources contributed to the selection of graves locations coupled with the ideologies between the connection of the dead and the living was based primarily on their intervisibility. As such a greater concern was over the control of the restricted aquatic resources. The visual association of the graves with the *qsur*, wells and the aquatic resources (depression and rivers) may have therefore held two significant cultural functions; first as territorial markers signifying resources ownership through kinship lineage, and secondly as an ideological connection between the spiritual world and the living one. These areas were economically and spiritually significant in the ancient Wadi ash-Shati funerary landscape, and further serving to affirm ownership of the resources in their locality.

6.4 Visual structures and the Landscape

This discussion will start off by consider the results of the visual prominence analysis from random multiple viewer points were compared with their respective *qsur* locations viewsheds (fig 5). After that, the discussion on the multiple and cumulative viewsheds results will follow (fig 6 and 7). However for the discussion on the random multiple viewshed from 5 viewer points and the binary ones, the results from *qsur* 1 will be discussed as a reference point to this analysis. This is because during the analysis, it was found out that the results from the 11 *qsur* together with their random multiple points showed no difference, hence only one was selected for this discussion.

During the comparison of the binary and random multiple viewshed results, it was noted that the probable viewshed or random multiple viewshed from one viewer point and the *qsur* location viewshed from around it (fig 5), are not essentially different. This is because the visible areas are much more the same even though they were taken around random location around the *qsur* location. The figure shows that when the five viewer points are taken into account there is no considerable difference between the ordinary and probable viewsheds. Finally, it is worth pointing out that the areas around *qsur* 1 with limited viewshed in the binary viewshed (fig 5) still retained their positions even when performing the analyses from five viewer points. Hence, the results of the binary viewshed would seem to corroborate the perception that the selection of the location of the *qsur* was based on the visual prominence. The next discussion will be on the multiple viewshed from each single *qsur*.

The results of the multiple viewsheds suggest that the *qsur* displayed varying visibility because of the differing locations on their micro-local context (fig 6 and 7). As the trading caravans moved in the landscapes the surrounding places may have phased in and out of the field of vision, but within a local context there would have been few locations that were continuously not concealed from the surrounding areas. The few places that would have not been hidden were often located on highly elevated grounds than their surroundings. This is the kind of landscapes were graves locations were continuously seen and experienced.

The landscapes' relative openness which it is believed it has not drastically changed much since the period the study area was populated by the Pastoralists and Agro-Pastoralists societies consecutively, is most likely a result of the study areas' topographies. Based on the spatial distribution of the *qsur* and graves from the visible locations, it can be argued that majority of their surrounding landscape could be seen to a much larger degree. It is thus imperative to suggest that these were positioned in the landscape to overlook each other and their immediate surroundings.

It is clear that the settlements which are the *qsur* in this case were visually connected to the depression, which is an area which most of the rivers in the Wadi ash-Shati were emptying their water. As such it was a strategic area to control. However the only settlement which is not visually connected to the depression or any graves locations is the one located to the north west of the depression, as shown in the viewshed analysis (refer to fig6 and 7). The multiple and the combined viewsheds results show the spread of visible space covering almost all the graves, which could be used to correlate this results with the notion that it is highly likely that the burial grounds were areas with a high symbolic or strategic value. A visual control of the restricted resources would have been cemented by the graves, and this would have granted the inhabitants of the Wadi ash-Shati area a better claim and control over them. The need for restricted resources could explain the relatively low or no visibility at areas around *qsur* 1 and also on areas south towards the sand dunes, and the upper parts of the study region (refer to figure 6 and 7). On the foundation of the viewshed and intervisibilty results attained by this study, the notion that the area was inhabited by a highly structured society is substantiated whereby each *qsur* visually controlled a given region of the landscape, linked to the other *qsur* through a visibility network.

