A Field Survey and Geographical Information Systems (GIS) Based Investigation of the Archaeological Landscape in the Niger River Valley, Republic of Benin

Volume 1

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Abstract

The Niger River Valley in the Republic of Benin is an archaeologically rich landscape, where hundreds of sites line the river's tributaries. Before this doctoral research was conducted in the region, the landscape here was a *terra-incognita*. In order to archaeologically investigate the area, several methods were used consisting of a field walking survey, and the use of satellite remote sensing and Geographical Information Systems (GIS). An integration of these methods, which are commonly used in research out of Africa, showed the diverse nature of archaeology in this region. The field walking survey revealed the position of over 300 sites and around 50,000 material culture artefacts, comprising of mainly ceramic vessel sherds. The field survey was undertaken over 45 days and covered a total area of 25km^2 within four geographical zones in the study area. A comprehensive gazetteer was produced from the data collected. Remote sensing methods that manipulate multispectral satellite imagery were used to identify sites from the air, because the archaeology of this region is not visible from standard air photographs. The mapping of sites using GIS facilitated in establishing fundamental landscape patterns, which helped substantiate theories surrounding West African urbanism and human-environment interactions. The results conveyed that settlements in this region favour areas where water is available, mainly close to perennial and ephemeral fluvial systems. Furthermore, the archaeological sites identified display strong evidence of spatial clustering, which has been shown in other West African contexts to be indicative of early urbanisation.

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Glossary of Terms

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer)

Digital Elevation Model (DEM)

Folded Strip Roulette (FSR)

Inland Niger Delta (IND)

Geographic Information Systems (GIS)

Global Digital Elevation Model (GDEM)

Global navigation satellite system (GNSS)

Global Positioning System (GPS)

High-density survey and measurement (HDSM)

Laboratoire d'Art, d'Archéologie et d'Expertises Patrimoniales (LAAEP)

Ministry of Economy (METI)

National Aeronautics and Space Administration (NASA)

Normalized Difference Vegetation Index (NDVI)

Normalized Difference Water Index (NDWI)

SPOT (Système Pour l'Observation de la Terre)

Unmanned aerial vehicle (UAV)

United States Geological Survey (USGS)

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Chapter One: Introduction

1.1. Overview

The Niger River Valley in the Republic of Benin (hereafter referred to as Benin) is one of the most archaeologically unexplored regions of West Africa, a *terra incognita*. In many archaeological studies, information can often be collated from prior surveys and excavations in the area, and potentially a broad ceramic sequence may have been established and site typology formulated. However, this is not the case within this study region and the information compiled for this thesis is the first inclusive archaeological overview of the area using the resources available in the three and a half years it took to conduct this doctoral research. This research demonstrates the potential of this extraordinarily rich archaeological landscape, which has evidence for hundreds of ancient sites. A series of methodologies including archaeological field survey and Geographical Information Systems (GIS) are used to gain an informed understanding of the history of the Niger Valley. These methods are currently underutilised in West African landscape archaeology research, but are being used successfully in research of other regions across the globe. The key outcomes of this work are a compilation of a comprehensive site gazetteer and extensive mapping of the archaeological landscape, the first in the region to date.

The main research objectives within this project seek to illustrate an overview of the region archaeologically in terms of settlement and material culture distribution and densities, and investigate how site placement relates to the wider environment. Additionally, it sets out to demonstrate how non-intrusive techniques using desk-based methods including GIS and satellite remote sensing, together with field walking, can establish a well-rounded and appropriate initial archaeological overview of a landscape. Furthermore, this research is important for the region as accurate and systematic recording of the ancient remains is imperative for culture heritage protection in the area.

This thesis will consider four central questions:

- How can we systematically and accurately record the distribution of archaeological sites and surface artefacts in the landscape and how will this benefit cultural heritage management of the area?
- To what degree does the environment influence settlement and material culture patterns?
- To what extent is this an urban landscape, such as those noted in other areas of West Africa, including the Inland Niger Delta (IND)?
- How useful are desk-based methods, specifically GIS and satellite remote sensing, in investigating the archaeology of the region?

This work has been undertaken within the context of a European Research Council – funded project led by Dr Anne Haour (Sainsbury Research Unit, University of East Anglia), *Crossroads of Empires: archaeology, material culture and socio-political relationships in West Africa*. The project was undertaken over five years and included four fieldwork seasons. The main aim was to study how medieval 'empires' influenced the patterning of settlement and material culture across the landscape. This was carried out holistically using anthropologists, archaeologists, historians and soil scientists, carrying out a survey of the region as a whole. Selected sites were subjected to trial excavation, while anthropological theoretical perspectives and ethnographical and oral-historical interviews were carried out building crucial background information for the archaeological data. The excavations established a broad chronology of settlements and material culture in the region, which was previously a complete unknown.

The chronology established within the *Crossroads* project will be used within this doctoral research. However, it is important to state that there is currently no refined time sequence for settlement and ceramic phases within this study region, and this is the ongoing work of the *Crossroads* project. Thus, discussion of chronological sequences at this stage is not a prime objective for this current research. It is hoped that this type of analysis can be established in later works, using the comprehensive information gathered for this thesis.

The first part of this chapter will provide an overview of the study area. Then a summary of the work of the *Crossroads of Empires* project will be given, to set the context of this research. This will be followed by a review of previous archaeological research undertaken within West Africa, particularly focused on the IND and its surroundings, thereby illustrating how much archaeological work has been carried out in West Africa. The aim of this review is to highlight the nature of past research from a methodological and theoretical standpoint, in order to situate the findings from this research. The chapter will then go on to provide a detailed synthesis of the research questions and aims of the thesis, accompanied by a short discussion of the objectives. Finally, the outline of this thesis document will be given.

1.2. Summary of study area

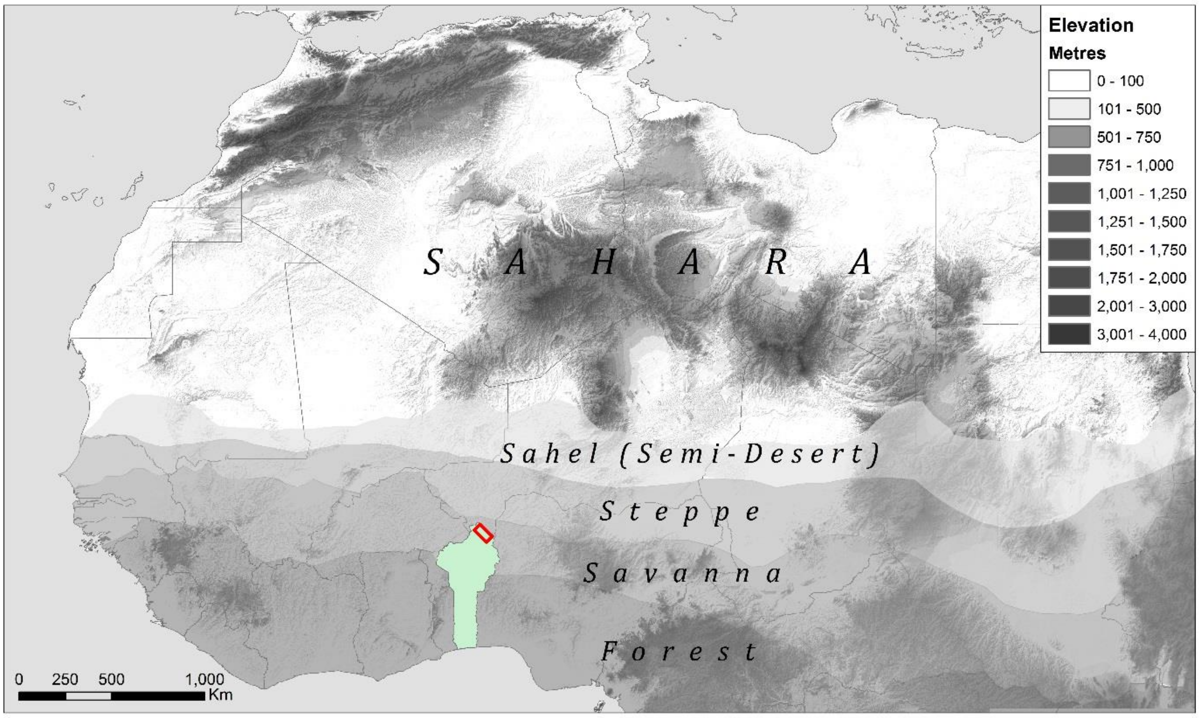

Figure 1.1 *Vegetation map of Africa showing the Republic of Benin in green and the study area of this research shown with the red polygon. Map: author's own.*

The Niger River Valley in Benin is located in the West African side of the Sahelian/Steppe belt between N 12° 22', E 2° 51 and N 11° 42', E 3° 33'. Shown in Figure 1.1 the Sahel is the area where the Sahara meets the Savannah and is a long, narrow, strip of semi-arid grassland that stretches across the continent of Africa (Grove, 1978; Tucker and Nicholson, 1999). It has long been established that the Sahara was once a lush green landscape, inhabited by many people and this can been seen archaeologically from evidence of stone tools, rock art and carvings (Armitage and King, 2013; Cancellieri and di Lernia, 2013; Foley and Lahr, 2015). However, this African Humid Period ended and climatic shifts led to the desertification of the Sahara and the movement of its people (Claussen *et al*., 1999). The Sahel region and in particular the Niger River in West Africa lying south of the Sahara offers a place with accessible water; therefore people would have had an inclination to settle here.

The key geographical feature defining the wider landscape of the study region is the Niger River and is a key focus for our research. The Niger River is the third largest river in Africa, measuring 4,200km in length with a drainage area of 2,090,000 km^2, and drains a large area of West Africa (Dada *et al.*, 2015; Oyebande and Odunuga, 2010). No geomorphological studies have been undertaken in the Niger River Valley in Benin; however analysis of historic aerial imagery suggests a very active river system which has changed its course over time (Jan Alexander, May 2014, pers. comm).

The study area under investigation sits in an important location, nestled in the middle of the Sahelian landscape on the southern banks of the Niger River, close to two major fossil valleys, the Dallol Bosso and the Dallol Maouri (Figure 1.2). The region is historically known as Dendi, which is the narrow band of land either side of the river, which is part of the larger Songhai Empire (Ayoba, 2000; Bako-Arifari 2000). The area spans around 100 km of the Niger River (see Figure 1.2) and encompasses two large river tributaries of the Niger, the Alibori and the Sota. Average elevation above sea level is around 200m where the highest points in the landscape consist of a range of ironstone and sandstone hills. A perspective of this landscape can be seen (Figure 1.3). Today the region is mainly rurally populated, with more than 70% of people living in villages or isolated areas. Between 1992 and 2013 the population in the region has doubled according to the research conducted by Behanzin (2014).

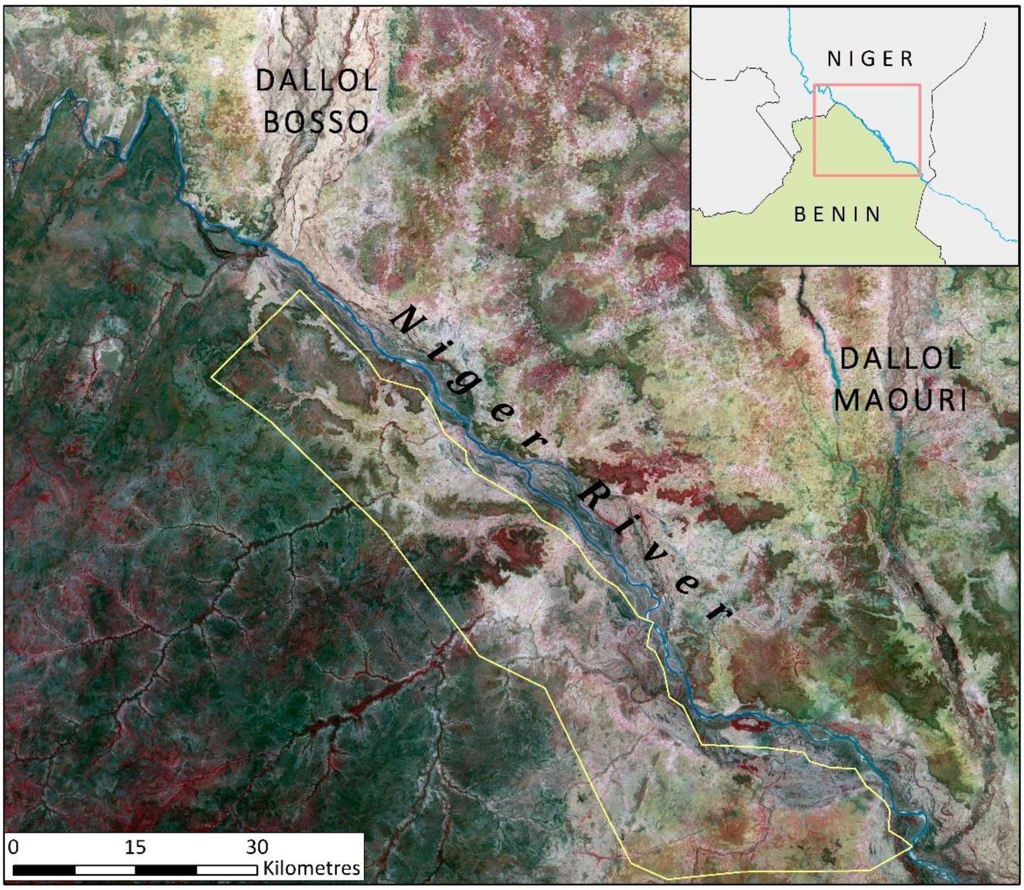

Figure 1.2. Landsat satellite image showing the study region. The study area in question lies in the Republic of Benin, which is the south side of the Niger River and is represented by the yellow polygon in the image.

The Republic of Benin sits within the southern extent of West Africa, flanking the Atlantic Ocean, and sharing its border with Togo, Burkina Faso, Niger and Nigeria. Historically it is best known euro-centrically for its colonialisation by the French and the trans-Atlantic slave trade (Gurstelle et al., 2015; Law, 1997; Monroe, 2005, 2007, 2012, 2013; Norman, 2009, 2012; Randsborg and Merkyte, 2011). However, as this research will reveal, prior to colonialism the region experienced a rich history, with diverse and complex societies inhabiting the landscape. In the country as a whole there has been some archaeological research in recent years, but with a relatively shallow time depth and mainly focused hundreds of kilometres to the south of the present research area. It has been highlighted that there is the need for more research to be undertaken in the country (Randsborg and Merkyte, 2011).

Current research includes the recent work of Gurstelle *et al*. (2015), working in central Benin, 450 km south of our study area. The research here considers site patterning and material culture of the Savè region in the early second millennium AD. Archaeologically this area has evidence of settlement site distribution and indication of agro-pastoralism, ceramic, lithic and iron technologies present. Gurstelle *et al*. (2015), states that findings in the area are similar to that found in the north of Benin and refers to the few publications of the *Crossroads* project (Haour *et al*., 2011; Haour, 2013). Other research in Benin includes Norman (2009; 2012) who considers the 17th and 18th century Huedan Kingdom, located in the far south of the country, close to the coastal area and likewise Monroe (2005; 2007; 2012; 2013) focuses on power and agency in the ancient Dahomey Kingdom, also in the south. These studies are articulated around the question of contacts between local populations and Europeans in the context of the Atlantic slave trade. More generally, Randsborg and Merkyte (2011) consider the history and archaeology of the whole of southern Benin, in their two volume book *Benin Archaeology: The Ancient Kingdoms.* This research focuses mainly on caves, palaces, geology, burials, iron and ceramics. Overall, the coverage geographically is quite sparse, with works focused more on the south of the country and only limited major research being carried out in the north.

It is evident from this summary that there is a clear need for research in the region. The next section will review the work of the *Crossroads* project between 2011 and 2014. It has been illustrated through this project that the study region shows substantial evidence archaeologically of being a hub of past human activity, with settlement mounds and dense pottery scatters littered throughout the landscape. The landscape offers a range of geomorphological topography, including many perennial and ephemeral river systems which, when analysed, can offer insights as to why people settled here.

Figure 1.3 *View of the Niger River Valley from the top of a hillside at Tin Tin Kanza.*

1.3. Crossroads of Empires

Historical evidence dating from the 19th century suggests that the wider region close to our study area was one of polities, empires and kingdoms, but these sources are limited in their scope with only brief mentions (Hourst, 1898). West African empires are well documented from the medieval period. The Ghana Empire, located between Mauritania and Mali, was the greatest empire in West Africa between c. AD 300 and AD 1200. It grew through trans-Saharan trade, where gold and other high-quality goods were traded for salt from Sahara (Davidson, 1971). This initiated a trade network between North Africa and the Niger River that flourished into the seventeenth century. Other notable empires after the collapse of Ghana are the Mali and Songhai empires. Written accounts of these empires have limited focus on the Niger River Valley. The major aim of the *Crossroads* project then was to consider how these medieval empires played out on the ground. Can they be seen through archaeology in the Dendi region and how have they shaped the landscape in terms of settlement and material culture of sites dating to the last 1,000 years? A multi-scalar approach was adopted for this using archaeological surveys and excavations in conjunction with ethnographic and historic enquiries (Haour *et al*., 2011). The core members of the team had varying specialisms, bringing different expertise to the project in order to decipher this historic landscape appropriately. They consisted of archaeologists, anthropologists, ethnographers, soil scientists, architects and archaeometallurgy and geophysics experts. The project as a whole aimed to make the first inventory of sites in the area known as Dendi and produce an archaeological and ethnographic map, focusing on the materialisation of past polities and on past craft productions.

As stated, there has been no research into the archaeology of Dendi, and historic records of the area are limited. One reference alludes to the presence of large mounds in the area shown on a map by Gado (1980) who identified four sites but reports them as 'Site archéologique non précisé'. Another map by Davies (1967) very broadly puts Early Iron Age sites in the region, but the exact locations are not stated. Petit (2005) considers the archaeology and history of North West Benin, ranging from stone-age prehistoric archaeology, to Iron Age and Historic Period, however this area is slightly beyond the Niger River Valley. Most recently, the work of N'Dah (2001) who is also a member of the *Crossroads* team, conducted a survey locally, which lies west of the study area. This survey identified the large settlement mound complex south of the modern village of Birni Lafia (Figure 1.4), which subsequently became the main excavation site of the *Crossroads* project.

Given this brief background of the *Crossroads* project, the following sections will consider the subsequent field surveys and excavations undertaken by the project between 2011 and 2014, which have provided the first radiocarbon dates for the region.

1.3.1. Field walking survey

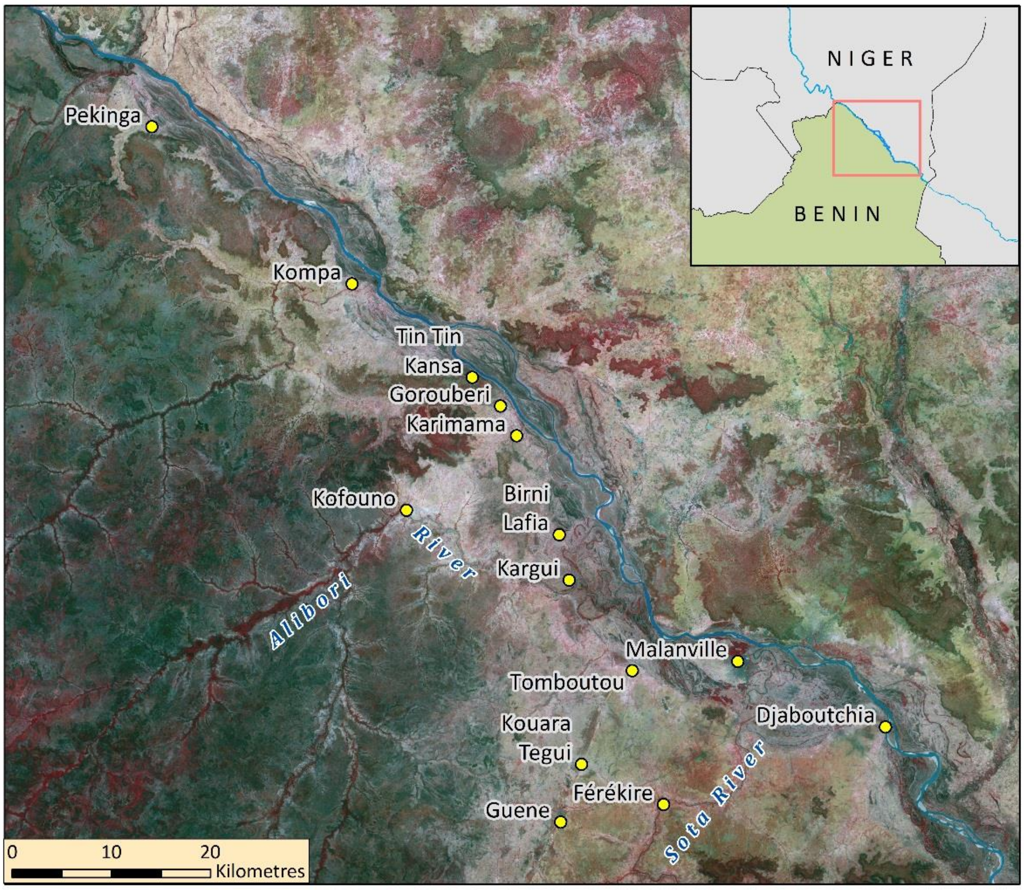

Figure 1.4 *Landsat 8 image showing the location of sites and tributaries mentioned in this text. The Niger River is shown running northwest to southeast in the image.*

As with any major archaeological project in its preliminary phase, a systematic field survey of the landscape was undertaken. During the four field seasons of the *Crossroads* project, which took place during January and February between 2011 and 2014, field walking was carried out by different members of the project team, all with the aim of identifying and recording new archaeological sites. During this time a total of 514 sites were discovered. Gazetteer One, found in the appendix of this thesis, is a table that outlines the findings of the project (an overview of this can be found in Chapter Four).