Certainly all the *qsur* were constructed in locations with intentional visibility to their surroundings and the archaeological features, as evidenced by the random points generated around each and every *qsur*. *Qsur* and graves were both built in locations with views to the drainages of the rivers systems, the depression and the wells, though *qsur* 1's view to the mentioned environmental and archaeological features is generally poor (see figure 4 and 5). These discussed features are hidden when viewed from *qsur* 1 locale. It is now substantial that there was a reciprocal view between the *qsur* and graves, and this resulted in such a way that they were used as territorial markers. Several theoretical and empirical studies by Saxe (1970) and Watson *et al.,* (1973) are corroborating this notion by postulating a middle range linkage between burials and territoriality. As argued in the previous discussion on the graves used as territorial markers, which would have been practical analytically for estimating socio-political boundaries and land use decision making approaches. It is also assumed that the river networks found in the study area served as a primary means of communication, transportation routes and resource access. One would assume that graves, whose positioning was in elevated grounds would have commandeered favourable views to these rivers, which, in my opinion, may have contributed to a growing sense of territoriality.

A number of conclusions arise from this discussion which was mainly based on the viewshed analysis results carried out in this study. First and foremost, it has been noticed that there is no visual difference between the random multiple viewshed from 5 viewer points and the binary ones. This means that the *qsur* were not located there by chance, but their locations were evaluated and selected looking at the views they could offer. The second conclusion which has been deduced from the analyses carried out was that the depression was certainly a factor for the archaeological sites location or selection mentioned in this study during those periods in discussion. This is attributed to the reasons or ideas placed behind such as the socio-economic behaviour of the ancient cultures populating the study area. In overall to all the viewshed analyses performed, it is imperative to state that the human population in the ancient Wadi ash-Shati landscape lived in a context where the ability to see where and how far individuals can see or lay claim to restricted resources in the landscape was of crucial importance.

6. 3 Chapter Summary

The crucial appraisal of the merits of environmental and cultural models of the settlement patterning or archaeological features positioning on the ancient Wadi ash-Shati funerary landscape has identified a uniquely prehistoric land use pattern. On a micro scale of the study area, the area topography and the presence of important environmental variable including water resources and grazing pastures governed the positioning of the qsurs and the burial grounds. These were determining the particular positioning of archaeological features on the landscape, and this is something that has not been figured notably in earlier studies of the Wadi ash-Shati region’s settlement history. Furthermore, cultural beliefs are key to land use decisions. In this sense, it is not possible to separate prehistoric beliefs and culture from the natural environment, nor would such a division be beneficial to this study. Based on the above discussions, prehistoric human populations in the study area were choosing different topographies for different land uses, because of certain beliefs and necessities of their daily life needs.

Chapter 7-Conclusion and Recommendations

7.1 Introduction

This Report has investigated the way in which funerary monuments and other archaeological features were arranged in the ancient landscape of the Wadi ash-Shati region, with the opinion that both cultural and environmental factors played a role in site selection decision processes. The study began by stating the research questions, and objectives of the study. The geographical and historical background of the study area was then discussed, followed by the review on the applications of the GIS and remote sensing technologies in archaeological studies. The methodology being applied in this study including data sources was then explained. The preceding chapter after this one was on the data analysis, with each steps involved for every single analysis outlined. The chapter on the results of the data analysis were then presented, followed by a chapter on the interpretations and discussions. The last chapter was this one on the conclusions and recommendations for future studies based on the study area.

The discussions in this chapter will provide a summary of the results and discussions discussed in the previous last chapter, which will be recapped within the research questions and aim and objectives of the study discussion. Finally, some suggestions for future studies are discussed with the hopes that the ancient funerary monuments landscape on the Wadi ash-Shati region will continue.

7.2 Research Questions Revisited

One purpose of this investigation was to analyse the distribution of archaeological features in the ancient funerary landscape of the Wadi ash-Shati region, and this was supposed to be achieved through the following research questions; what is the spatial patterning of the Garamantian funerary earthworks in the landscape of the Wadi ash-Shati region? and lastly what are the potential significances expressed in the layout of the cemeteries and settlements in terms of their positioning in the landscape?

The better understanding of the distribution of archaeological features in the Wadi ash-Shati region was attained, and the suggestion on this spatial analysis is that both cultural perceptions and beliefs and environmental variables were influencing settlement patterning. This is because it was found out during this investigation that places for burying the dead during ancient periods were located in elevated surfaces than their surroundings and overlooking the areas allocated for domestic activities such as residential and farming activities to name a few. It is believed that the cultural perceptions regarding the connection between the dead and the living was the main driving force behind the location of the graves and the residential areas in relation to their topography. This indicates that both cultural and environmental variables played a great deal in the selection of particular areas for the establishment of burial grounds and other site forms.