Archaeological visibility in the landscape on the ground is good. There is an abundance of material culture on the surface pinpointing the existence of archaeological sites. The majority of material culture on the surface comprised of ceramic vessels sherds, but lithics, slag and beads are also present. Settlement mounds were the most detectable archaeological site encountered during survey and were easy to recognise even from a distance. Other sites were flat or cultivated; therefore material culture on the surface is the only indicator of archaeology.

The survey undertaken in 2011 launched the project and aimed to gather as much archaeological data as possible, over a large stretch of terrain, in a short amount of time. Traditional impact assessment survey methodologies were carried out with an instinctive approach to site discovery, targeting areas close to water sources or raw materials. A full synthesis of the methodology that was undertaken will be presented in Chapter Three. In total, over 400 archaeological occurrences were recorded during a 10-day period. These occurrences ranged from isolated ceramic sherds, to very dense artefact scatters spread over a vast distance. The survey showed that there were a large quantity of sites in the direct vicinity of the Niger River, with variable concentrations of large settlement mounds and material culture spread spatially over the region (Haour *et al.,* 2011).

The survey in 2012 was much smaller in comparison to that of 2011 due to technical difficulties. Nevertheless, this enabled the team to conduct comprehensive, smaller surveys around the known mound sites of Birni Lafia and Pekinga, where excavations also took place (Figure 1.4). This gave some valuable context to these key sites for the project, which revealed continuous occupation around the site of Pekinga, and a distinct lack of cultural occupation around the immediate vicinity of the Birnin Lafiya mound.

The survey in 2013 sought to put excavated test pits into context within the wider landscape (these excavated sites will be discussed in the next section of this chapter). A systematic survey was carried out in the vicinity of the $11^{th}/12^{th}$-century site of Kompa Dune, which revealed substantial evidence of iron-working craft in the area (Robion-Brunner *et al*., 2015). A survey between Tin Tin Kanza and Gorouberi to coincide with excavations at both of these large settlement mounds was carried out, revealing 20 sites concentrated close to the test pits. Both of these sites are situated on substantial settlement mounds, which dominate the landscape and sit on the edge of the Niger. The occupation of Tin Tin Kanza dated between AD 900 and AD 1400, however Gorouberi appeared to fall earlier, beginning in the first centuries of the first millennium AD (Champion and Haour, 2013; Khalaf and Haour, 2013). A list of C14 dates can be found in the appendix. The last survey locale for this field season was around the Alibori River, a tributary of the Niger River. Some sites had been identified here during the 2011 survey, but the 2013 survey revealed a concentration of over 80 sites, which made up almost a third of the sites located this field season. In total, 287 sites were discovered across the region as a whole during the 2013 field season.

The final survey of the *Crossroads* project was undertaken when the survey for this doctoral research took place (the method and results of which will be discussed Chapter Three, Four and Five). This included a short survey between Tin Tin Kanza and Karimama, revealing a handful of sites close to the Niger River. Furthermore, an 11.5km transect was undertaken along the plateaux south of Tomboutou, where 37 sites were recorded, consisting mainly of eroded, flat sites and a few settlement mounds.

1.3.2. Excavations

This section will briefly discuss excavations undertaken by the *Crossroads* project. During the field seasons, test pits and larger scale excavations were carried out alongside the field surveys discussed in the previous section. One priority was to establish a chronological sequence for the settlements within this region. This objective is relevant to the results of this research so it will be briefly discussed here. However, the results of the *Crossroads* project as a whole can be found in Haour *et al*. (forthcoming, 2017).

The excavations between 2011 and 2013, as previously stated, were carried out on prominent large settlement mound sites. These sites were relatively homogenous in morphology, and all had similar positions in the landscape, close to the Niger River. These sites are shown in Figure 1.5, and date between AD 700 – AD 1400, with the exception of the early site of GOB-13 (Gorouberi), which had many dates, but included one at AD 10 (Beta-345501: Cal BP 1940 to 1940, error BP 1930 +/- 30). All dates in the research calibrate with Oxcal or by Beta Analytic, and are given at 2 sigma. The other dates obtained for the project mainly came from the excavations at the main site of the Crossroads project, Birnin Lafiya (Blaf on Figure 1.5). This site was chosen for excavation because it is extremely large in size, apparent deep stratification and potential evidence for well-preserved architecture in association with pottery pavements seen on the surface. During 2014 test pit excavations were carried out in the centre of villages to bridge the gap between AD 1400 and present day, which is where the rest of the dates came from.

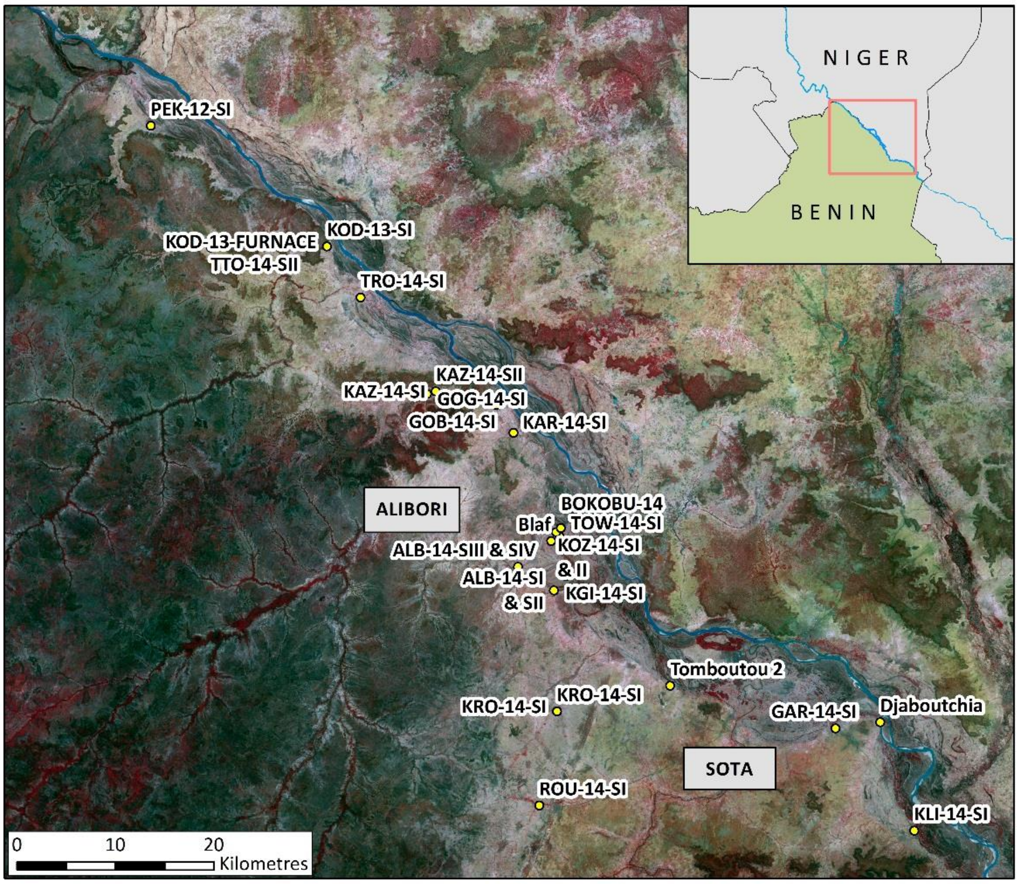

Figure 1.5 *Locations of excavated and dated sites of the Crossroads of Empires Project. Numbers represent the year of excavation. Note Djaboutchia was not excavated and a date was obtained from retrieving charcoal from an eroding section.*

Figure 1.6 illustrates the distribution of C14 dates obtained from all excavations during the *Crossroads* project, 70% of which fall within the 500 AD – 1400 AD date range. Although we have a good spatial distribution of sites throughout the landscape, the dates are somewhat biased towards large settlement mounds, as excavations at these sites were the focus of the project. It is important to consider there are a range of other sites present in the hinterland. Nevertheless, because research in this region is in its infancy, these dates are extremely useful for setting the archaeology in context. The dates obtained by the *Crossroads* project are particularly valuable for this doctoral research project as the type of mound dated represent a phase of occupation, and many similar mounds were found during survey.

The dates for the abandoned archaeological sites in the Niger River Valley are around 1400 AD. This is significant in the discussion of archaeology in the wider region, because this chronological phase links to other regions of West Africa, which are notable for the rise of early urbanisation, which also disappeared around 1400 AD.

1.3.3. Birnin Lafiya and site formation

The largest excavation of the *Crossroads* project took place at ancient Birnin Lafiya (the modern village is referred to as Birni Lafia after the French colonial period; however, the 'Birnin Lafiya' spelling is closer to Hausa grammar). This section will briefly discuss the findings made here. However, it is important to state that this research project focuses on a non-intrusive survey and remote sensing methodology, and the excavation data is ancillary to this project. Excavations at Birnin Lafiya were carried out over 15 weeks with 20 trenches excavated, the site measures 260,000 m^2 (26 hectares) and the mound extends 8m from the ground surface. Publication of the excavation at Birnin Lafiya is currently in press, but preliminary findings indicate this site was a large settlement mound with early mud architecture, circular structures, potsherd pavements and human burials (Haour *et al.,* (2016)). The site has occupation remains concentrated on the elevations and there were remains on lower-lying areas but due to flooding were less so. It remains unclear at this stage whether the site had a continuous occupation between the 4^{th} and 14^{th}-centurys AD, or whether it is formed of successive occupation at different times and places across the site (Haour *et al*., (in press)). Initial analysis of data from the excavations of the site show that the site formed on a naturally occurring mound close to the river; there are no defensive ditches or enclosure walls, which are often seen in West Africa (Connah, 2009). Wet and dry sieving of the excavated remains at Birnin Lafiya has revealed rich data regarding the diet and lifestyle of the past dwellers in the region. Faunal remains showed that fish were the most represented in the assemblage, as well as some wild mammals and rare domesticates (Veerle Linselle pers. comm.). In the archaeobotonical assemblage, pearl millet, African rice and cotton were all dominant (Dorian Fuller pers. comm.). Overall the preliminary discoveries of the excavation illustrate the reliance on the riverine environment and suggest a potentially wetter environment in the past.

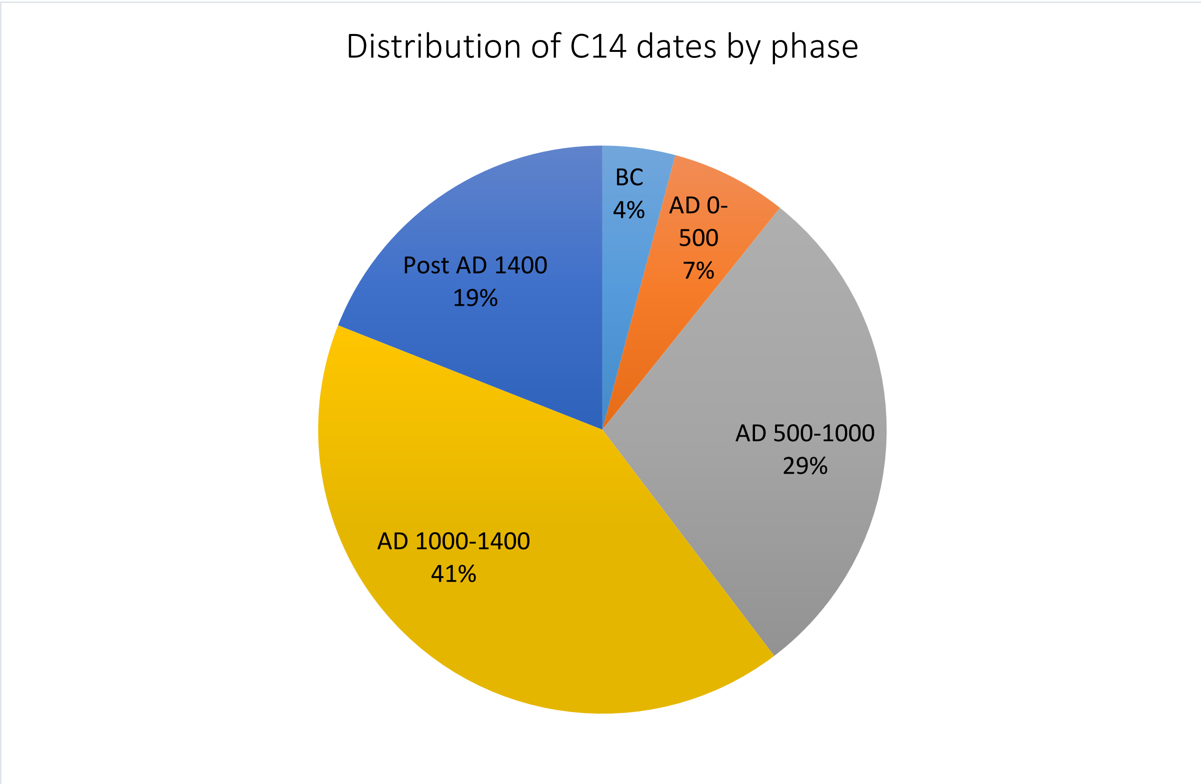

Figure 1.6 *Phases of dates found within excavations of the Crossroads project.*

1.4. Settlement archaeology in a West African context

To situate this research within the context of methodological and theoretical perspectives of the wider region, this section will focus on the relevant archaeological research that has been undertaken in West Africa. Numerous surveys and excavations have been carried out in the past 40 years, the results of which show that many regions of West Africa display a complex array of ancient settlement site remains throughout the landscape. Notable examples include the Chad Basin (Lavachery, et al., 2010; Magnavita *et al*., 2009), central/southern Ghana (Insoll, 2008; Stahl, 1994) the Senegal Valley (McIntosh and Bocoum, 2000) and in the Inland Niger Delta (IND) in Mali (Clark, 2003; McIntosh, S.K. 1995; Schmidt, 2010; Togola, 2008).

The IND has been chosen because the notion of urbanism and the question of settlement pattern have been most theorised and hotly contested here. Furthermore, the sites in question within the IND are broadly contemporaneous with the sites under discussion in this thesis, dating to the medieval period, as discussed previously uninhabited mound sites dating 500-1400 AD. This research does not consider sites from as late as the post Atlantic trade or as early as the Neolithic. The IND in Mali features the well documented sites of Jenné-Jeno, Dia, the Méma region, Sadia and Timbuktu, which, as will become clear later in this thesis, bear striking resemblances to those sites found in northern Benin (Figure 1.7).

The key themes which shape the settlement archaeology of the IND region have focused on urbanism, settlement patterns and environmental determinism. Much of the work conducted so far in the Niger River area has been through regional surveys, which often produce maps illustrating settlement patterns. These maps which often depict the surrounding natural landscape are then used in conjunction with other information, such as excavation data, material culture present on each site - either on the surface or through excavation, to draw hypotheses. Such an approach only makes very partial use of the huge potential of GIS studies, and is one of the key contentions of this thesis. How GIS is used successfully in archaeology in other regions is developed in Chapter Two. The present chapter aims to give an overview of the current methods and themes driving the study of West African landscape archaeology.

1.4.1. Urbanism

One of the major current themes throughout the work on settlements in West Africa is urbanism. The discussion of urbanism in the IND was first highlighted by the works of S.K. McIntosh and R. McIntosh during their work at Jenné-Jeno in the 1970s and 1980s, which developed into several publications, where the subject has been discussed extensively (McIntosh, R. 1991; 2005; McIntosh, S.K. 1995; 1997; 1999; McIntosh and McIntosh, 1984; 1993; 2002). The main conclusions of these works are that a typically urban settlement found within the IND displays evidence of a diverse population which provides an assortment of functions, manufacturers and services to the surrounding hinterland. The work of S.K. McIntosh and R. McIntosh on urban culture is significant, as it changed the general perspective some had about pre-colonial Africans; part of this perceived inferiority involved the absence of cities. S.K. McIntosh and R. McIntosh (1993; 2003) argued a case for the presence of cities in the IND, but without the iconic standing architecture usually associated with it. Previous to archaeological research, Africa was often construed as a place of 'inferior people, institutions and accomplishment' (Robertshaw, 1990). A more detailed account of Jenné-Jeno will be discussed within the case study section of this chapter, providing further examples of why this settlement structure was regarded as urban.

The term urban can be defined as processes and location relating to a town or city, as opposed to the countryside (Oxford English Dictionary). More recent work on urbanism has questioned the way in which an urban settlement and culture should be defined. Firstly, it should be acknowledged that there is an impediment in describing Africa's urban past, as every area (and even region) does not share a common theoretical approach or methodology, and therefore the generic definitions of urbanism do not apply (Anderson and Rathbone, 2000). Secondly, due to the lack of written evidence in these areas, it is only archaeology that has been the driving force for the recent interest in pre-colonial urbanism in West Africa. With that in mind, archaeologists have borrowed the theory of urbanism from geographers and other disciples and manipulated it to suit these studies. This often consists of a list of different factors that settlements must adhere to, to be considered as ‘urban’. The basis of these traits are taken from Childe (1950:9), who described urban settlements as those which have a large population, social stratification, a central bestowal of excess food, and monumental public architecture. LaViolette and Fleisher (2005), highlight this tendency for African urbanism to be defined by these classifications and trait lists, which means the theory can be descriptively static, but on the other hand, influential in their uniqueness. Even today, there is no generally accepted definition of urban (Moran, 2010).

Settlement patterns are another current theme which shapes the focus for the studies of the IND presented in this chapter. Spatial patterns of settlement naturally have a direct link to urbanism and the notion of site clustering has been discussed considerably in relation to archaeological research in the IND (McIntosh, R. 1991; 2005; McIntosh, S.K. 1995; 1997; 1999; McIntosh and McIntosh, 1984; 1993; 2002). In the IND for example, we see a particular type of clustering where smaller ‘satellite’ settlements will cluster around a central, larger settlement, often known as the urban centre (McIntosh and McIntosh, 1993). This theory is known as Central Place Theory and it is often borrowed by archaeologists from geographers to describe the functions of urbanism. Von Thünen first developed the concept of central place hierarchy in 1826, where a central place, measured by distance on a homogenous plain, has a direct effect on land use, economy and population (Moran, 2010). He also posed the question of how location, namely in the physical landscape, was affected by land use; these topographical issues will be considered later.

Within the IND, excavation and surveys carried out by S.K. McIntosh and R. McIntosh indicate that urban centres are self-organised and independent, and indicative of a heterarchical society. The idea of a heterarchical society, which is prominent in the discussion of complex societies in the Americas and is perhaps where the theories were inspired from, is echoed throughout the studies in the IND. A heterarchical society is described by McIntosh (2005) as a non-linear complex system, where individuals learn and provide information about specialised tasks and crafts from their neighbours, rather than waiting for guidance from a trend setter. This is seen archaeologically through an absence of elite burials or any other status indicators.

From the evidence collected in the IND, there is certainly no doubt that ancient settlements here demonstrate a degree of social complexity, but to what degree is questionable from archaeological evidence alone. Theory and hypotheses surrounding the subject of urbanisation in West Africa by the McIntosh's, primarily discuss state formation processes, specialist groups and heterarchy, but this should not be considered an open and shut case. It is suggested by Mattingly and MacDonald (2013:68) that archaeological definitions of hierarchy and heterarchy should be the focus of future debate, and even though these terms are widely used to describe these urban processes in Africa, they require further development. Mattingly and MacDonald (2013:76) also question whether urbanism in the Middle Niger (another term used for the IND) can only be determined as heterarchical, or whether there is another feasible model. These points are important to bear in mind when discussing these current themes, as most theoretical models in the IND are based on the work of McIntosh and Keech-McIntosh and their counterparts, and therefore should be open to interpretation.

As the urban debate in West Africa is consistently growing, it is important to recognise that archaeological work here is still new in comparison to other global contexts where urban societies are more understood. The IND for example, has the potential to have hundreds, if not thousands, of archaeological sites, the majority of which have not been investigated (McIntosh, 2005). There is evidence to show that this area once had a thriving population and society spanning over three millennia, and as Andrews (1995) states, most scholars would accept that urbanism, cultural development, and social organisation are the main traits of a complex civilisation, all of which there is evidence for here. For the time being, research in Mali is suspended in many areas for political reasons, and therefore the work of this project further along the Niger River can add to this debate surrounding early complex societies in West Africa.

Theories surrounding urbanism have been shown as a contemporary problem that researchers are focusing on, and this theme is tackled in this research project. Another debate that needs to be addressed is the methodology used to collect the data to create these theories. Kense, although writing in 1990, makes comments that still hold relevance today, stating that studies undertaken so far show the great scope of West African data; nonetheless the development of the research in the region is not complete. Themes and methods across the region are relatively homogenous, comprised of a standard survey and excavation. Kense (1990) highlights the reluctance to trial advanced methods of analysis, particularly highlighting that techniques for surveying are poorly developed in West Africa, in comparison with the rest of the continent. This is most evident by comparing publications of landscape archaeological research from other regions, which will be highlighted for their advanced methods in Chapter Two. Kense (1990) further comments that advanced methods (for example the use of a magnetometer), should be used to analyse the topography of West Africa, such as vegetation cover and terrain, in order to recover sites and determine size and distribution. Mauny writing in 1953, before the publication of his thesis entitled *Tableau Geographique de l'Ouest Africain au Moyen Age,* also urged for sites to be recovered and recorded extensively. He recognised that ceramic and metallurgic analysis and aerial photography were needed. Alas, over fifty years after these comments were made, there are now many studies considering the material culture of West Africa. The use of aerial photography and advanced survey methods, however, seem to have been neglected. There have been some words undertaken using this technology for example geophysical work undertaken by Magnavita in Chad (Magnavita *et al*., 2009). More recently Randsborg and Merkyte (2010), point out that Africa is archaeologically rich, a 'treasure', which can be used to explore different methods to gain a greater understanding of the organisation and development of ancient society. Thus, one of the major aims of this research project is to fill the methodological gap by using advanced prospection methods and satellite remote sensing imagery.

Production of site inventories, or gazetteers, with adjoining geographic information and maps is common procedure in archaeological practice globally. These can be produced after surveying work is undertaken. It is important not only because it gives an idea of spatial distribution and site types, but it is useful in the preservation and protection of sites. This type of work is not redundant in Africa: notable site gazetteers have been produced through work in the Sahara (see *The Archaeology of Fazzan - Volume 2*, Mattingly, D. eds. (2007)) and work in the Chad-

Cameroon area by Lavachery *et al*. (2010). Given the size of West Africa, there are limited examples where this has been undertaken, compared to the overall amount of work carried out there. Schmidt (2010), whose work in Dia will be outlined later, details the need for an inventory of the sites in her thesis, highlighting that archaeological research in West Africa is still very behind archaeology in other regions. The handful of gazetteer examples that exist focus on prehistoric sites, for example *Carte archéologique des abords du lac Tchad: (Cameroun, Nigeria, Tchad)* by Lebeuf (1969) and more recently MacDonald *et al*. (2009) work at first millennium BC sites at Dhar Néma details site locations in Mauritania. There are two relevant examples of site gazetteers that relate chronologically to the work of northern Benin and this comes from research undertaken at Dia and Méma, two important archaeological regions. The work at Dia in the IND (Bedaux *et al*., 2005) includes a site inventory, as does the work at Méma (Togola, 2008). It is surprising there are not more available gazetteers considering much of the work on urbanism and clustering is based on the spatial distributions of archaeological sites. Having a catalogue of accurate site locations is also important as it has been argued by LaViolette and Fleisher (2005) that in order to fully reveal whether settlements are influenced by their hinterlands, the view which has been used extensively by projects in the IND (e.g., Jenné-Jeno and Timbuktu), major and expensive work is needed consisting of survey, test pits and large scale excavation. However, what will be demonstrated in this thesis is that using spatial technologies in GIS, accurate site locations, and freely available satellite imagery, we can gain an understanding of the site within its landscape without major and expensive work. The publishing of these gazetteers are also important for areas that are no longer accessible.

This section has covered a general array of the current themes and problems that are encountered in West African archaeological research relevant to this thesis and has highlighted ways to tackle this.

1.4.2. Environmental Determinism

One of my principal research questions is to consider the role of the environment in settlement placement in the landscape. There are a range of environments present in West Africa, from the semi-arid but fluvial landscape of Sahel, to the densely vegetated Savanah, all of which would have attracted past settlers. The concept of a human-environment relationship in West Africa was first focussed on in the work of Mauny's *Tableau Géographique* (see Kense, 1990 for discussion). As highlighted, the IND was densely settled in the past and currently the thinking is that people moved from here due to the encroachment of the arid environment from the Sahara coming south, making the landscape hotter and drier, and ultimately uninhabitable (Post Park, 2010). However, there is also the possibility that people moved from the area due to the changing routes of trade, making it economically unstable to continue living in the region. The probability is that a combination of both factors played a part in abandonment. There are also echoes of this debate in North Africa where pre-Islamic society suffered not only from the challenging environment, but also from political and economic shifts (Mattingly and Sterry, 2013).

Environmental determinism is thoroughly discussed in the research of the IND; however, palaeoenvironment data for West Africa are at a coarse level, which is a major drawback of the research that has been undertaken. Palaeoenvironmental research in relation to African archaeology will be briefly discussed here, as it is one of the primary focuses of why settlement came about in this region, and was subsequently abandoned.

The IND itself refers to an area of a former lake of late-Tertiary times, which was drained to connect with the Lower Niger (Harrison Church, 1961). The Niger River and its tributaries are said to be 'life-givers', as water is used for rice cultivation and fishing (Harrison Church, 1961). Archaeologically, rivers are important for the research of settlement. Karmanov *et al*. (2011), states that rivers are often subject to river lateral migration, change of hydrological regime and incision/aggradation cycles which affect both human occupation and preservation of archaeological sites. The Niger River is no exception in its archaeological importance and this is attested to by the amount of settlements that line the river.

The climatic environment in the Sahel region of West Africa, on the whole, has been very changeable as stated by von Hellerman (2010), describing the vegetation and climate history as 'turbulent'. She notes 'catastrophic' dry periods, which took place in Africa around 4,000 and 2,500 BP; this can be seen in vegetation patterns today. She also states that historical records show dry and wet phases. This is echoed in the work of climatologist S.E. Nicholson (2013) who analyses rainfall regime in the West African Sahel. Work by Post Park (2010) focuses directly on the climatic situation within the IND, particularly around his study area of Timbuktu. Here, climate phases for the Holocene are only partially constructed, so it is difficult to determine the exact effect that climate had on past society in the area, however, he comments that climatic conditions in Timbuktu were strenuous (Post Park, 2010:9). Post Park further indicates that more climate data are needed, which is a general consensus of the region. One key paleoclimate study in West African research was undertaken by Mayor *et al.* (2005) when considering the Dogon Country in Mali. This work considered numerous sites that were exposed by erosion and evidence taken from the stratigraphy revealed human occupation from the Lower Palaeolithic to present times.

Comparatively, East Africa is in a similar situation. Like West Africa, the palaeoenvironmental records lack a sufficient resolution to be useful in correlating it with settlement and land use chronologies. Research in East Africa has shown that there is no clear trend towards increasing or decreasing aridity, and there is evidence to suggest that there are major fluctuations of both extremes. This is emphasised in the work of Davies (2012), who acknowledges the need for a long-term analysis of the human-environment dynamic, which includes the on-going analysis of current climate and environmental changes to analyse reciprocal human response (Davies, 2012). Again, this highlights the need for more research to be undertaken in sub-Saharan Africa to understand such dynamics.

Like the debate in West and North Africa, consideration for both natural and human impacts of the environment is considered by Davies (2012). For example, is soil degradation a product of climate change or was it an anthropogenic influence, such as intensification and decrease in demand in some areas? Davies (2012:320) recognises that archaeologists may be ‘missing a trick’ here within their research, particularly as archaeological data can be used to analyse land use, which can illustrate change in environment, resources, sustainability and demography. Davies’ approach to settlements is advancing on the theories that were built by the McIntosh’s in the Middle Niger, which make theoretical progress towards looking at the natural effects of the environment but lack data, and rarely consider the human impacts. Contemporary scientific studies on human impact on the environment reinforce Davies' hypothesis. Land use and land cover change are a key component of global change; uncontrolled development of the land deteriorates the environment, and leads to loss of productive agricultural lands (Salifu and Agyare, 2012).

What can be taken from this section is that the palaeoenvironment is an important aspect of the research of settlement in West Africa and may lead to answers about how settlements formed in the area, and why they were abandoned. Davies (2012) pinpoints the usefulness of tracing settlement patterns and demographic trends, which act as markers for change in land-use of areas. There is certainly a difficulty at the moment with correlating settlement and land use with palaeoenvironmental records. This research will consider settlement patterns, changes in land cover through satellite imagery and modern population, so that potential inferences can be made about human and environmental impacts on the landscape, which will help us understand the historic environment.

1.5. Case Studies

Having discussed recurrent themes in West African archaeological research, this section will now give an overview of individual case studies found in the IND region, Mali and the nearby Niger Bend. Consideration of methodology and results will be made, so that the main concepts can be taken forward for this research. This area is often described as archaeologically rich, where thousands of settlement mounds similar to tell-like occupations are spread throughout the landscape and line the river systems. These sites range in date generally from the first millennium BC to first millennium AD. The cases are being illustrated here as they resemble the archaeology found in northern Benin and are broadly contemporaneous with sites discovered during the *Crossroads* project. The methodologies used and theories that manifested will be considered in relation to the research within the Niger River Valley.

Figure 1.7 Map showing the location of the archaeological sites within the IND. Red polygon illustrates the location of the study area in Benin.

1.5.1. Jenné-Jeno

Extensive research by S.K. McIntosh and R. McIntosh, since the late 1970s, revealed the complex landscape and settlement structure of Jenné-Jeno dating to the late first millennium BC, and being abandoned around AD 1400. This was the first sustained study of archaeological settlement patterning in West Africa that drew on modern methodologies and analysis. Initial investigations at Jenné-Jeno had an emphasis on the cultural significance of the upper IND, based on the pottery assemblage of the area. In their investigation, themes such as urbanism are prominent; here urbanism is understood as being manifest through the clustering of settlements (McIntosh, 1995). This fundamental concept has been echoed throughout the other studies in the IND, including all the sites that are described within this chapter. Many scholars use site clustering as a signpost for urbanism based on the work at Jenné-Jeno. The Sahelian landscape of Jenné-Jeno bears striking similarities to the study area of this PhD research, 800km away along the Niger River, where settlement mounds are also a noticeable landscape feature.

Settlements that cluster together are seen to demonstrate evidence of heterarchy, where settlements work together for social and economic functions (McIntosh and McIntosh, 2002). Generally this type of archaeological site appears as a sizeable settlement mound, which has an area of between 20 and 80 hectares and an elevation of up to 10m; it is enclosed by smaller mounds in the vicinity of 200m (LaViolette and Fleisher, 2010; S. McIntosh, 1999). During work at Jenné-Jeno in 1977, 404 sites were discovered using aerial photography and field survey, and of these 65 (16%) were clustered within 4km of Djenné. McIntosh (1999). Of the 42 sites randomly selected for surface investigation, three quarters of sites had material no later than Phase IV (AD 100-1400), indicating abandonment during that phase. It is evident there is a higher degree of clustering in the Niger River Valley than the IND.

The sites around Jenné-Jeno were discovered over a long period, with varying methodological survey techniques used in each season of field work. The initial stages of the survey focused on mapping sites and taking surface collections. This [work] was later followed by deep excavation (McIntosh, 2005). Research by Clark (2003) made a further development on the work conducted at Jenné-Jeno. In her PhD thesis, she identified a very complex settlement dynamic within the site clusters, not quite as straightforward as site hierarchies, but in one urban area she discovered that there were multiple 'focus' sites that each had their own satellite sites and sub-clusters (Clark, 2003; R. McIntosh, 2005). Furthermore, she identified specialist economic activities within these sub-clusters, this gave rise to the new definition of the urban centre at Jenné-Jeno, which is now interpreted as a 'clustered city… [of] segmented community specialists who voluntarily come together to take advantage of the service of others and to exploit the larger market for their products, but who maintain physical separation in order to reinforce their separate identities' (R. McIntosh, 2005:185).

Many sites were identified during field walking surveys at Jenné-Jeno. The sites were then mapped and shown through basic distribution maps available at the time. The research at Jenné-Jeno provides a good comparative case. However, the research project outlined here aims to develop a solid grounding between settlement evidence on the ground within the physical landscape through the use of satellite remote sensing and GIS. This is so that subsequent theories developed on the spatial distribution of sites is based on substantiated evidence, and not just basic distribution maps such as those provided at Jenné-Jeno.

1.5.2. Dia

Dia is a significant complex of settlement mounds that lies in the southern part of the IND and includes Dia-Shoma and Dia-Mara, the cultural occupation here dates to around the first millennium BC – first millennium AD. Early work by Haskell *et al*. (1988) pinpointed the environmental deterministic nature of settlement in the area where he states that site clusters deteriorated and became abandoned after the disappearance of the marigots, small lake areas where people could obtain water, highlighting the importance of the environment for the survival of large populations of people.

On the contrary, research by S.K. McIntosh (1995) does not place major emphasis on the environmental factors that may have influenced the abandonment of settlements at Dia, but focuses on economic and trade reasons, disagreeing with her previous findings in the work of Haskell *et al.* (1988). S.K. McIntosh (1995) notes that new sites that arose in the area did not occur near flowing marigots, and states that environmental factors were not an influence. Instead, commercial opportunities elsewhere were the reason Dia became abandoned between AD 850 and 950, which were 'rapid and widespread' (S.K. McIntosh 1995: 375-376).

Extensive work was later carried out by Bedaux *et al*. (2005) who document around 100 sites in a gazetteer. The innovative catalogue provides geographic locations of a range of archaeological occurrences that were found during prospection, including the size of site, type of site, and material culture found. The significance of this catalogue is that it leaves scope for the landscape to be analysed in detail in the future. This also includes a record of archaeological features which are not analysed in the main text, such as potsherd pavements.

The study by Bedaux *et al*. (2005) provides an interesting comparative example for the work in northern Benin, as the archaeology described in the gazetteer is similar, including the presence of pottery pavements which have now been noted in the Dendi region by the *Crossroads* project.

Schmidt (2010) carried the work at Dia forward methodologically, adding to the gazetteer and conducting a comprehensive survey of the area unlike ones that came before. Schmidt (2010) started her investigation using three complementary methods: regional survey, site survey and excavation. Geographical information systems were used to compare the distribution of sites with their geomorphological setting; this was used as a tool to infer the occupant's site selection strategy. This feeds into the theme of environmental determinism for the choice of site, based on natural characteristics of the topography (Schmidt, 2010). The prospects and limits of this method are considered by Schmidt (2010) and are important to bear in mind for this PhD research, which is similar in scope and aims. It is acknowledged that survey offers the opportunity to set out the regional diversity of settlement distribution; however, only excavation can reveal a detailed chronology, but it cannot be undertaken on every site encountered (Schmidt, 2010). Nevertheless, the major conclusions of Schmidt's (2010) work suggest that the Dia area manifested important urban traits. Within the complex of settlements there was homogeneity of material culture, which suggested that there were close contacts between the urban centres and the surrounding hinterland (Schmidt, 2010). It is questionable whether this urban development came about because of the ecologically rich nature of the Niger Delta that meant there was a diversity of resources or the advance was due to trade contacts (Schmidt, 2010). However, settlements were found no less than 300 metres from the river, illustrating the significance of the Niger as a natural resource.

Methodologically work at Dia conducted by Bedaux *et al*., (2005) and Schmidt (2010) offer approaches that are quite innovative for the region. For each site, size and exact geographic location were recorded, along with associated surface material culture. Furthermore, excavation of some sites was undertaken, to obtain a detailed chronology, revealing most importantly the abandonment phase so that inferences can be made as to why this once heavily populated area is now sparsely populated. Schmidt (2010) makes the important observation that the whole region has not yet been covered, and a chronology of every site found cannot be made yet. A site gazetteer and GIS were important tools used in the Dia research and these methods will be used within this doctoral research in a similar fashion.

1.5.3. Sadia

More recently, the works of Huysecom *et al*. (2015) in Sadia on the Seno Plain (Dogon Country, Mali) highlight that research considering West African settlement mounds is lacking, and as a result they are still poorly understood. To understand the emergence and development of these mound complexes, Huysecom *et al*. (2015) argues that chronostratigraphic information is needed, along with cultural, economic and environmental data, all of which is generally lacking from other research projects in the region. However, this type of analysis was carried out at the site of Sadia, where a complex of settlement mounds was excavated. The main results of this 15 year project showed that many settlements of a similar size were established between AD 750 and 1250, demonstrating the development of rural and non-centralised societies (Huysecom *et al*., 2015). Furthermore, it is argued that these settlements were self-sufficient and politically independent of the urban centres of the IND (Huysecom *et al*., 2015).

An in-depth survey of Sadia carried out by Loukou *et al*. (2013) showed that there was a cultural homogeneity between 14 settlement mounds sites that were revealed in the surrounding area. This was shown through the presence of surface ceramics which all demonstrated similar decoration, apart from two sites which were drastically different (Huysecom et al., 2015; Loukou *et al*., 2013).

Using the holistic approach at Sadia consisting of survey, excavation and environmental data demonstrates the depth of knowledge which can be reached when developing theories about the past dynamics of the area.

1.5.4. Méma

Another region which has seen important research undertaken relevant to the study of Dendi is the Méma region of Mali. Here there is an interesting array of settlement evidence, encompassed in deep alluvial deposits west of the seasonally flooded IND. A record of settlement distribution was undertaken in this region by Togola (2008) through survey and excavation, revealing a range of sites, where most dated to the late first millennium BC. Like this research project, Togola (2008) aimed to locate sites in an area which is previously unknown but exhibits substantial potential for settlement evidence.

The regional survey undertaken within the Méma recorded over 130 sites, which like Dia, saw settlement size recorded and mapped. Sites were discovered by field walking conducted across different geomorphological zones. Archaeological sites here took the form of settlement mounds, or *tells,* which have a striking resemblance to those found elsewhere in the Middle Niger. It was not clear whether there were more sites to be discovered in the region as a range of difficulties in the field meant that only thin transects could be made (Togola, 2008).

Like elsewhere in the IND, settlement mounds showed evidence of clustering, calculated by measuring the vicinity of mounds from one to another. Over 75 percent of the sites appear within a group of 13 clusters, illustrated on a map. The clusters were analysed chronologically by the material culture found on the surface, and it became apparent that the abandonment phase was the same throughout all of the sites encountered (Togola, 2008). It was the size of the sites that varied considerably through the dates of the birth of the site. The earliest sites had the smallest mounds and measured to less than a hectare in size, and were found in packed clusters, whereas later sites had a high concentration and larger mounds, with most sites 10-20 hectares in size (Togola 2008:16). The latest sites in the region were in the minority, and were small, between one and three hectares.

The results presented by Togola (2008) for the Méma region are encouraging because it shows the scope of information that can be revealed from a regional survey. There is however some drawbacks of the survey which include the small area covered, perhaps biasing the results. There is large potential to find more sites in the area, which would further validate the observations from the original survey. Also, Togola (2008) did not publish a site catalogue, so no geographic reference is known about the sites that were discovered. This is surprising as the work presented ample discussion on the distribution of settlement. Overall though, mapping site distributions is useful for areas that have not yet been investigated, as it gives an informed overview of the ancient landscape in a particular region.

R. McIntosh's (2005) discussion of the settlement sites of the Méma region uses the study as an opportunity to further test the implications of the natural environment and its influence on settlement location, particularly considering the bio-physical landscape. Méma is used as a testing ground to show a 'geokistic' approach to analysing settlement (R. McIntosh, 2005:98). Geokistic is a term used to describe the suitability of a settlement within its geomorphological setting and can be used as a predictive model for site location. It takes into account several factors including movement and access in the landscape (e.g. slope, aspect, relief, geological hazards), and topographical matters that may affect vital resources (R. McIntosh, 2005). The concept first introduced by Hassan (1985), states that this may be used to explain the placement of settlement. However, the use of a GIS for analysing movement in the landscape is a more contemporary and widely adopted method for this analysis and used in other regions for settlement research - this will be outlined further in Chapter Two. R. McIntosh also adopts a more universal approach by mapping the geomorphology and hydrology of the region using satellite imagery, which gives a clear outlook on the nature of the landscape. It shows the diversity of the geomorphology in the region. It would have been useful then for McIntosh to take this and apply the same understanding as he did the 'geokistic' diagram.