The second research question was also achieved because from the analysis and results, a number of significant findings were revealed. Based on these findings, it was concluded that the graves were located on prominent locations or highly elevated areas, and as a result of that, they had a greater visibility to their surrounding landscapes. There was intervisibility between the graves and the *qsurs* or residential areas and including the areas with restricted resources such as aquatic sources and agricultural resourceful areas. Based on this statement, it is them imperative to say that the graves and *qsurs* or other archaeological features were placed intentionally on their current locations. Besides the environmental or topography of the area, cultural factors also played a key role in selecting sites, as argued by (Tacon, 1990; Buikstra and Charles, 1999) that prominent locations in the environment such as outcrops, hills or mountains are viewed as threshold zones between the earth and the sky, with the sky believed to be where the ancestral spirits are residing and overlooking their descendants. In order to wrap up this discussion, it is credible to argue that the relationship between environmental variables and site locations both for cultural and subsistence reasons, suggests a strong relationship with the underworld.

To sum up this discussion, this investigation of the settlement patterns in the Wadi ash-Shati study region in general provided insights into the connection between archaeological features and environmental variables.

7.3 Consistent Challenges

While this research has helped to better understand the settlement patterns of archaeological features and the environmental influence s in the Shati region, a number of limitations remain hence the need for further study in the region. The most significant limitation for this study has been the lack of adequate archaeological data particularly foggaras, graves types or categories and palaeo-environmental data for the ancient Wadi ash-shati region.

Another limiting factor which needs to be evaluated is to separate the studied graves into different categories based on their grave goods, which could be another reason on the clustering and isolation of them. Without that information, the study may be misleading because it is just looking at one possibility on why there is such behaviour exhibited by the graves. With that argued, it is possible that there are undocumented relationships between the graves goods and their locations in the landscape. The lack of palaeo-environmental data should also be mentioned as a limiting factor when one is doing this kind of study, as it is feasible that it may have large impact on the analysis of visual associations between the qsurs and the graves. It is likely that some of the graves and *qsurs* were categorized as visible or not visible, but the results being otherwise because that missing information. Also it should be noted that the results for all the analyses would have been different if a DEM of higher or lower resolution was used. This is because the DEM used by that time would have hidden or created artificial models of the results being analysed that would have been different from the ones existing in reality.

Another challenge regarding the resolution is the lower imagery resolutions in Google Earth program which made systematic digitising of the graves challenging. The areas in the study region which had low resolution imagery were not thoroughly surveyed for the graves because of poor visual of the imagery. If all of the study area had a high imagery resolution, a systematic survey was going to be possible, and this resulting in a better understanding of larger scale patterns throughout the study area being studied and identified. As a result of that, the graves dataset is somehow biased. However it is hopeful that imagery of higher resolutions will be acquired either through Google Earth or data vendors, and a systematic surveying and mapping of the whole area be conducted in order to reduce bias in the interpretation of the ancient settlement pattern of the study region.

In summary to this discussion, the challenges discussed above were addressed to an extent possible with the available data during this study. These issues of generalisation are relatively common in archaeological investigation or other fields using GIS as an analysis tool. With that in mind, they should not be blindly acknowledged, and potential investigations should attempt to incorporate both the palaeo-environmental and other missing archaeological data on grave goods if there are any. The challenges stated are amendable by using enhanced and more sophisticated modelling programs, however they are challenges that most studies endure.

7.4 Chapter Summary

The combination of environmental, ideological and social variables archaeological investigations using GIS is relatively a new concept. The approach attempted here, in which the mentioned variables are combined in spatial analysis, is one that has not vigorously tried in much of the studies conducted in the Sahara Fazzan region including the rest of the African continent. By combining these variables, it has been feasible to create the land use model of the ancient human societies which once occupied the region, including with their perceptions of their surroundings. Together both environmental and cultural factors influenced ancient human behaviour in site selection, and this is because the specific location of an archaeological site was tied to the topography in its locality and the cultural significant or role it will play in the daily activities of the society. Ultimately, I have high anticipation that this study has facilitated in building a better understanding of past lifeways and advanced our knowledge on past human perceptions and the utilisation of the landscape.

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