The overall conclusion from the Méma region is that environment was the main factor for abandonment. S.K McIntosh states that Méma appears virtually depopulated by c. AD 1300- this was due to the same arid conditions that motivated the abandonment of Kumbi Saleh, Mauritania. Survey and mapping were useful tools to illustrate site clustering, which is indicative of urbanism. Furthermore, use of satellite imagery is also worthwhile in putting sites into it geomorphological context. Again, all of these considerations will be adopted within this research.

1.5.5. Timbuktu

Research of the prehistoric, Late Stone Age (c. 500-400 BC to c. AD 900-1000) settlements around Timbuktu carried out by Post Park (2010) considers prehistoric urbanism, shown by mapping settlements within the hinterland. Post Park (2010) offers some of the most advanced types of settlement analysis methodology undertaken in the Niger River region, building on his landscape interpretation using climatic data where possible and elevation in the landscape.

During the survey (which first took place in 1984 by S.K. McIntosh and R. McIntosh and then again in 2008 by Post Park), transects were conducted between the palaeo wadi el-Ahmar and Timbuktu. A total of 192 sites were discovered in the area. Once again, settlement mounds were revealed, with large central mounds (between 10 and 40 hectares) which had three to 9m of material culture accumulation (Post Park, 2010:3). There were also smaller sites which are regarded as satellite sites, surrounding the central sites. Post Park (2010) extensively mapped four of the settlement clusters, which occurred within close proximity to the palaeo wadi.

Post Park’s survey concludes with a working hypothesis, as further work is required to get a definitive overview of the prehistoric settlements within the landscape. He suggests that temperamental environmental conditions played a major role in the abandonment of settlements, yet the research only provides secondary data as evidence, which is incomplete. The approach Post Park (2010) takes to the research in Timbuktu will be echoed to a degree within this research project, by using a range of data to complement the research. However, it intends to go a step further in integrating landscape topography and environmental conditions to settlement patterns, in order to provide detailed analysis of past people’s interactions with the landscape.

1.5.6. Bentia

Like the research at the IND, the Niger Bend also has evidence for ancient settlements and two cases will be highlighted here for their methodology in recording them. Arazi (1999) working in eastern Mali, south of the Niger bend recorded sites in a region that had not been investigated previously, much like the area of northern Benin under investigation here. Arazi's (1999) aim was to systematically record sites in the area, from remains found on the surface, and collect various data associated with them for a better understanding of the region. This information included locational coordinates, site size, surface features, artefacts, and a broad chronology gained from the material evidence (Arazi, 1999). Due to economic constraints, there was no excavation and only 40 km^2 was covered over two transects.

The study analysed surface pottery and lithic evidence, illustrating continuous occupation since the second millennium BC (Arazi, 1999). Settlement was evident along the Niger River and its tributaries (something that became apparent in northern Benin during the 2013 field survey). Arazi (1999) points out that this is due to the river's function for agricultural production, particularly in the floodplains. Furthermore she argues that the rivers enabled social and economic interactions. The methodology demonstrated here is sound, and a similar set of site traits will be collected for the sites along the Niger River in Bénin where a wider area will be surveyed.

1.5.7. Overview of case studies

The featured analyses of settlement within the IND landscape are innovative for landscape archaeological research in West Africa; previous work had been limited only to single site investigations. Nevertheless, some research strategies are based on outdated techniques, where sites are recorded during a non-systematic survey, or accurate maps and gazetteers are lacking. As we will see in Chapter 2, sophisticated survey and GIS techniques are consistently being undertaken in Mesoamerican and European archaeology, to analyse settlement, and these types of methods would benefit research in West Africa. Such methods are being neglected in the landscape archaeology of West Africa, perhaps as it does not offer impressive architecture or obviously opulent archaeology as do Mesoamerican and European sites (McIntosh and McIntosh, 1993). Nevertheless, the archaeology of this region should warrant the same methods, which are being used to aggregate and enhance theoretical interpretations of the landscape. At present, methods used in GIS are being carried out in settlement studies, and are now widely adopted in archaeology. Katsamudanga (2010) identifies the lack of GIS methods in sub-Saharan African archaeology. This is evident from the studies undertaken in West Africa and this research aims to use this study area to illustrate the usefulness of these methods in this region. Given the vast ancient geographies of concern and the comparatively limited resources available to archaeologists, geospatial technologies are likely to play an increasingly significant role in archaeological research, including in Africa.

1.6. Research aims and objectives

The overall aims of the project, which tackle two major issues, are the basis of the research questions outlined here. The first problem is that the archaeology of the Niger River Valley in the Republic of Benin has had limited exposure to research compared to other areas of West Africa; therefore procurement of information of sites in the region is imperative as a first step. Secondly, West African field survey strategies and the use of certain technologies are in some aspects generations behind those that are carried out in other global contexts. Because of this, methodologically this research aims to draw on a combination of GIS and survey methods used elsewhere for a more holistic up-to-date approach.

This research is intended to ultimately give an understanding of how the environment has impacted organisation of settlements in the area. Accordingly, four research questions will be considered:

- How can we systematically and accurately record the distribution of archaeological sites and surface artefacts in the landscape and how will this benefit cultural heritage management of the area?
- To what degree does the environment influence settlement and material culture patterns?
- To what extent is this an urban landscape, such as those noted in other areas of West Africa, including the Inland Niger Delta (IND)?

- How useful are desk-based methods, specifically GIS and satellite remote sensing, in investigating the archaeology of the region?

The first focused area of research in this thesis will consider how to record the distribution of settlement and material culture in the landscape, and how this may benefit cultural heritage management in the region. This research question will be achieved by conducting a systematic field walking survey, compilation of a site and material culture gazetteer, and production of accurate maps to establish spatial patterns which in turn will help us understand past human activity in the region. Densities and type of material culture, particularly ceramic decoration will be quantified to establish whether there are cultural differences between sites. Also size of sites in the region will be established. Survey is useful as a primary method of investigation as a wide coverage can be obtained. It is a quick, non-intrusive and effective method used to characterise the landscape.

The second research question seeks to consider how far the natural environment determines where people settle. This will be achieved in several ways; firstly, sites discovered will be mapped within the landscape, so that the interactions between people and topographic and geomorphological landscape features can be assessed. As the Niger River and its associated tributaries are a key aspect of the landscape, human-environment interactions with this fluvial system will be a significant focus. Much of this work will be done with the use of satellite imagery, where not only surface water can be identified; changes in these fluvial areas can be recognised. Furthermore, analysis of satellite imagery will also consider other variables like vegetation and elevation of the landscape as environmental characteristics that would influence past settlers. What can satellite imagery tell us about the surrounding environment? What types of features in the landscape are the most attractive for settlers? How does the environment influence the distribution of material culture between sites?

The third research question considers evidence for an early urban landscape within the Niger River Valley, similar to those cited at the IND, Mali. Is there archaeological evidence to verify an urban culture? This will be achieved by considering site size, which has been highlighted as an indicator for urbanism. Also, the distribution of material culture, particularly ceramic decoration will be analysed for patterns. Evidence for craft specialists in the landscape will also be considered, such as the distribution of iron working remains in relation to settlement sites.

The fourth research question focuses on the methodological potential within this study by using field survey, GIS and remote sensing methods to analyse the landscape. This will be outlined in further detail in Chapter Two by considering research from other areas away from West Africa. This research question aims to investigate how much information can be gained about the study area in north Benin by using satellite remote sensing and techniques used in GIS. Furthermore, it has been identified in general that there are a lack of GIS methods in sub-Saharan African archaeology (Katsamudanga, 2010).

Overall, the aims and objectives broadly set out to expand our knowledge of how people in this region were using space and their environment in the past. The research will consider four main research questions; spatial patterns in the landscape will be quantified, the extent of environmental determinism will be assessed, evidence for urban culture will be considered, and finally an overall evaluation of desk-based studies will be made. The next section will briefly outline the background approach to the methodology.

1.7. Outline of Thesis

The thesis is divided into seven chapters, and this section will outline what will be found in each chapter.

- Chapter Two: Methodology in Landscape Archaeology

This chapter will discuss research that has been undertaken in landscape archaeology across the globe, outside of Africa. These examples are relevant to the study of the Dendi region as the landscape and situation of the archaeology are similar, and the methodologies discussed will be tested later in the thesis. The chapter is divided into three broad sections: field walking and survey, remote sensing and the use of GIS. The use of GIS and satellite imagery in archaeology is common procedure in many archaeological projects, so this chapter will highlight where this has been successful and how it can aid as a tool in our understanding of the Dendi region.

- Chapter Three: Fieldwork Methodology

This chapter outlines the fieldwork methodology that was undertaken in the study region. The fieldwork for this research consisted of field walking for prospecting of archaeological sites. The chapter first considers the methodology of the *Crossroads* project, who conducted field survey between 2011 and 2014. Then, considering the *Crossroads* methodology, along with examples cited in Chapter Two out of an African context, the methodology for this research project is outlined. This includes explanation of equipment and survey sheets, transects walked, site identification and recording and material culture collection and recording. Furthermore, the methodology for cataloguing material culture and photographing in the field is outlined.

- Chapter Four: Survey Data: results and analysis

This chapter discusses the results and preliminary analysis of the data obtained during fieldwork. First the entire study area results are considered, including total sites found and material culture quantities and types discovered. Then the chapter discusses the results of the field walking broken down into the four areas surveyed. The survey areas vary geographically and topographically to test whether different groups of people were populating the landscape. Distribution maps and tables and graphs will show the variation of archaeology and material culture between each survey area.

- Chapter Five: The Landscape and Spatial Analysis

This chapter examines the Dendi landscape archaeologically by using remote sensing and GIS methods that were discussed in Chapter Two. Satellite imagery of the area will be studied in relation to the position of the sites found, particularly considering the geomorphology of the landscape. High resolution satellite imagery will be analysed for the potential of site discovery away from the field. Medium resolution satellite imagery will be scrutinised for its capabilities of analysing the environment of the landscape. Also, GIS spatial analysis will be conducted to reveal patterns in the landscape, looking principally for site clustering, which is seen in other areas of the Niger River.

- Chapter Six: Discussion

The results that were generated from the field walking survey along with the GIS spatial analysis and satellite imagery examination are discussed within this chapter. These results will be deliberated in relation to the themes, the research questions and objectives that are outlined in the first chapter.

- Chapter Seven: Conclusion

This chapter will outline the final conclusions of the thesis, particularly highlighting the project's unique contribution to research in the region. Furthermore, this chapter will provide a framework for future research that can be conducted in region, and argue the case for the use of desk based methods such as GIS and remote sensing in analysing unknown landscape.

Chapter Two: Methodology in Landscape Archaeology

2.1. Introduction

Spatial analyses of archaeological phenomena, such as artefacts and settlements, are common procedures in landscape archaeology and a wide range of methodologies are available for approaching this. Theories around space in archaeology are also significantly developed, and looking at people's use of space can provide insight into behaviour and social organisation. As detailed in Chapter One, a key aim of this research is to consider the spatiality of settlements within the Sahelian landscape of the Niger River Valley, in the Republic of Benin, by using survey, remote sensing and GIS spatial analysis methods.

This chapter will discuss the background to the methodology used to collect and analyse data for this thesis. It will draw from examples of other research projects outside Africa. The methodology for this research uses GIS and remote sensing based techniques that have been implemented successfully elsewhere with good results. A number of case studies are outlined in this chapter, chosen because the research questions seek to address the objectives of the present research project. For example, cases will be highlighted where survey is used to establish a historic characterisation of the landscape, satellite remote sensing is used to analyse the natural environment and identify sites, and GIS methods are undertaken to understand spatial patterns, so that the themes of urbanism and environmental determinism can be explored. Firstly, this chapter will consider field walking survey techniques, the main method used for site prospection in Benin throughout this project. The chapter will then go on to discuss the use of satellite remote sensing and where it has been used effectively in other regions, particularly in mapping the landscape, quantifying vegetation, and using multispectral bands from the imagery captured to see features that may otherwise have been invisible. Lastly, the chapter will discuss spatial analysis methods used in GIS, in relation to case studies where the methodology has been implemented. As discussed in the previous chapter there is a distinct lack of remote sensing and GIS use within West African archaeology, and it is only now starting to be recognised and adopted. This chapter will show what can be learnt from other examples around the globe.

Prominent studies that have successfully used GIS methods include the Göksu Archaeological Project and Avkat Archaeological Project both based in central Anatolia, where GIS was used to accurately show land use patterns and artefact densities within their geomorphological setting (Newhard *et al*., 2013). As discussed in the previous chapter, land use and geomorphology are important indicators in understanding human-environment interaction and a combination of such data is needed in the Dendi region. Another notable project, the Kythera Survey Project, uses comparative GIS methods in its analysis of the Greek island, by combining environmental, archaeological and historical viewpoints to consider the landscape and place their findings in the wider Mediterranean context (Bevan and Connolly, 2013). Artefact and settlement data distributions were recorded around the island, and after extensive spatial analysis it was revealed that there was abandonment and recolonisation of whole areas. The advantages of implementing GIS tools into the methodology can be seen through these examples. Particularly, its ability to store information, detect patterns and compare different types of data. This use of GIS will aid in answering the research questions outlined in the previous chapter, particularly considering settlement and material culture distribution and patterns, the environment of the Dendi region, and the use of desk based methods in archaeological investigation. With this in mind, the following sections will take a closer look at how these methodologies were implemented in non-African contexts and how they have been used within this research project.

2.2. Field walking and survey

Systematic field walking (if the area is accessible) is common procedure in any landscape when attempting to make an historical characterisation of the area by identifying archaeological remains. This section will consider field walking and survey methodology when prospecting for archaeological sites, with the main aim (as outlined in Chapter One) to determine accurate settlement and material culture distribution in the landscape. The considerations made in this section were used to devise the survey strategy for this research, which is outlined in the next chapter. A significant issue to consider when discussing field survey and one which will be highlighted by scholarly examples is post-depositional processes. Finds are rarely, if ever, *in-situ* and have suffered some degree of disturbance either from anthropogenic or environmental influences, therefore finds must be treated with a certain degree of caution. Regardless of this, field survey has been proved to be the most effective way for site discovery and an advantageous and quick way to decipher the landscape which has been used for decades (see Banning, 2002; Foley, 1981; Schofield, 1991).

Published survey methodologies have rarely been considered in detail by West African archaeologists. Mentions of 'regional surveys' are frequently made, for example, from the case studies cited in the previous chapter, Jenné-Jeno (S. McIntosh 1995), Méma (Togola, 2008), but they do not detail specific methods other than mentioning the use of field walking and an explanation of total area covered. The authors do make inferences about the archaeological visibility in the landscape, where mounds are very obvious to spot, therefore making it easy to conduct a survey. It would have been useful for these texts to outline considerations such as transect spacing, what recording strategy had been used, and the type of surveyors used, in the same way excavation methods are discussed in some detail at Jenné-Jeno (S.K. McIntosh, 1995:25). Because this type of detail is lacking from West African examples, consideration for other examples away from the African context will be used here, where methodological advantages and disadvantages have been outlined comprehensively. Furthermore, as archaeological visibility in the Niger River Valley is not always as good as the settlement mounds identification in the IND, case studies that consider surface material are also drawn upon.

There are few texts that discuss pure survey methodology explicitly without intertwining it within specific research undertaken in the field. Banning's (2002) book *Archaeological Survey,* is one example. A reason for this is that every study region is different and ultimately a survey methodology must be devised that best fits the geographic area and resources available. Banning (2002) discusses the particulars of a general field walking methodology, including transects, which are important to consider within this research of northern Benin. Using transects during archaeological field survey is the most traditional method carried out, the length and spacing of transects are dependent on the type of area and sites that are being analysed. The main aim of the survey is to walk the maximum coverage accessible while still being able to identify sites and artefacts accurately, and this is usually dependent on the resources and personnel available which has to be modified accordingly. Parallel transects are a very common form of arrangement to cover a survey area; however, they may be the most difficult depending on the terrain and other mitigating circumstances, such as access to a vehicle (Banning, 2002). This type of transect involves surveyors walking parallel to each other, usually over a long distance, following a coordinate or bearing. Walking in transects can also disturb the cost-effectiveness of a field survey, which is vital within a West African context as both time and money are often limited. It is commented that line walking in transects varies in the amount of time taken to cover an area dependent on the spacing between people - the wider the spacing, the less time it takes to cover a predefined area Fasham *et al*. (1980) . The line walking methodology discussed here follows common procedure and practice and is well-documented in many archaeology manuals found online such as ‘What is fieldwalking? – Cambridge Archaeology Field Group’ and ‘Fieldwalking Survey – Archaeology Skills Passport’. However, although this process is described simply by Banning (2002) and outlined in manuals, there are other important considerations that must be addressed when conducting field walking and they will be discussed here.

Banning *et al.* (2011) acknowledge that there are limited examples of research that explicitly explain their field walking method, particularly the effectiveness or reliability of detecting surface artefacts. This appears evident in publications of surveys in West Africa (shown in Chapter One), therefore this thesis tackles this problem directly. It is well documented that the collection of surface remains is the only satisfactory way of assessing artefact density and studying the types of artefact involved; it can also be used for calculating degree of fragmentation (Fasham *et al*., 1980). Banning and colleagues demonstrate an experimental approach measuring the detection ranges in terms of 'sweep width' based on a hypothetical artefact distribution. Width (*W*) of transect is dependent on the following:

$$W = \text{(Detection rate)} / \text{(Artefact density*search speed)}$$

Where detection rate is the number of artefacts found per minute, the artefact density is the number of artefacts per m^2, and search speed is in metres per minute. Such a model is applicable to many surveys and Banning *et al*., (2011) demonstrate the effectiveness of precise measurements of detection. However, in the case of northern Benin where time is limited and there is a large area to cover, conducting such experiments in transect spacing may inhibit rather than perpetuate identification and collection of material remains. Therefore it is not always possible to have a strict field walking strategy, but consideration has been given to the best transect spacing and will be discussed in Chapter Three.

There are several case studies that discuss the problems that may be associated with field walking and are worth bearing in mind for the methodology used in this research. Haselgrove *et al*.'s (2007) book *Archaeology from the Ploughsoil,* which is a compilation of papers on field survey resulting from a conference held in 1982 outlining case studies from UK based work, comments that unstratified surface material is vital; particularly to bridge the gap between excavated sites and those that cannot be excavated, and in some cases it may be the only kind of evidence available. But, there is often little debate on its interpretation as it is often taken at face value, therefore a collection strategy using sampling must be put in place. Furthermore, one must recognise that artefacts visible on the surface are a minimal percentage of the overall assemblage of that area (Haselgrove, 2007). It is said that to increase the confidence in the sample collected field walking must be undertaken over a delimited zone that incorporate systematic surface collections, as it is argued that archaeological inferences can only be assumed if this is achieved (Haselgrove, 2007). This is further echoed by Mills (2007), who states current knowledge of the natural and human landscape under investigation is essential for the design, implementation and interpretation of survey strategy. Also, when designing an adequate field walking programme, the region under scrutiny must be divided into different zones based on geology, pedology and topography, to offer different interpretations of settlement and land use (Mills, 2007). This is also highlighted by French (2007) in the same volume, where he states that ecological context of survey needs to be taken into consideration.

Surveyor bias is another aspect to consider when conducting systematic field walking, thus it is valuable to acknowledge this when considering the limitations of the survey methodology. Mills (2007) suggests that to limit bias the person implementing the survey must have a broad knowledge of artefacts from the period, with an understanding of how their distribution patterns may be affected by weathering and mass movement (Mills, 2007). Also, Haselgrove (2007) makes the important assessment that variable recovery and visibility between different surveyors will alter perceptions of the results; this is simply because some field walkers are more proficient than others. Therefore, an aim must be to make the survey methodology as consistent and easy to follow as possible, with few variables, which can be implemented with the use of structured recording forms.

As stated, the use of record forms or survey sheets can reduce bias between field walkers. In general, the survey technique and methodology literature tend to cover quite technical mathematical models for field walking and material culture collections, for example Banning's (2002) *Archaeological Survey,* and there is limited information on documentation of survey findings in the field. Observably these are dependent on the type of survey being undertaken but it seems that this information is often assumed, but would be useful to document, in the same way excavation recording methods are well documented. Nevertheless, White and King (2007) make some important considerations for physically recording sites on the ground, which have been absorbed within the survey method for this research. They state that one surveyor should be responsible for writing the documentation of the site, such as assigning a unique site number which is written on the site record sheet and on a tag to be placed with the artefact collection. Using only one member per team to do this task reduces the risk of inconsistency which would add bias to the results. White and King (2007) also state the importance of a site sketch map and photography. They encourage such practice because a sketch and photograph can depict natural and archaeological features, artefacts on the ground, and often provide enough detail for visitors to come back to that site (White and King, 2007). However, we must be aware that sketches are based on the surveyor’s perception, which will differ from person to person; nevertheless, the use of sketches and photographs are useful.

Generally there appears to be a lack of transparency in describing standard and basic field walking survey techniques in archaeological works. Instead, research on survey methodology has evolved in recent years to feature highly technical advancements, which may not be practical in real world examples, particularly in West Africa. The term high-density survey and measurement (HDSM) has been coined by Opitz and Limp (2015) which summarises these developments appropriately. HDSM brings together the emergent suite of technologies being used in survey including; airborne LiDAR, real-time kinematic global navigation satellite system and global navigation satellite system (GNSS), global positioning system (GPS), robotic total stations, terrestrial laser scanning and unmanned aerial vehicle (UAV), structured light scanning and close range photogrammetry (also known as structure from motion) (Opitz and Limp, 2015). Using these technologies are supporting data acquisition for recording form, location and orientation of archaeological remains, with relatively little time and expense according to Opitz and Limp (2015). It is evident that these technologies are shaping a new generation of survey techniques and this can be seen for example from Howland *et al*. (2014) who uses 3D technology in the Near East, and Hare *et al*. (2014) who uses high-density LiDAR for the mapping of the ancient city of Mayapán, Mexico. However, what the authors fail to acknowledge is that appropriation of some of these technologies can be very expensive or impossible to use in some contexts. For example, airborne LiDAR for mapping terrain and archaeological sites at a high resolution in the Benin study region would not be possible due to accessibility. These technologies are noted here as they would be extremely useful for future research in West African contexts. Nevertheless, the research methodology implemented for this research project focuses on the more attainable technologies such as GPS and GNSS, which can pinpoint archaeological phenomenon anywhere on the globe using a handheld device.

Overall, the examples given in this section highlight some important issues for consideration that are taken forward into the field survey methodology conducted within this research project, which are detailed in depth within Chapter Three. As demonstrated in this section, Mills (2007), acknowledges that many field walking techniques exist and before conducting a strategy one must realise that the range and limitations of their survey requirements may vary from area to area, therefore no single technique can be regarded as ideal. This is particularly relevant in the Benin study area where fieldwork conditions are not ideal; for example, the study area has heavily dissected terrain which is not always accessible, even on foot, and the harsh climate is often challenging for the surveyors. Furthermore, spacing of field walking transects impacts identifying surface material which is vital; particularly to bridge the gap between excavated sites and those that cannot be excavated. Spacing also has an implication on the time it takes to survey, all of which is taken into account for the survey of the Dendi region, so that maximum coverage and archaeological visibility of surface material is obtained. Lastly, bias can be limited by consistency in the methodology and structured recording forms; both of these have been developed for the survey outlined in this research. All of these considerations are detailed in Chapter Three. The next section will discuss the use of satellite remote sensing for mapping and analysing the broader landscape to set the context of the archaeology.

2.3. Remote sensing and mapping

As has been stated, knowing and understanding the landscape and topography of the study region under investigation are imperative to the successful implementation of the survey, and this can be achieved using satellite imagery. The use of satellite imagery in this research aims to investigate two research questions which were outlined in Chapter One; the first considers how much information can be gained through desk-based methods, and the second is to understand to what degree the environment affects settlement placement preference. Both of these questions can be explored using information from satellite imagery. The following section will consider how remote sensing and mapping has been used in archaeological contexts to achieve this and how it has been applied within the Benin study region.

2.3.1. High resolution imagery

High-resolution satellite imagery is undoubtedly one of the most useful sources of aerial imagery data short of flying a plane over a selected study region. Readily obtainable examples of this type of data are illustrated within the Google Earth application. Raw high resolution aerial imagery of this nature is available globally for download at a cost, usually around \$250 per 25 km^2. Within the realms of this research a combination of high resolution and medium resolution satellite imagery is used to test the suitability of this technology within a West African context, and a dataset from each has been obtained. This research shows through remote sensing methods how much information can be gained about a study region remotely, invaluable for archaeological application particularly where conditions can be tough on fieldwork or inaccessible areas (as discussed in the previous section). Moreover, there are no published examples of archaeological satellite remote sensing work being undertaken in the Niger River Valley and examples of remote sensing use in sub-Saharan archaeology on the whole are few and far between. From the post-war era onwards, high-quality aerial photographs have been commonly used in archaeology to detect crop marks and other features from the air.

Spatial resolution of an image is defined by pixel size. High resolution imagery is taken using satellite systems in orbit around the Earth that capture data at < 4m per pixel, meaning features less than 4m in size can be seen. Applications of high resolution imagery range from military intelligence, to disaster response, forest management, water resource management and transportation planning, to name a few (Lillesand *et al*., 2014).

As part of this doctoral research project, a high resolution dataset was obtained for the study area around the modern village of Birni Lafia (highlighted in Chapter One for having a complex array of settlement mounds visible) and is taken from the Quickbird satellite sensor. High resolution satellite imagery exhibits the same qualities as air photos, but with additional advantages. Unlike aerial photography, sensors such as Quickbird capture data with a range of multispectral bands: red, green, blue and near-infrared, as well as the panchromatic band. The Quickbird sensor has a multispectral resolution of 2.4m per pixel, but records a panchromatic band at 0.6m per pixel, which means that after enhancements a spatial resolution of 0.6m can be achieved. The very high resolution comes from the panchromatic data, which is taken by the satellite at the same time as collecting multispectral information, it is of higher spatial quality and can be merged with the multispectral bands to increase resolution. Consequently, the key advantage of such high resolution data obtained for Benin is that features which are over 60cm in size can be identified within their overall context of the landscape. It was felt that such precision was required in order to facilitate adequate archaeological interpretation, as many surface archaeological features are small and remain undetected when analysing lower resolution imagery.

A range of examples are cited to illustrate the usefulness of high resolution aerial imagery in different landscapes. Archaeological sites in Turkey will be the first focus that will highlight the advantages of this technology for archaeologists, as opposed to low-resolution imagery. In Hisar, in the east of Turkey, images taken by different sensors with varying ground resolutions were used to examine their potential for extracting archaeological information of unexcavated archaeological features using GIS, pixel-based and object-based computational methods (De Laet *et al*., 2007). In the study, *ASTER* (Advanced Spaceborne Thermal Emission and Reflection Radiometer), *SPOT5* (Système Pour l'Observation de la Terre) and *IKONOS-2*, were scrutinised for their capabilities. The *ASTER* and *SPOT5* satellites were disregarded from the outset in the study as *ASTER* has a spatial resolution of 15m per pixel and *SPOT5* has a resolution of 10m per pixel: this means that any archaeological features that are smaller than 10m cannot be detected. However, *IKONOS-2,* which is a high resolution sensor with similar capabilities to the sensor

Quickbird that is being used in the Benin survey study area, provided optimum output for the extraction of archaeological features at Hisar (De Laet *et al*., 2007). To produce this ideal result, the method of 'panchromatic sharpening' was used to enhance the resolution of the imagery; because as stated, the panchromatic band has a finer resolution, which can be merged with the multispectral bands. The outcome of this process at Hisar was a multispectral map that has a ground resolution of 1m per pixel.

Visual identification and automated extraction of archaeological features can be carried out from the sharpened satellite imagery to identify unexcavated structures based on shape, tone, linearity and spatial patterns, prior to fieldwork (De Laet *et al*., 2007:834). This process is relatively straightforward, and the main obvious features that are identified can be documented and digitised within a GIS. The features identified in this example in Turkey, were fragments of Byzantine and Early Hellenistic defence walls - locating these walls was invaluable prior to fieldwork as the researchers knew what to expect before conducting work on the ground and already had a base plan (De Laet *et al*., 2007; 2009). Overall, De Laet *et al.*'s study using high resolution imagery was successful - on the ground, producing a map of this scale would have been extremely time consuming, therefore remote sensing has been a very useful tool here. Furthermore, using medium resolution imagery would not have allowed for this sort of result.

Using remote sensing for mapping sites within their landscape is a common practice. This tool has been adopted on ancient Minoan features in Crete, where imagery was used as a mapping tool to track ancient roads and other features (Pavildis *et al*., 2001). By mapping the sites in Crete, an establishment of archaeology within the landscape was made, as it situated settlements and other areas in their surroundings. The topography of the island was a vital aspect in shaping Minoan society and mapping through remote sensing showed the physical routes and internal interactions between settlements (Pavlidis *et al*., 2001). This method was also used on an archaeological site in south-central Iran, whereby the outer boundaries were identified and mapped within the wider landscape (Aminzadeh and Samani, 2006).

Although the type of archaeology in northern Benin is very different from the examples described, which consist of visually explicit archaeology in planar view, similar tactics of site mapping have been employed within the study area. This will mean settlements sites, which often take the form of mounds or eroded, flat areas close to palaeochannels, can be recorded and measured with little time commitment on the ground. Furthermore, the imagery has then been used to relate the sites to their physical, topographic surroundings. The land cover in northern Benin consists of vegetated and non-vegetated areas, fluvial expanse, hillslope and palaeochannels. Identification of archaeological sites however relies on differences in reflectance of spectral bands to detect features, and this is somewhat problematic if the archaeology and the surroundings possess the same reflectance due to the nature of the terrain; this for example happens in arid desert contexts, where sites are instead detected by shadows of the architecture (for example, satellite remote sensing work of the Trans-SAHARA Project, University of Leicester). It is noted that high resolution imagery works better in areas where there is a greater difference in ground cover, creating more pixel variation (De Laet *et al*., 2008, 2009; Pavildis *et al*., 2001).

While there is a distinct lack of remote sensing research undertaken within West African archaeological contexts, other areas with a similar environment have been researched. Research in the semi-arid area of Homs, Syria, has benefited from the use of high resolution satellite imagery in a study conducted by Beck and Phillip (2013). This study is important for two reasons. Firstly, the remains are not visually clear on the ground, so spectral and spatial resolutions are important. Secondly, since the geographical location analysed cannot be visited due to the civil war, this case illustrates a safe and accessible way of conducting research regardless of the country's instabilities. This is a topic of increasing concern amongst scholars, particularly in light of the 'Arab spring' and the rise of the so-called 'Islamic State'. Previously in the Syria region, Bronze and Iron Age tells in this area were easy to identify on the ground as they were prominent in the landscape. However, now using remote sensing, the challenge is to identify the spectral differences in soil marks of Hellenistic and Islamic sites originally made up of mudbrick remains which have now decayed. Mudbrick remains have a different moisture content, which was detected through satellite imagery due to its differing reflectance properties (Beck and Phillip, 2013). In this study, it was found that colour differences between archaeological and non-archaeological soil were clearer during peak aridity, due to the moisture retention of archaeological soils (Beck and Phillip, 2013). The use of satellite imagery in this area was very successful, which bodes well for the study of Benin. Mudbrick and rammed earth/wattle and daub architecture is a common feature of archaeological remains found in West Africa, and recent excavations at Birnin Lafiya in the Benin study area have found the presence of buried mud architecture and pottery pavements. Therefore, the use of satellite imagery in identifying archaeology in this region has been used.

To conclude, these case studies were successful in applying satellite imagery to facilitate in answering a specific research problem. Similar techniques have been employed within the northern Benin study region, to argue the case for desk-based methods in mapping and site identification within this research project. Like De Laet *et al*.'s (2007) study of Hisar, pan sharpening has been undertaken on the imagery obtained from modern Birni Lafia, to see if any archaeological remains are visible. The pan sharpened image is also used to map the survey area in advance, which takes in a range of geomorphology. This imagery can also establish whether there is a relationship between the topography and settlements (such as the studies undertaken by Aminzadeh and Samani, (2006) and Pavildis *et al*., (2001)). Association of hinterland and settlements was proved in some of the IND examples cited in Chapter One. Lastly, detecting changes in spectral reflectance associated with archaeology, like the study at Homs, Syria, has been carried out to consider its usefulness in a Benin context. All of the results of this analysis are outlined in Chapter Five.

2.3.2. Medium resolution imagery

This section will discuss the use of medium resolution imagery for remote sensing, and will cite research from a variety of disciplines. Medium resolution imagery has a very different function to high resolution imagery and is utilised for geomorphological and environmental research of the landscape. The main advantages of this data are that it is free to download, has global coverage and is available for many months and years. The Landsat Program, for example, has been recording imagery since 1972, so comparing change in the landscape between then and now is possible. Furthermore, storing medium resolution data requires less memory as the files are smaller.

The main difference between medium resolution and high resolution imagery in archaeological application is that medium resolution images do not have the spatial resolution suited to identifying sites from visual interpretation or automated approaches. This is because the pixel size is greater, generally between 20m and 100m per pixel. However, the imagery gives a good overview of the topography and geomorphology of the landscape, as it can cover a large geographic area within one data tile. Medium resolution imagery's main use is to aid analysis and interpretation of the natural and built landscape. This will be useful for the Benin study area as the main geomorphological and topographic features, for example, the Niger River and its tributaries, vegetation, soil moisture and elevation, all visible on medium resolution imagery, provide insight as to how people are interacting with the environment within the landscape. Most studies of remote sensing in archaeology focus on the use of high resolution imagery for site identification, as the main aim of this tool is to find sites, and there are few studies which take advantage of the use of free, lower resolution imagery. This section will demonstrate ways it can be used for landscape archaeologists. This methodology hopes to make an innovative contribution to archaeological remote sensing using free satellite imagery, not only in West Africa, but also in regions elsewhere.

Two types of data have been acquired for the study area and they are taken from the *Landsat* and *ASTER Global Digital Elevation Model (GDEM)* sensors. Landsat is a multispectral sensor with eight spectral bands and has a spatial resolution of 30m per pixel. The advantage of this imagery is that it provides repetitive coverage of the earth since 1972, so different seasons and different time scales can be addressed. *ASTER GDEM* data, on the other hand, is elevation data also with a 30m resolution per pixel. The resulting product is a grey-scale image that expresses height, rather than spectral reflectance. An example of the images is presented in Figure 2.1.

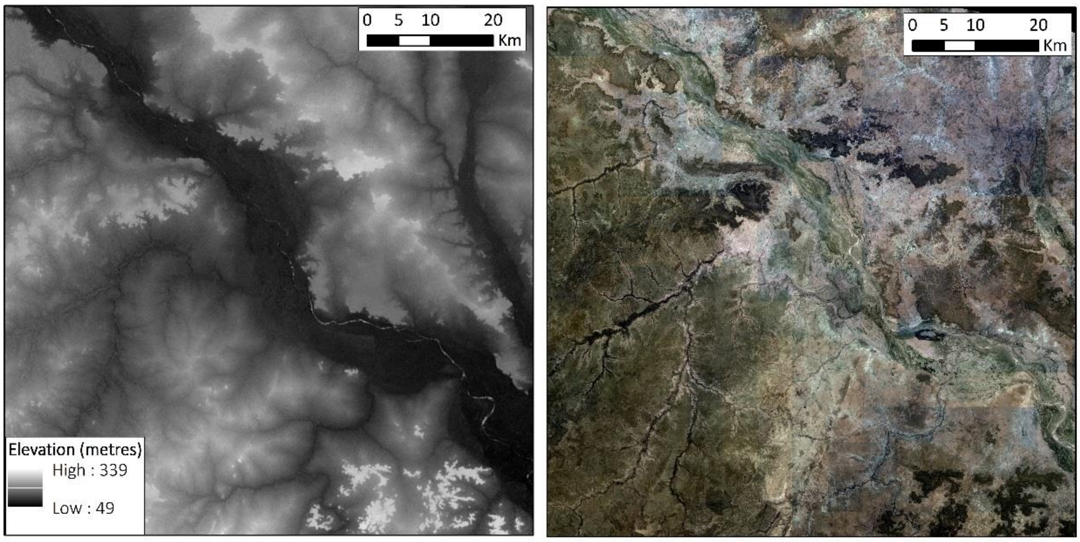

Figure 2.1 *Image on the left is the ASTER GDEM image of the region and the image on the right is a Landsat 8 image (bands 1, 2 and 3). ASTER GDEM is a product of METI and NASA.*

Detecting change in the landscape over time is an important aspect of this research and the technique of ‘change detection’ is common amongst remote sensing researchers. It is defined as a process of identifying and recording changes in the structure and use of the landscape, by observing differences over time and this can be achieved using Landsat imagery. This technique is a computational automated approach; it classifies the landscape in all images across a time frame, and then calculates the degree of change for each geomorphological feature. It is useful in the study of the Dendi region for several reasons, firstly change in the modern landscape will affect archaeological visibility; processes such as increases in surface water and vegetation/cultivation which typically cause erosion of archaeological remains can be detected over time. Changes in the Niger River and its tributaries within the study area are quantified and analysed to see how the river has changed over a 20 year period. In doing so, interpretation about placement of settlement and movement between settlement and water is made. This method will also consider how vegetation density has changed over time. This type of analyses gives insight into settlement density patterns; for example, some settlements may cluster close to lush vegetation and water systems identified through satellite imagery.

Another important application of *Landsat* imagery is mapping geomorphological features. This is particularly important for the study area as cartographic depictions of the region, which are few and far between, misrepresent topographies such as the Niger River, partly due to the river's changeable temperament and because of heavy generalisation in the mapping. In order to fully investigate human-environment interactions within this fluvial system, which is an objective of the research, a comprehensive map of the river is necessary. Mapping using this type of medium-resolution data is a common procedure. Kawakubo *et al*. (2011) undertook this in southeastern Brazil, where coastal geomorphic features were mapped using *Landsat Thematic Mapper* (TM) *and Landsat Enhanced Thematic Mapper* (ETM+): these are two sensors launched at different time scales . Two sets of images were used to identify the changes in the landscape, and between the two time scales vegetation, soil and clear water observed the most change. This study was useful as it mapped erosive and depositional features, yet was valuable simply in mapping the geomorphic features like the coastline, which is constantly changing (Kawakubo *et al*., 2011). This study not only illustrates the usefulness of the data for detecting change, but shows a practical way to map as it would be expensive and time consuming using a GPS device in the field to record these geomorphic features in detail.

To what extent does the Niger River flood, and how variable are the flood plain boundaries, are two useful questions that address the nature of the river and how it may have affected settlement distribution. Flood inundation patterns can be detected using *Landsat* imagery and this is cited within a study by Thomas *et al*. (2011) of the Macquarie Marshes of semi-arid Australia, which used *Landsat* images from 1979-2006. After pixel-based classification of water in the area, the basic principle was to compare pixels from each image of every year and see if the same area was still classified as water or if there was another land cover type present. In turn, this will identify the amount of flooding in a region. Thomas *et al*. (2011) successfully created an index of change based on this method at the Macquarie Marshes, showing that the area is becoming drier over time. This method has been conducted within the Benin study area, and it is hoped it will shed light on why settlements did not occur in some areas. The assumption, based on archaeological work in Mali, is that people settle within close vicinity to the water and if areas have a consistent availability to surface water, then a higher preference will be given to inhabiting these areas; however this has yet to be proven.

Quantifying surface water in the landscape has been undertaken using Landsat imagery by creating a Normalized Difference Water Index (NDWI) of the area, which calculates the availability of surface water. This index uses the multispectral bands of the satellite imagery to enhance the presence of water in the landscape, beyond the visible spectrum. The equation for expressing the NDWI is shown below after McFeeters (1996):

$$NDWI = \frac{Green - NIR}{Green + NIR}$$

It uses the green and near infra-red (NIR) spectral bands to maximise the reflectance of water, resulting in an image where water has positive values, but vegetation and soil display negative or zero values (Xu, 2006). The method has been successfully carried out within a number of contexts, mainly for agricultural use, for example crop mapping in Iowa, USA (Jackson *et al*., 2003), however it is beginning to evolve within archaeological applications. Most notable is Lasaponara and Masini's (2012) study of the Anicent Nasca Puquios, Peru. The region is extremely arid; therefore irrigation and artificial wet agro-ecosystems were necessary to facilitate human life in the area. Using Landsat and ASTER satellite imagery Lasaponara and Masini (2012) identified perennial, ephemeral and dry areas to support the detection of ancient aqueducts, such as the ancient disused *puquios*. This proved that sporadic characteristic of water flow in the area did not prevent past populations from farming, and thus provided knowledge of survival strategies, settlement distribution, agricultural production and social organisation. By identifying the areas of surface water, Lasaponara and Masini (2012) argue vital points relevant to the research questions of this doctoral thesis regarding human-environment interaction. This has been undertaken within the Benin study region to map the presence of surface water and will be discussed later.

2.3.3. Normalized Difference Vegetation Index (NDVI)

This section will consider the use of NDVI using high and medium resolution imagery. Like the water index discussed previously, this remote sensing process measures the healthy vegetation in the landscape. Visual identification of sites and mapping is not the only way that satellite imagery can be utilised to understand the historic landscape. Change in vegetation and soil moisture are key aspects that can also be adopted for extracting archaeological features from satellite imagery, particularly when using the near-infrared spectral band. The method of NDVI is an index of plants photosynthetic activity, and measures area of green reflectance on the earth’s surface using remotely sensed satellite imagery. The green indicates healthy, flourishing plants, therefore signals fertile soil, and this technique is often used in agriculture and land use management. It is useful in archaeology for two reasons; the first is that buried archaeological features modify the appearance of the vegetation that grows on top of it, in comparison to the natural vegetation. Therefore, when this process is undertaken on high resolution imagery, crop and soil changes may become apparent signalling archaeological features. Secondly, healthy plants indicate fertile areas where crops are able to grow to support human life, so signal areas of human activity, and this can be used on medium resolution imagery for large regions. The equation to calculate the NDVI in a multispectral image is as follows:

$$NDVI = \frac{Near\ Infrared - Red}{Near\ Infrared + Red}$$

This equation allows for the exploitation of the spectral responses in the near-infrared band, where vegetation response is the greatest. In a nutshell, NDVI expresses the plants photosynthetic activity, relating to the green leaf area index. This method can also be used on high-resolution imagery to detect archaeological crop marks created by vegetation patterns (Lasaponara and Masini, 2012).

Examples where the method of NDVI has been carried out features both extant and subsurface remains which are not obviously detectable visually from the air, like the case in Benin. The technique has been considered for the Sahelian environment of Benin, to see if remains that are not clear from inspection of the visual bands (red, green, blue) can be identified from the near-infrared bands. Masini and Lasaponara (2007) tackled such an issue in Italy, where they used remote sensing to detect buried features, which were buried under different types of geological surfaces, through a range of techniques using images from the *Quickbird* satellite sensor (the same high resolution sensor which is used within this study). This method places emphasis on the analysis of the red and near infra-red bands, rather than the visual bands, as these bands are more capable of detecting different phenological states of vegetation and difference in soil moisture. As stated, vegetation and soil moisture are both affected if they are concealing archaeological remains. Masini and Lasponara (2007) tested the technique of analysing the red and near-infrared bands on a non-vegetated and vegetated site. The non-vegetated site revealed that by merging the red spectral band with the panchromatic band, buried remains were revealed. As the near-surface archaeological deposits affect the moisture in the soil, the spectral reflectance of the soil decreases as the soil moisture increases, in turn creating a different spectral response, which is recorded by the satellite sensor and then identified by the researchers (Masini and Lasaponara, 2007). When analysing the vegetated site, the near-infrared band was most useful. This is because the near-infrared band can detect subtle changes in the vegetation, so in places where the vegetation has a shortage of nutrition or water (because of underlying archaeological remains), and this can be identified in the reflectance of the plant leaves (Masini and Lasaponara, 2007). Figure 2.2 shows the results that were obtained when analysing the near-infrared band on the vegetated site, which was consequently mapped. These spectral changes are subtle, but identified archaeology that would not have been detected at ground level. Overall, what was found from the analysis of the *Quickbird* image was a fortified structure and ditch, with possible monastery and village, thus showing the great capabilities in examination of the spectral reflectance of the ground from the air.

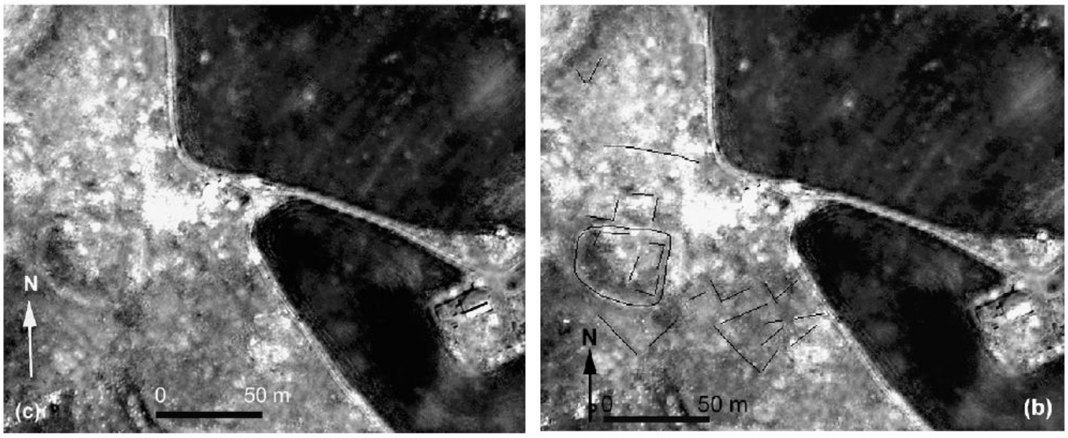

Figure 2.2 *Taken from Masini and Lasaponara (2007) an image to demonstrate the usefulness of the near-infrared band. The left image is after processing and the right shows the mapping of the site undertaken within a GIS.*

The red and near-infrared bands have been analysed in a similar fashion to detect differences in the soil moisture in the Benin study area. The successfulness of the approach will be discussed later, but it was hoped that this method is successful due to the semi-arid nature of the study area. Because the region has a variation of wet and dry periods, soil moisture should have a big enough variation that archaeology can be detected from the high resolution satellite imagery that has been obtained. The successfulness of this method is useful to document within this PhD research, so it can be ruled out as a technique to be used in future for researchers working in similar semi-arid contexts. However, a range of data should be employed from different seasons throughout the year as vegetation does change.

Another case where this method proved useful was in the discovery of a medieval settlement in Italy. The site was identified using this technique in a densely vegetated area in southern Italy. Large crop marks were recorded after NDVI was carried out, as the archaeology meant vegetation in this area had different values to the natural surroundings (Lasaponara and Masini, 2006). Detailed maps were produced from this process which used Quickbird imagery, however, the initial detection of the medieval site was taken from identification of vegetation change in medium resolution imagery (Lasaponara and Masini, 2006).

Within this research, calculating NDVI indices has been carried out on both medium and high resolution imagery within the study region of northern Benin.

Medium resolution imagery is used to detect healthy vegetation in the region, which in turn, illustrates areas good for crop cultivation which may have been attractive for past settlers. Furthermore, a change in vegetation density over time is considered as this will affect archaeological visibility and preservation on the ground. Secondly, the process of NDVI has been carried using high resolution satellite imagery in order to identify possible archaeological crop marks or changes in the soil moisture, which was evident from the case study examples described in this section.

2.3.4. Digital Elevation Model (DEM)

The final medium resolution remotely sensed dataset to be discussed is the DEM. The DEM is useful as it records both two and three dimensional aspects of the landscape, which together shape the way in which people interact and settle within it. Many archaeological studies use elevation models to consider various scenarios for placement of sites; for example, accessibility and 'viewshed' analysis are common. Accessibility considers the ease in which one location can be reached from another with the aim to create a map to show how accessible each location is to another within the study area (Llobera, 2000; Herzog and Yépez, 2013). It is always assumed that those who have settled in any landscape would take advantage of the routes which have the greatest ease of accessibility when travelling from one place to the next. The types of landscape feature that may slow down access are slope, soil type and vegetation (Llobera, 2000); therefore DEMs are useful as slope can be classified, and the other information can be gained from multispectral imagery.

The analysis of DEM derived data is shown at the study of Valle de la Plata, Columbia, in the analysis of settlement patterns of prehispanic chiefdoms (Drennan *et al*., 2006). The degree of slope was classified throughout the study region and mapped, this resulted in an image that showed areas with a steep slope highlighted. What was discovered through this analysis was that this landscape was used differently dependent on the occupation phase. For example the mobile, prehistoric hunter gatherers were utilising all areas of the study region, regardless of the elevation of the landscape, whereas later in the Classical period, fewer areas of the land were being occupied and people tended to stay on flatter land (Drennan *et al*., 2006). This landscape led to dispersed settlements; people in the Classical period were keen to remain within their cultivated settlements, unlike the hunter gatherers who had to move for their food. This case study illustrates the usefulness of medium-resolution elevation satellite data within a landscape archaeology context.

Within this research of northern Benin, as has been stated ASTER GEM data of the region has been obtained. Different classifications of the elevation model have been made, illustrating the variance in elevation in the landscape in relation to where the sites are situated. This includes producing a contour map. Furthermore, placing known sites on an elevation map indicate patterns of where people are most likely to settle, which in turn can be used to predict where sites occur or do not occur for future surveys.

2.3.5. Summary of remote sensing methods

To conclude, this section considers remote sensing methods in archaeology that have been adopted for the investigation of Dendi archaeological landscape. High resolution imagery is commonly used for site identification and detection of soil moisture and vegetation changes, both of which may point to archaeological phenomenon in the landscape. Medium resolution remote sensing is used to aid interpretation of fluvial processes of the Niger River. In particular, the multispectral bands can identify surface water, detect geomorphic features, such as palaeochannels, and produce an index of vegetation, all of which will help address the major research objective: human-environment interactions in the landscape.

An overview of the use of high resolution satellite imagery across a range of archaeological sites has been provided to argue for its utilisation within the study area of northern Benin. The main advantages that can be seen are; firstly, the capabilities of site identification, particularly in areas that have not been visited or cannot be accessed. Site identification in the Niger River Valley region is perused by visual interrogation of the imagery in the first instance, and then by automated approaches and manipulation of the red and near-infrared bands to detect variations in soil moisture and vegetation. Secondly, there is a benefit of mapping sites within their hinterland, not only the natural topography but also the elevation, which is of fundamental importance to any archaeological project. Ultimately, an integration of all of these methods help to build a profile of archaeological sites, within their wider landscape. The results of the high resolution imagery analysis will be outlined in Chapter Five.

It is has been argued that medium resolution data is not only useful for a two-dimensional approach to the wider landscape; for example, mapping of the rivers and vegetation of the region, but also can be used to assess the three-dimensional elevation of the area. By quantifying the different features of the landscape using Landsat and ASTER GDEM data, as demonstrated by the case studies in this section, interpretation of settlement within the hinterland can be made and archaeological patterns established. The results of these analyses will be shown in Chapter Five.

2.4. Spatial analysis in archaeological GIS

Spatial analysis using GIS is often integrated into large scale surveys. As mentioned at the beginning of this chapter, projects such as the Kythera Survey project uses substantial GIS methods (see Bevan and Connolly, 2013). For this research an integrated approach of spatial analysis methods used in the study of GIS and the terrain information obtained from satellite imagery is implemented to tackle the research objectives. As explained, the use of remote sensing is intended to obtain a comprehensive understanding of the natural environment, with particular emphasis on fluvial systems, vegetation, surface water and elevation. This information combined with detailed spatial analysis, can give insight into human-environment interactions. The current section will outline different types of GIS spatial analysis methods that are used in this research on the dataset collected in northern Benin to address the broader themes. The collection of geographic data is vital for the process of analysis in any archaeological study; archaeologists' main goal is to produce an accurate record of ancient remains and material culture in space and time. Spatial analysis methods in GIS are based on the first 'law' of geography, and that is 'everything is related to everything else, but near things are more related than distant things' (Tobler, 1970:236).

Settlement and site patterns are a prominent discussion of landscape archaeology studies, yet GIS techniques are not always used in their analysis. One example is work in the IND; here spatial survey data is only presented cartographically on a standard distribution map, where a visual, non-quantified identification of patterns is made and resulting interpretation derived (see R. McIntosh and S. McIntosh, 1999; R. McIntosh, 2005). There are, however, examples where the distribution of archaeological events have been analysed beyond the distribution map, which has been incorporated for the study of northern Benin and relevant case studies are outlined in this section.

2.4.1. Catchment, proximity and buffer analysis

In a study of Bronze Age sites in West Cyprus, Agapiou *et al*. (2013) illustrate how GIS can be used for interpretation and analysis of the landscape. As in this PhD project, the authors have considered the importance of topography, whereby the topographic and geomorphologic traits of the region were investigated to correlate them with the trends of the Bronze Age sites (Agapiou *et al*., 2013:177). One aspect of the work was catchment analysis; this term is used in archaeological GIS, but it is a process seen in other areas of GIS, for example location based assessments for roads or businesses. It has been used in various archaeological works, for example Hunt's (1992) investigation on settlement patterns of horticulturalists in northeast America and investigation of the Nasca lines and geoglyphs in the desert on the south coast of Peru, where a wide regional analysis of the landscape was needed to understand the Nasca culture (Lambers and Sauerbier, 2003). Catchment analysis was first introduced by Vita-Finzi and Higgs (1970), who define it as 'the study of the relationships between technology and those natural resources lying within economic range of individual sites.' It implies that mobility and human activity are restricted to a certain geographical range dependent on the landscape (Hunt, 1992). In Agapiou *et al*.'s study in Cyprus, the use of this technique revealed that the earliest sites were located at a low altitude and within one hour's walking distance from the coast; however slightly later sites were located alongside the Dhiarizos and Ezousas rivers and at varying altitudes (50m to as high as 650m). It was found that sites at higher altitude coincide with copper deposits on the slopes of the Troodos Mountains (Apagiou *et al*., 2013:180). Interestingly, it was also found that settlement patterns within the island were in constant change and there was a shift to the role of ports and coastal settlements because of copper exports (Apagiou *et al*., 2013). This study illustrates that external factors (in this case port sites), change the settlement patterns in the landscape. Landscape change here was due to the economic benefits of trade, but earlier people had been settling within close proximity to fluvial features.

Another common technique that is used in spatial analysis of archaeological sites is proximity analysis, a method somewhat linked to catchment analysis. Again, a universal technique in the study of GIS, for example used in policy making and marketing, it analyses the relationship between one place and another considering different variables. This type of analysis yielded 'significant' results for the study of Bronze Age sites in Cyprus (Apagiou *et al*., 2013). It determined that locations of sites corresponded to the *châine opératoire* of copper processing as it identified the mining areas in the Troodos hills, then the transportation of metal along the river until it reached the port settlement. By taking the mining point to the port point, proximity analysis used the topography in-between to determine the route of production. It was also observed that there were no sites in areas of the mountains that exceeded the altitudes of the copper mines, which is expected.

Similar to proximity and catchment analysis is the use of buffer analysis. Buffer analysis is described by Connolly and Lake (2006) as 'a region containing all locations within a certain proximity to particularly geographically referenced entity (the origin).' A study focusing on Bronze and Iron-Age mounds in Norway illustrates the usefulness of using buffers (Fry *et al.,* 2004). Buffers of 100m were placed around arable fields, as sites were known to occur close to arable fields, thus, these 'buffer zones' were investigated (Fry *et al.,* 2004).

Catchment, proximity and buffer analysis has been conducted within the study area of this research. This doctoral project has similar themes to the research conducted in West Cyprus, such as settlements' proximity to water and impact of different elevations. Furthermore, quantifying vicinity to these landscape features will reveal patterns that were not evident from the distribution map alone. In a similar fashion to the work of Connolly and Lake (2006) buffer zones are placed around settlement points within the Benin study area, to ascertain which key features of the landscape are in the closest vicinity, thus providing evidence for settlement distribution in the area. This will be discussed in the results chapters.

2.4.2. Point-pattern and cluster analysis

The case of Bronze Age Cyprus offers a good example of where GIS spatial analysis techniques have been used and gives great insight into the layout of the landscape, but studies such as this are not restricted to Cyprus. Point-pattern analysis used to test whether a set of points are clustered, dispersed or regularly distributed in a given area, is one of the bases of spatial analysis in GIS based study. Describing a spatial pattern is more difficult than it seems, particularly due to *first-order* and *second-order* effects, which are a way of defining and modelling spatial patterns through various statistical analyses (O'Sullivan and Unwin, 2003). *First-order* effects are broadly defined as spatial variation across a study area that varies due to underlying properties of the local environment. A simple example given by O'Sullivan and Unwin (2003:29) would be that cases of crime may differ spatially because of variations in the population density. However, *second-order* effects occur due to local interactions with the environment. To illustrate this, referring to the example of crime incidences, crime may occur in areas close to bars or clubs, or in socioeconomically deprived areas: these are referred to as 'hotspots'. How do such analyses relate to archaeology? People may settle in areas close to water, which would illustrate a *first-order* effect, whereby the local environment is a factor. On the other hand, if people settle where trade or materials are accessible, then this is a *second-order* effect and statistical methods can test such theories. Such analyses are missing, particularly in settlement studies within West Africa, and simple processes like this need to be addressed here.

Analyses using algorithms to explore the first and second-order effects were utilised in a study of Neolithic Burgundy, France, to explore the extent to which archaeological and environmental changes were correlated, evaluating human and environmental interactions (Pillot *et al*., 2013). The three methods used for looking at patterns of points of Neolithic sites were Ripley's K-function, nearest-neighbour distance (in GIS study this is commonly known as Cumulative Empirical Probability Distribution G (w)) and Kernel Density Estimation (KDE). The *Ripley's K function* was used to test three hypotheses of distribution: one was to see if any sites were unique, the second was to test for homogeneity between sites and the third was to identify isotropic processes. This type of analysis has also been used by Bevan and Connolly (2006) in the Kythera Island Project. The island of Kythera is situated between two significant regions, mainland Greece and Crete; therefore an important aim of the project was to investigate the nucleation and dispersion of settlement in this area. Where this scenario has been documented in other areas of the Aegean, it shows the response to the expansion and contraction of inter-regional trade and exchange, so is an important pattern to investigate (Bevan and Connolly, 2006). *K*-function was therefore used to detect any evidence of nucleation or dispersion. This illustrated that there were clusters of villages in some areas, which reflected that people were more likely to settle in inland areas near suitable agricultural land (Bevan and Connolly, 2006).

Linear regression and spatial autocorrelation are the final themes to discuss in relation to spatial analysis, and are perhaps the most used statistical approaches across the discipline of archaeology. Linear regression is a quantitative approach, which can be used to describe the degree of correlation between two variables; usually one variable is dependent and the other independent. Connolly and Lake (2006) give the best example of this in an archaeological context. They state that the dependent and independent variables can be thought of as cause and effect, for example, the distance from the source will affect the amount of raw material in a given place, and thus, distance and quantity are negatively correlated (Connolly and Lake, 2006). Because the amount of material is determined by the distance from the source, the dependent variable in this case would be the amount of material. This example may seem obvious; however some archaeological examples given by Connolly and Lake (2006) are not as straightforward. For example, when assessing the correlation between artefacts and site size (which is explored within this research project for iron working sites), it is possible to discuss this as interdependence, and possible to test the strength of the correlation (Connolly and

Lake, 2006). This concept feeds into spatial autocorrelation, which takes into consideration the distance and the values between variables, so if variables are close together perhaps they are more similar (positive autocorrelation). This echoes Tobler's first law of Geography (near things are more related than far things), on which spatial autocorrelation is based.

Spatial autocorrelation is important for archaeology because data can only be interpolated if there is a degree of spatial autocorrelation. This is observed by Premo (2004) in her analysis of patterns in the Maya lowlands. She points out the lack of spatial autocorrelation used in archaeology, with the majority of it being applied to Maya archaeology. In the Maya lowlands, spatial autocorrelation helped to open and elucidate interpretation of the landscape; it found that sites that terminated the earliest were found in specific spatial 'neighbourhoods', as were the sites that terminated the latest, showing that these areas were directly affected by their environment (Premo, 2004). Premo (2004) makes the important point, that such statistical analysis is not the only justification to make certain hypotheses, but do help to make them clearer.

Why invest time in statistical analyses? Site clusters as an archaeological pattern may be clear from a visual analysis of a map, however, when relating this information with other variables, other patterns may become apparent. For example, research of fortified castles by Ladefoged and Pearson (2000) on the island of Okinawa, south-western Japan, considered site clustering, but took into account soil type. It was found that clusters of polities had developed close to ecotones of different soil types, which made it successful to grow crops, making a strong case for environmental determinism (Ladefoged and Pearson, 2000). Rather than sites clustering together for economic and social interaction of urbanism like that described at Jenné-Jeno, it appears survival for food was a key element in this case. This research aims to assess in the same way the degree to which environmental variables or economic and social interactions were the most important for settlers, using statistical analyses of points of interest in the landscape.

2.4.3. Overview of GIS methods

As is clear from the overview of methods in this chapter, there is a strong case for the inclusion of GIS spatial analysis procedures in the landscape. The key processes that will be undertaken in this research will be: catchment, proximity and buffer analysis, point pattern analysis considering clusters, linear regression and spatial autocorrelation.

It is important to acknowledge that the role of GIS in archaeology has not always been positively welcomed. These criticisms are picked up in detail by Llobera (2012) in his consideration of the challenges of developing digital methods within an 'interpretive' landscape archaeological framework. This is an important issue to raise as it may be that the rise of digital methods in archaeology in West Africa is hampered by these considerations commented on by notable scholars. For example, Tilley (2004: 28) who remarks that conveying an understanding of prehistoric remains cannot be known from maps, diagrams or photographs and are made worse with the use of statistical analysis, GIS and simulations. It is insinuated from his text that Tilley believes the archaeologist alone, through field observations, is the only source of knowledge needed for interpretation. This is where 'middle ground' solutions can be suggested and are documented by Graves McEwan and Millican (2012), who argue for the potential of combining qualitative spatial studies with theoretically explicit approaches of past landscapes. Overall though, it is well noted that GIS methods need to be used in conjunction with experiential based approaches. This will be picked up again in the discussion chapter of this thesis (Chapter Six).

2.5. Conclusions

This chapter sought to use case studies to demonstrate novel and interesting ways that remote sensing and GIS can be used for the investigation of historic landscapes in the Niger River Valley. Survey consisting of field walking is the primary and best method for site identification, however, vital consideration must be given to the natural landscape and should be understood thoroughly before conducting such works. Each survey conducted is always dependent on the area being surveyed and regardless of published methods, should be the primary concern.

Remote sensing, particularly the use of high-resolution imagery, has been shown to be a quick and useful method for identifying sites away from the field. However in cases where the archaeology from the air is not obviously seen from a visual inspection of the image, algorithms such as NDVI and panchromatic sharpening can be applied to detect changes in the vegetation that signify archaeology. Medium resolution data including multispectral satellite imagery and DEMs can be used for accurate mapping of the landscape, which not only act as a backdrop to the sites identified can but can offer insight into settlement preference.

The positive role of GIS in archaeology is on the whole acknowledged as a valuable tool for identifying spatial patterns, which can aid in the interpretation of the landscape. Geospatial methods can assist in answering long-standing research questions, particularly ones that contextualise the relationship between site and environment, and consider settlement patterns. Furthermore, the documentation of sites through a map is vital for cultural heritage management and can facilitate in the protection of sites.

The next chapter will discuss the field survey carried out in northern Benin and the methodology devised in order to obtain information from surface remains about the archaeology here.

Chapter 3: Fieldwork Methodology

3.1. Introduction

This chapter outlines the methodology used for the fieldwork, which draws upon experience from previous field seasons undertaken by the *Crossroads of Empires* project, which will be discussed in this chapter, and surveys outside of Africa that were outlined in the previous chapter. The main aim of the field walking survey (as discussed in the introduction chapter of this thesis) is to accurately and systematically record settlement and material culture distribution density in the landscape. Fieldwork was undertaken between 7th January 2014 and 12th February 2014. Prior to fieldwork commencing, imperative considerations were factored in to make the method workable in this West African environment, and these became important factors in how the methodology would be carried out. This included the acknowledgement of limited resources in West Africa, namely restrictions on infrastructure, such as the provision of electricity, which made recharging devices needed for survey difficult. Similarly, it was required that all equipment and devices that were to be used had to be transported from the UK to Benin. The scarcity of qualified (and in some cases literate) personnel was also factored in so it would not hinder the project. Furthermore, a limited budget which was spread across a wide variety of resources became an influence on decision making. Finally, environmental elements, such as bush fires and rapidly rising temperatures between January and February made workable time in the field short. With these issues established at the forefront of planning, traditional archaeological survey techniques (outlined in Chapter 2) had to be adjusted to fit the nature of this diverse, semi-arid, fluvial landscape, to capture as much information as possible in a systematic way. How this was achieved successfully will be outlined within this chapter.

Previously, prospection in the region by the *Crossroads of Empires* project between 2011 and 2014 involved a broad, comprehensive coverage of the area, suited to the fact that this was largely an unknown zone archaeologically. This work identified some 600 'sites' and based on a predominantly qualitative recording system, the sites were mapped with a handheld GPS. These earlier surveys aimed to show the broad distribution of sites in the area, pinpointing the hotspots of archaeological activity with a brief written description of the type of site encountered in note form. Material culture type and density were documented through a visual inspection on the ground and collections or counting of pottery was rare. Nevertheless, this resulted in course-grain macro boundaries of material culture patterning being established, and spatial cultural variants were recognised (Haour *et al*., 2011). For the initial phase of the *Crossroads* project, this was sufficient and produced an ample distribution map of sites in the area. Using the *Crossroads* methodology during the 2013 survey (the first survey I attended) gave the opportunity to reflect and make changes in order to produce a more systematic, intensive survey strategy, and to gain a detailed understanding of where the targeted survey areas, in the context of the doctoral research presented, would be located.

As discussed in Chapter One, N'Dah (2001) highlighted the evidence of settlement mounds in the area when he did a brisk assessment of the area. We already know the Niger River in Mali is known for its iconic archaeological sites, and historic references of the Dendi region spoke of ancient empires and polities; therefore it was no surprise to find archaeological activity here. The *Crossroads* project had their first field season in 2011 which followed on from the survey carried out by N'Dah. The chapter will now discuss the individual survey methodologies that were carried out on the *Crossroads* project and how they were integrated into the field walking survey method used to collect data for this thesis.

3.2. *Crossroads* Survey Method and Results

This section will outline the field walking method used by the *Crossroads* project between 2011 and 2014. The methodology was adjusted each year dependent on the fieldwork aims of the specific season.

3.2.1. The 2011 Survey

In 2011, the field walking survey of the Dendi region in northern Benin was carried out over 10 days in January. The work was undertaken by a team of between two and five people at any one time, who were all well experienced in West African archaeology, and the findings are published in *Nyame Akuma* (Haour *et al*., 2011). Field walking was conducted from a car travelling northwest to southeast on the main road which runs directly through the Dendi region and runs alongside the Niger River, this section of the road totals around 100km. At 5km intervals along the road the car stopped and short, parallel transects were walked following a bearing on a handheld compass. Walkers were spaced several metres apart, walking perpendicular to the road, looking for archaeological remains. There was no formality in transect spacing during this survey. As discussed in Chapter One, archaeological visibility is good in the area, and sites can be found from material culture scatters (mainly ceramic vessel sherds) on the ground, or the presence of mounds in the landscape. These occurrences were localised with a handheld GPS. Once a coordinate was established, written notes were made in the individual surveyor's notebook, these included descriptions of the geomorphological position of a site, vegetation cover and an estimate of quantity and distribution of material. Furthermore, recording of decoration techniques, including impression, incision, roulette or paint were detailed where possible. In some cases the record was completed with a photograph of the overall site and artefacts present. It was then the surveyors' individual responsibility to transcribe the results into a Microsoft Excel table.

Transects walked during this survey were recorded by GPS by Alexandre Livingstone Smith as 'tracks'. Tracks locate geographically accurately each area walked in the landscape and record it as a line on the map where the survey was undertaken. Tracks, in geospatial terms, refer to the GPS tracking technology found in the GPS device, whereby the device records and stores real time geographic positions of all distances travelled through the landscape. This function is very useful as knowing where the archaeological sites are located is as important as knowing where the sites are not. Being able to show the exact area surveyed on a map, indicating where there are sites and illustrating empty areas where there are no sites, can later allude to environmental, geographical and cultural factors for site preference as we can see the areas people did not want to settle.

The 2011 survey recorded very useful information, and the general structure of this survey was carried on throughout the later surveys. The major conclusions of the first survey highlighted the importance of certain geographic areas and geomorphological landforms for archaeological site preference, particularly placement next to the river. One of the issues of this survey however, was that it was carried out relatively quickly; therefore not all details were recorded. As there were no structured survey sheets that had to be filled in, notes were sometimes sparse, with little information. Furthermore, not all GPS devices were recording tracks, so some transects were not mapped. These two problems were addressed in the methodology of the survey carried out for this project, whereby survey sheets were created (these will be discussed in detail later in this chapter) and the track function was enabled on GPS so that an accurate map was available of the areas that had been covered by surveyors, in order to observe where sites occur and where they do not.

Figure 3.1 *Dr Anne Haour and Dr Didier N'Dah recording an archaeological site and collecting surface artefacts during the 2011 field survey. Photo courtesy of Dr Alexandre Livingstone Smith.*

The overall survey in 2011 established the position of over 400 archaeological occurrences of 'findspots', ranging from small events such as isolated ceramic sherds, to dense pottery concentrations on large settlement mounds. When producing the gazetteer of sites discovered, not all 400 archaeological occurrences were documented. This was because 174 of the GPS points were recorded and described in the archive as 'isolated pot remains'. These were instances where one sherd was found. These records were discounted due to their post-depositional bias, as one sherd did not mean there was a site present. The other sites that were omitted from the gazetteer were sites that two or more surveyors had recorded at the same time; in this case the record was combined.

One of the most obvious findings at this stage was that most of the sites occurred close to the Niger River, and as the survey moved away from the river, the density of sites started to diminish. It is commented by (Haour *et al*., 2011:29) that sites seemed to concentrate close to 'wet or dry riverbeds'. Additionally, an apparent spatial difference in material culture recovered throughout the survey area was identified, marked by a distinction between the east and west of the region. The major conclusions of the first survey highlighted the importance of some geographic areas and geomorphological landforms over others in archaeological settlement preference, a hypothesis which required further testing. From these preliminary findings stemmed two major aims of the methodology devised for this research. One was the investigation of fluvial/river systems in the Niger Valley landscape. The second was the examination of two different geographic regions to ascertain if there are spatial differences in settlement distribution and material culture types, which would infer that two different groups of people inhabited this landscape.

3.2.2. The 2012 Survey

The 2012 survey was very short and focused around the excavations at Pekinga and Birni Lafia (this was discussed in Chapter One). This was due to the lack of transportation in the field at this time. Nevertheless, what can be learnt from this survey is that locating sites close to the excavation areas is as important as the regional survey. Prospection close to excavated areas gives context to the excavation. Around 12 sites were located close to the Pekinga excavation and there was a distinct lack of sites located close to the Birnin Lafiya excavation (this was discussed in Chapter One). One of the mounds that made up the large mound complex at Birnin Lafiya ancient site can be seen in Figure 3.2.

Figure 3.2 *Dr Didier N'Dah and Dr Sam Nixon surveying Birnin Lafiya settlement mound in 2012. Photo courtesy of the Crossroads project.*

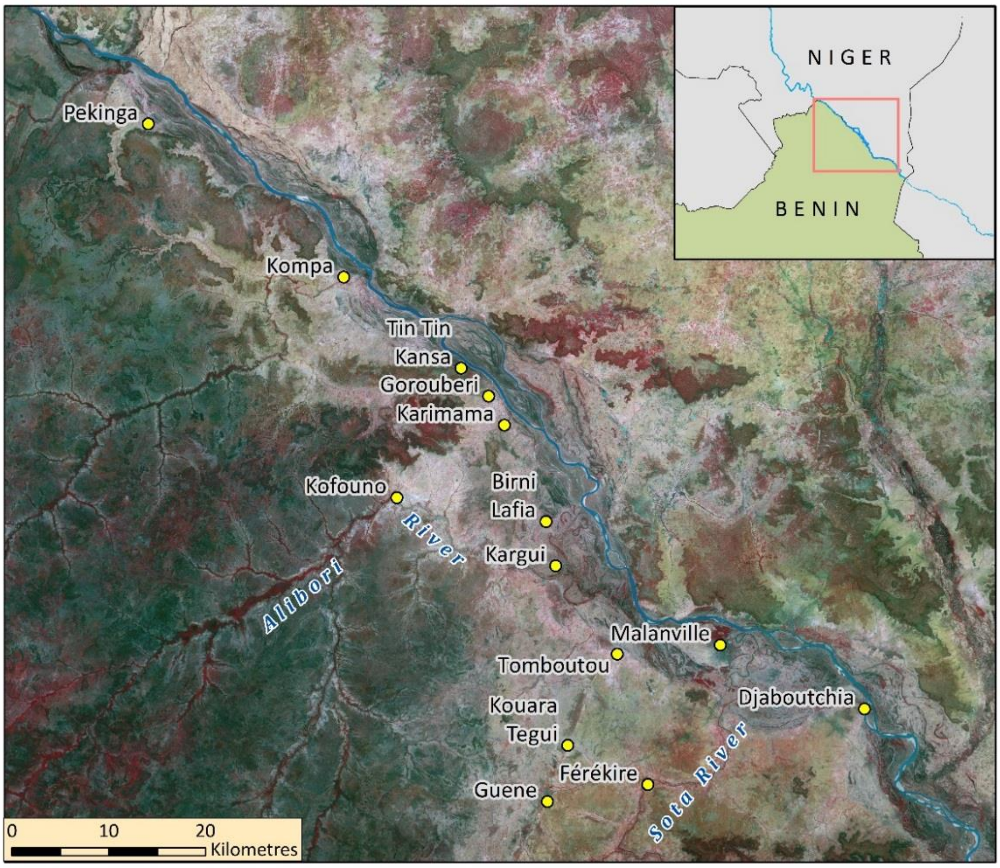

***Figure 3.3** Landsat satellite image showing the locations of sites mentioned throughout this chapter.*

3.2.3. The 2013 Survey

The survey of 2013 was the largest survey undertaken by the *Crossroads* project in terms of the amount of time taken to conduct and the total personnel involved. Field walking was undertaken over 17 days and 287 points of archaeological interest were discovered. A summary of the method and results will be detailed here, with reflection on how they were used to develop the methodology embarked on in this research. This was my first season and visit to the study area in Northern Benin so I aimed to excavate a series of test pits to gain a good understanding of the archaeology, which as discussed in the previous chapter, is imperative for developing a sound survey methodology that limits bias. The results of one of the test pit excavations can be found in Khalaf and Haour (2013) and will not be discussed here. The second aim was to conduct a survey, so that I had a solid understanding of the archaeology and surface assemblage in the landscape. Here, the methodology devised by the *Crossroads* project was used. The knowledge gained on this survey, particularly the advantages and drawbacks, shaped the methodology for my own research which took place the following year. As discussed in the introduction of this thesis, the fieldwork of 2013 was mainly focused on the archaeological 'hotspots' that were identified during the 2011 and 2012 seasons and test pits were carried out on large, abandoned mound sites. The survey areas were also focused on these areas which took place at Pekinga, Kompa, Tin Tin Kanza, Gourouberi, Birni Lafia and the Alibori River (Figure 3.2).

Unlike previous field seasons, survey protocol sheets (a copy of which can be found in the appendix), produced by the *Crossroads* project were used - a change from personal note books used previously. The record sheets were written and completed in French and later translated into English for the purpose of the Gazetteer found in the appendix of this research thesis. The surveyor was requested to complete the sections of the sheet by ticking boxes that related to the site they were investigating. This meant the choice between two or three variables in order to classify aspects of the archaeology including: category of site, landscape position, size of site, material culture density and type of artefact. There was also the opportunity to leave additional notes. Once again, GPS hand held devices were used to pinpoint the exact location of archaeological areas and there was a section for the geographic coordinates of the sites to be detailed on the sheet. The use of photography was also encouraged, but not required for every site, particularly due to lack of cameras. The usefulness of site photography is detailed in the previous chapter, but it gives a somewhat unbiased depiction of the landscape, dependent on the quality of the photograph.

During this survey, various techniques were used for field walking and site discovery, depending on personnel and resources available. Close to the village of Kompa, where a series of test pits were being excavated, survey was targeted close to areas with dry river beds, as previous experience had highlighted. Transects were spaced at 20m, and around eight people (comprised of *Crossroads* team members, local people and students) made up the survey line which covered a swath of 1.4km. Between the eight people, three handheld GPS devices were used and a compass bearing was followed from a handheld compass. If a site was discovered by any member of the team, the closest person with a GPS would take the coordinates of the site and those that were literate would write them down on the survey sheet and proceed with the rest of the site recording. Then the transect line would continue. A similar strategy, but with fewer people was undertaken close to the Alibori River, a tributary of the Niger River and between Karimama and Birni Lafia.

In terms of recording, survey sheets were filled with varying degrees of information, whereby some surveyors simply ticked the boxes, whereas others wrote more detailed descriptions in the extra comments box. Tracks of where had been surveyed were not recorded but points were taken at the location of the sites. As discussed, knowing where there are sites is as important as knowing where there are none; as a result, accurately recording and storing tracks became an important element within the methodology devised as part of this research.

Information collected on the survey sheets by the surveyor revealed some interesting observations that had not been highlighted in previous surveys. The first observation is the site typology. Characterisation of the sites or *nature du site,* were split into three categories; 'mound', 'furnace' and 'unknown' – Table 1 shows the results. This characterisation revealed that over half the sites (52%) were considered to be mounds or *buttes*, becoming the most typical form of landscape archaeological feature in the area. On the other hand, just under a quarter of the sites (20%) are simply described as being of 'unknown' nature. These were sites that were not mounds, or did not have any evidence of iron working. Furnaces, the other site type named on the survey sheets, were simply iron-working furnaces that were located and usually identified through the presence of slag and tuyère fragments. These results were encouraging as they identified the large presence of mounds in the area, which bears similarities to sites found elsewhere on the Niger.

This type of site identification however, was sometimes problematic during the 2013 survey. Mounds took varying forms and were not always easily detected, as in most cases they were discrete entities in the landscape that could only be recognised with a trained eye. Other types of site encountered were often flat and much eroded, and in most cases the surveyor classed these as unknown or *inconnue.* Based on this shortcoming, the new survey sheets produced as part of this research (which will be outlined in a later section of this chapter) sought to allow the surveyor freedom to characterise the site, allowing them freedom for a written description rather than a tick box. Furthermore, to supplement the site identification process, the use of photography and a general site shot was implemented for the new survey. What became apparent after the 2013 survey with a large number of 'unknown' sites is that these were difficult to interpret away from the field and an image would have assisted greatly.

Site type	Quantity	Overall percentage
Settlement mound	149	52%
Furnace	52	18%
Unknown	58	20%
Flat, unvegetated	8	3%
River erosion	19	7%
Destroyed/machined site	1	<1%

Table 3.1 *Categories reported in the Nature du site section of the protocol sheet collected during field walking survey in the Crossroads of Empires field season 2013.*

Having identified the type of site, the field survey sheet then asked more general questions about the physical characteristics of the area being recorded, which aimed to establish how the site was positioned in the landscape and included the size of the site. Two categories could be chosen from in this instance and they were grand (trop grand pour être évalué) meaning too big to evaluate, or petit (quelques metres) meaning a small site - here the surveyor was instructed to specify an estimation of square metres in the notes section. The advantage of this method was that it was quick to make an evaluation so survey could progress. However, this meant that no sites found during the 2013 survey were physically measured with a GPS device for their size, but were estimated from a visual assessment. As discussed in the introductory chapter of this thesis, the size of a site (particularly in the Inland Niger Delta region) can indicate how intensely the area was settled and whether or not there are similar sized sites in the landscape which it may have had contact with, and indicate evidence of heterarchy and hierarchy. This body of data influenced the decision to measure site size using the track function on the GPS during the 2014 survey.

Figure 3.4 *Surveying a flat, unvegetated site during field walking in 2013.*

The position of the site in the landscape was the next question that required an answer on the survey sheet. Again, answers were completed in a tick box, and the surveyor could write additional notes if he/she required. The set answers here were *colline* (hillside), *pente* (slope) and *berge* (river bank). Then the survey sheet went on to ask the condition of the site, whether it was *sous cultures* (cultivated), erodé (eroded) or coupé par kori (cut by river/stream). All of this type of topographic information was useful in understanding the environmental conditions of the site and collating similar information was desired for the survey undertaken in this research.

The use of tick boxes and predefined categories for recording the archaeology was successful because it was quick and simple to make a decision about a site by ticking the appropriate boxes. However, the major drawback was that these descriptions were often not detailed enough to gain a thorough and comprehensive outlook on a site and sometimes the box was left blank. This issue was addressed in several ways during the 2014 survey, which will be discussed later, but generally by the use of photography and sketch drawings. The use of photography was optional during the 2013 survey, and was reserved for those that had brought a personal camera to the field. As the field season was not survey intensive, there was little emphasis on the provision of survey equipment, as test pitting and excavation were the main objectives.

After the morphology and position of the site had been recorded on the sheet, the material culture found on the site was considered. The prospection allowed the surveyor to distinguish between sites that had a concentrated or dispersed amount of material culture on the site surface, measured by a visual inspection. This revealed 54% of sites having a dispersed amount of remains, 31% with a high concentration, and 14% of sites were recorded without documenting any density of remains. For the purpose of the survey, this was revealing in showing the variance of material culture density per site, however there were several drawbacks to this method. Firstly, stating whether finds were concentrated or dispersed is subject to the opinion of the surveyor, where one surveyor may believe an artefact spread is dispersed, another may consider it concentrated, making an accurate quantitative assessment problematic. Furthermore, if the surveyor regarded the site to have a dispersed artefact spread, the survey sheet asked the surveyor to estimate how many artefacts were on the ground per square metre. Again, this was measured visually, and therefore was not accurate enough to include in a quantitative assessment of the area, but was still useful in describing a site. Secondly, for 14% of the sites surveyed, no estimate of artefact density was made, so it is difficult to make material concentration comparisons with the other sites in the region. Densities of material culture are important because it can be indicative of the amount of erosion that had occurred, or how intensely a particular area was settled in the past. Because of this, increasing the accuracy of measuring density was an aim of the survey in this research, rather than simply estimating. The following sections in this chapter will address how a more efficient approach was carried out, which not only looked at quantity and weight of material, but considered analysis on every artefact identified.

Overall, the survey carried out in 2013 was important as it adopted the use of survey record sheets, which meant that the surveyors were required to consider specific details of the site and recording was homogenous throughout. Furthermore, this survey confirmed the archaeological importance of the Alibori River area, with over 80 new sites identified here. This testified to the prominence this zone had in the past, which made the area an obvious candidate to be further investigated within this PhD project. The sites on the Alibori River took many forms ranging from vegetated mounds that line the side of the river, to flat, unvegetated sites, with material culture consisting predominantly of pottery, but also frequent lithics and evidence of slag. These diverse aspects of site morphology required a survey method that could accurately illustrate this, which will be discussed later.

3.2.4. The 2014 Survey and Conclusions

The survey in 2014 by members of the *Crossroads* project was not as large as previous seasons, mainly as this research project was running alongside it and focus for *Crossroads* was on test pit excavation. Nevertheless, four team members targeted a geographic area which had not been considered in previous surveys. The method of this survey was similar to 2011, where transects were walked and notes were taken. However, GPS tracks were recorded and many photographs taken. The survey revealed 36 sites.

Overall, the surveys carried out by the *Crossroads* project offered a wealth of archaeological information which gave a good basis for this research project, not only in site discovery but also in methodology. The advantages and disadvantages of the field walking methodology have been considered thoroughly in order to develop a satisfactory systematic approach that was carried out in this research.

3.3. Survey Areas

This section will outline the targeted geographic survey areas that were chosen for survey within this research. As stated in the previous chapter, current knowledge of the natural and human landscape is essential for the design, implementation and interpretation of survey strategy (Mills, 2007). Furthermore, the first step in designing an adequate field walking programme is that the region under examination must be divided into different zones based on geology, pedology, and topography, to offer different interpretations of settlement and land use (Mills, 2007 and French, 2007). With this in mind, survey areas were selected based on knowledge from previous field seasons and the use of aerial satellite imagery.

An objective of the fieldwork methodology was to conduct a systematic and intensive survey of a pre-defined area by field walking in transects which will increase confidence levels of coverage and reduce bias (see Chapter Two). The first area chosen for survey was centred on the modern village of Birni Lafia. This village lies around a kilometre north of the main excavation of the *Crossroads* project. This area was chosen for excavation because of the large settlement mound complex in its vicinity consisting of concentrated surface artefacts and pottery sherd pavements, making this area a prominent feature in the landscape. A satellite image of the area was used to outline the limits of the area to be surveyed as this is very close to the Niger River, and not all areas were accessible. An area of $7km^2$ was chosen in this zone intended for a short, systematic survey of around two days. The aim of this survey was to understand what archaeological materials are close to the important large site, and to offer some context. Furthermore, this area is very close to the flood plains of the Niger River to the east (see Figure 3.3), so the research questions considering the role of settlements close to fluvial systems is also under scrutiny.

The ancient site of Birnin Lafiya was omitted from the survey and the results of this thesis for several reasons. Firstly, the site had undergone an extensive survey by other *Crossroads* project members and comprehensively mapped using DGPS. Secondly, results of this survey and the adjoining excavations are to be published separately by the *Crossroads* project and the data from these publications will be drawn upon as supplementary data for future publications after the completion of this PhD thesis.

Around 5km from modern Birni Lafia to the south, is the Alibori River, a tributary of the Niger River. During the 2013 survey, a high occurrence of archaeological remains (within 1km of its river bank) was found here, and paired with its close proximity to the *Crossroads* project most important site, it became an obvious focus area for systematic survey to be carried out. The river today is a perennial system, which runs from the Banikoara region, northeast through Benin and flows into the Niger River, it is around 120km in length. It is important for local people today because it is used for daily life activities such as washing, watering animals and crop irrigation.

A portion of the Alibori River spanning 12km^2 was chosen to survey systematically taking into account different topographical areas, including Badlands and vegetated areas, all identified prior to survey using satellite imagery. Badlands are heavily eroded expanses of sedimentary rock, which have been heavily worn by wind and water. The areas were chosen due to their accessibility by car and on foot. As there are few tracks suitable to drive down, much of the field walking was undertaken by foot amounting to several kilometres walking a day. The Alibori was also chosen as both sides of the river could be investigated (if the Niger River was investigated for example only one side is accessible).

Remotely sensed satellite imagery made it possible to analyse the landscape from above and understand its various topographical features in order to locate the most accessible area to carry out the survey, so that full coverage can be made. This process of preparing and analysing this imagery is illustrated in Chapter Five, and the usefulness of using satellite data is reviewed in Chapter Two. The rivers in the Benin study area are useful as they act as topographical boundaries to follow during field walking. Orton (2000) comments that topographic limits are the most sensible to follow during survey, particularly because humans are more likely to follow topographic boundaries in the past and this shaped the nature of settlement. The transects started from the main road and travelled west along the river between Kargui and Kofuno, with a transect heading away from the river for comparison. The exact transects were not set out beforehand due and the unpredictability of the terrain and environment (for example some areas may appear non-cultivated on Google Earth but are on the ground, or the car may not be able to reach an area, so another plan must be made). However, some points were marked pre-field season to act as a guide so that areas were not missed; they were then entered into the handheld GPS.

It is important to note that the 5km or so between the Alibori and the Birni Lafia survey area was not considered to be within the systematic survey zones. A lot of time was spent in 2013 walking here to consider the extent of the Birni Lafia settlement mounds and the area was driven regularly to reach the Alibori survey area. Although there were many baobab trees (which are known to be associated with ancient settlement), there was no indication of any archaeological evidence. This will be picked up in the discussion chapter later, but as Birni Lafia sits on a flood plain of the Niger River, it may be that any sites in this area have been eroded away by water.

A third area, intended to act as a comparison to the landscape around the Alibori River, consisted of a much smaller, non-perennial stream. This tributary, which comes from the Sota River, a tributary of the Niger River, differs vastly from the Alibori. Firstly because of its size, just under 10km in length, and secondly, water does not flow all year round, in fact, it is difficult to determine how frequently water flows along this stream. This was identified via satellite imagery as a potential location for survey. It had not been surveyed before and was located close to historically significant areas such as Guene (this was identified as important in the past by Olivier Gosselain and Lucie Smoulderen during their field enquiries as part of the *Crossroads* project fieldwork). It also lies close to the village of Kouara Tegui and for the purpose of this thesis will be referred to as the Kouara Tegui survey area. Furthermore, an aim of surveying here was to identify the differences in site density and proximity from a perennial river to an ephemeral one.

Finally, the last survey area was located in the east of the Dendi region, close to the modern town of Malanville. This area was chosen for two reasons. Firstly, there had been very limited survey undertaken there in the previous field season due to its location in the east, relatively distant from the main excavation at Birnin

Lafiya. The survey in 2011 that followed the main road demonstrated that were many sites here, and that they were under threat by the building of a road running east to west. Secondly, this area was chosen as it had been documented ethnographically as culturally different to the area around the Alibori, signifying traditions of two different groups. An aim was to determine if this could be seen archaeologically through the field survey. Due to the closeness to the Sota River, this survey area will be known as the Sota. The area was in line with the building of a modern road, which compromised the sites there, so survey was important to retain a record of the sites. In 2013 a site was discovered that had been completely destroyed by machine. This area also had a range of fluvial activity within it, including relic streams and a non-perennial channel running close by. Slightly further east of this area was a site named Djaboutchia. This had been established in the 2013 field season as a major site on the banks of the Niger River, and subsequently a C14 date was collected here of AD 650-690 (Beta-345493: Cal BP 1300 to 1260, error 1350 +/-30) This site was also incorporated into the survey.

The field walking survey areas concentrated mainly around perennial and ephemeral water channels, which somewhat bias the results of the survey. The decision was made to focus on these areas because in the previous *Crossroads* project seasons most of the sites discovered were located close to river channels (as discussed previously in this chapter). Although not recorded by GPS tracks systematically, various transects were made in areas away from the river systems and very limited sites were found during previous seasons of the *Crossroads* project. To illustrate the lack of sites away from the river, a transect head south from the Alibori River was put in place. Furthermore, one of the research objectives of this project was to record as many sites as possible in order to benefit the cultural heritage management of the area; therefore focusing on areas with known archaeological potential was at the forefront of the survey design.

3.4. Pre-fieldwork preparation

Prior to fieldwork, a systematic approach to survey in the area was considered; this included provisions for equipment used, preparation of survey sheets and a clear methodology that everyone could follow in the field. It was important to get all this in place before going into the area as there were very limited resources once in the field. As discussed in the previous chapter, archaeological prospection is not a new concept and a variety of methodologies have been devised to suit different areas. A method to suit all the outcomes of this project was devised, based on methodologies produced elsewhere. The reality, though, is that survey areas are all too different to apply exact methods, so one must compile a useful strategy to gain as much information as possible within a particular region. First this section will describe how I envisaged the field walking and recording strategy before going to the field, then discuss the equipment, survey sheets, GPS and camera.

3.4.1. Step-by-step guide to survey 2014

Before entering the field, a plan was compiled on how the surveyors would conduct the field walking on the ground. This plan was translated into French and distributed to the surveyors to read, and all the information was spoken through at the time of survey. The plan worked with teams of two people equipped with one handheld GPS, and one equipment recording kit (both of these will be explained in more detail in the later sections of this chapter). The full guide can be found in the Appendix (page 269), but will be outlined briefly here. General instructions were outlined at the beginning of the document, such as, when walking in transects, maintain visual contact with the person next to you and avoid densely vegetated areas. This was due to safety issues such as traversing the sometimes difficult topography and the presence of dangerous mammals in the landscape, such as snakes and crocodiles. The guide then describes exactly how the survey will be performed, including exact instructions for GPS usage; from turning the device on, to the menu and other button functions. I also demonstrated physically in the field how to do this. Transect directions were maintained following a coordinate that was 1km away in a particular direction; these were usually simple such as north, east, south or west. Surveyors were instructed that when walking transect, they must be observant for archaeological phenomenon such as settlement mounds, pottery sherds, lithics, slag and furnaces.

Recording a site was also explained in person and detailed within the instructions. Site identification is outlined later in this chapter but surveyors were instructed to look for all the visible boundaries of a site, then start at a memorable point (or leave a marker) and walk around the external boundaries recording a track with a GPS.

The team consisted of me, one to three students from the Universite d'Abomey-Calavi in Cotonou, Benin, who studied archaeology and history, and one to three local people from the village of Birni Lafia, where the *Crossroads* excavation was taking place. The team varied between two and seven people at any time depending on the availability of team members. One of the students acted as a translator between me and the local personnel who spoke Dendi. The core team, which consisted of me and a student translator (who was also local to the area and fluent in Fulani, Dendi, French and English) and the locals, had all experienced the archaeology in the landscape. This was necessary to avoid bias, such as that discussed in the previous chapter (see Miller, 2007).

3.4.2. Equipment

There were several items of equipment that were required for the recording of the archaeological sites and were brought to Benin from the UK. This ranged from hi-tech equipment such as, compact digital cameras and handheld GPS devices, to lower tech items, such as tape measures and plastic bags for artefacts. When conducting a survey of this nature in West Africa, every possible eventuality needs to be considered as it is possible that the item will be difficult to find in the field.

- Global Positioning System (GPS)

The most fundamental and essential piece of equipment used on archaeological field survey is the GPS. These devices come in a variety of forms and types and the type of GPS chosen for this research was a handheld device. A total of three, state-of-the-art, handheld GPS devices were used for the survey compiled in 2014, and a selection of other similar devices were utilised in the collection of supplementary data presented in gazetteer one (2011-2013 surveys). The device chosen was the Garmin *GPSMAP 62s*, due to its robust nature, durability and the best accuracy of its kind (within 2m). A handheld device was chosen over a larger, differential GPS (which has millimetres accuracy), as it is less time consuming to operate, easy to transport from the UK and in the field, simple to use with little training required and is inexpensive in comparison with others. Furthermore, if this methodology is to be used elsewhere in countries that are developing their protocol for recording archaeological sites, like Benin, factors such as ease of operation and expense are important.

The step-by-step guide outlines exactly what should be done with the GPS once in the field. The most commonly used functions of the GPS were 'mark' and 'track'. The 'mark' button allowed the surveyor to mark a coordinate where they wished to accurately locate a point, mostly used when taking a point in the centre of a collection unit. The user could change the name of the point so that it would coincide with the information on the sheet and the label that accompanied the artefacts collected. A point was also taken on small finds and other features that were interesting and needed to be accurately mapped. The track function was also used so that once away from the field, the places that were walked and investigated for potential archaeology could be seen on a map. This is important for identifying areas where archaeology did not occur and analysing any landscape patterns which suggests the reason for this.

- Digital Camera

As discussed, the written interpretation of a site is very useful, however it should be noted that it is also a subjective way to gather information. As part of the survey, each surveying team was equipped with a camera so that they could record the archaeological occurrences they were describing. The cameras chosen for this task were simple, easy to use, point and shoot cameras with 16.1 megapixel resolution. The automatic function, which adjusts the light and focus before taking the photos, was always used so that the best quality of photo could be produced. The surveyor was also able to playback the photo easily by pressing one button on the camera, which also displayed the photo number so that it could be written on the survey sheet in the space provided. Scales and north arrows were also required in each photo to understand the size and orientation of the landscape features in each photo.

The one disadvantage of the use of cameras is storage of photographs. Like any digital data, this requires not only an amount of specified storage (storage and data will be described in section 3.1.), but also a back-up of the storage, two or three times, to ensure the security of the data.

Figure 3.5 *Nadia Khalaf (author) using a survey digital camera to take a photo of a collection unit on a site in the Alibori region.*

- Walkie Talkies and Whistles

Keeping contact with surveyors was a crucial focus of the methodology devised in this region and warrants attention in this thesis. Maintaining contact was important for two main reasons, the first was safety, the environment of northern Benin in the 'bush' as it was referred to by the students is challenging, and even those that are from the more developed areas of southern Benin are not used to challenging conditions.

- **Other equipment**

Other equipment used for the field survey and brought to Benin from the UK were: finds bags (heavy duty with tie), tape measures, nails, tags, pens, clipboards and rucksacks.

3.5. Field walking strategy

Survey transects were undertaken in parallel lines in 1km strips. The survey would start with formulating the line, where everyone was required to remain 20m apart. Everyone was required to follow the same compass bearing shown on the GPS device, when conducting the field walking. There were three handheld GPS devices and five surveyors, so a survey line consisted of a surveyor with GPS, surveyor without, survey with GPS, surveyor without, and so on. This was so that at both ends of the line there was a GPS and one in the middle, maintaining the accuracy when walking. The 20 metre spacing between the surveyors was measured using a long tape and transects were only a kilometre long so that consistency could be kept with the spacing. If the team had to stop to record a site then the survey transect was re-measured. If there was difficult terrain, including dense vegetation (where venomous snakes like to hide), then the person would often walk around this obstacle or the survey transect would change course.

3.6. Survey sheets

The written record is one of the most important parts of any archaeological field survey, and outlining a record sheet that will be useful when away from the field is imperative. The record sheet, which can be found in the appendix in the original French form and translated into English, was formulated using hindsight gained from the previous surveys undertaken between 2011 and 2013, and adapted to have a greater emphasis on quantitative data, as well as qualitative.

There are several differences between the record sheets used in the survey described in this chapter to the ones produced by the *Crossroads* project previously. Firstly, there was more freedom to describe the nature of a 'site' by inscribing a written description without being limited to categorise through a pre-defined set of words. The characterisation of a site was problematic, and perhaps the most difficult to define, particularly as erosion in the study area is pervasive making it onerous to determine the extent of a site. Furthermore, the surveyor was required to draw an illustration in planar view of the archaeology that is present in relation to the rest of the landscape, such as the river, vegetation and current inhabitation; this was enhanced by photographs of the total area, which also had to be recorded on the sheet. Although the written description is subjective, the surveyor could express how he/she saw the site. As discussed, there were too many sites which were 'unknown' in nature from the 2013 survey and this had to be avoided. Also, mounds for example, had individually different traits which could be described on the newly evolved sheet, such as shallow or eroding into river. This was all backed up by the use of the camera which is discussed in more detail later, so the subjectivity of the description could be analysed thoroughly away from the field.

The survey sheet allowed a categorisation of position in the landscape along with the current use of the site to be detailed. These were separated into categories based on the experiences of the previous field season and required surveyors to circle one of the descriptions which they felt best defined the site. The sheet offered a choice of describing the site as either next to a palaeochannel/dry river, river, hillside, valley or 'other'. The 'other' section required the surveyor to state their own example of where the site was in relation to the landscape, giving them the autonomy to identify its placement in their own words. This section is useful as the information obtained can be used to take into consideration the vicinity of the site within the potential natural resources surrounding it. This is where patterns can emerge from site placement, which helps to build a wide scale understanding of settlement processes within the landscape. The current use of the site is also important as it directly affects the archaeology beneath it. The surveyor could choose whether the current area was cultivated, abandoned, inhabited, covered with vegetation, no vegetation, or 'other', again the surveyor was asked to describe what that 'other' use may be. Cultivated sites for example, generally have a low material density due to the disturbance of the ground and artefacts are often removed in large quantities before the crops are planted.

Characterisation of the surface of the site (size of the site and concentration of artefacts) was made through a number of quantitative aspects, which varied greatly from the previous surveys. Previously, an estimation of the size of the site was divided into too large to record, or small and an estimate written. For this survey, the surveyor was required to walk around the areas where the archaeology was present; this was the entire extent to which the material culture covered the ground. Whilst walking, the area was measured using the area calculation function on the GPS device. The entire process was made simple by being transcribed into a 'step-by-step' guide (see Appendix for English version), which was translated into French and given to the surveyors in the field before undertaking work. Also, the procedure was carried out several times, so the surveyors were very familiar with it. Once taken, the measurement was stored in the GPS, under the unique code name given to each site, and it was also written on the survey sheet in case the GPS failed.

Further characterisation of the surface of the site was achieved by measuring the concentration of artefacts on the ground through the use of collection units. As mentioned in the previous chapter, Fasham *et al*. (1980) commented that surface collection is the only accurate way to calculate density of material culture. This was the most beneficial process to the survey, though necessarily the most time consuming. The aim was to calculate, as accurately as possible, the density of material culture, the fragmentation and the type of artefact that was present on the site. It was carried out by identifying the centre of a site, and using the equipment provided, measuring a circle of $10m^2$. All material within this circle that could be picked up from the surface (without excavation) was collected including, ceramics, bones, lithics, metal objects and glass. These were recorded on the survey sheet, subsequent to the survey, by counting each sherd and weighing the material culture per collection unit. Furthermore, the ceramics were photographed and the photo number written on the survey sheet. This collection approach was successfully utilised on the *Ghadames Archaeological Survey,* whereby a circle with a radius of 1.78m was measured in the ground and the material culture found within the circle was collected (Mattingly and Sterry, 2010).

The survey sheet required the coordinates of the collection unit to be written out, again in case of GPS malfunction, or errors by the surveyor, plus the coordinates of any significant find or feature encountered. This could be a small find such as a bead or metallic object, or a feature that is prevalent in the area like a furnace or a potsherd pavement. A photo of these items, *in situ,* was also recorded. Finally, a space for any supplementary notes or observations, which could be made by the surveyor filling out the sheet, could be provided, with a space on the back to continue if necessary.

There is limited literature that looks at archaeological interpretation of sites through written proforma and most, if not all of this literature is looking at recording during excavation, i.e., book chapter 'Meaning, Materiality and Agency in the Process of Archaeological Recording' by T. Yarrow, in *Material Agency: Towards a Non-Anthropocentric Approach.* Much of the literature on survey recording focuses on the methodology for that particular site or area, therefore it is generally not applicable to other areas unless working in a similar landscape. Many authors go as far as discussing data collection routines, with homogenous descriptions of transects and artefact collection. Furthermore, it is unusual for these authors to circulate the survey sheet used beyond the project itself. There is a general consensus on some functions of the pro-forma, for example, where possible the use of photography to illustrate written interpretation. Also, the need for a general written description of the area is often necessary, although subjective. For researchers coupling survey with GIS, which today is always the case, the survey will make a reference to the landscape features, these will be contemporary with the objective to link it back to the ancient landscape, for example survey on the Island of Kythera, Greece (Bevan and Connolly, 2002).

3.7. Identifying sites

Identifying and defining an archaeological site is one of the biggest challenges when conducting survey, particularly in an archaeologically unknown landscape. Any archaeological occurrence encountered during the survey for the purpose of this chapter will be referred to as a site. This research seeks to improve the criteria for definition of a site in this region, a question which will be discussed in the results chapters. The surveyors that took part in the survey had all been to this region before and were aware of the morphology of an archaeological site.

Implemented within the survey were some key indicators of an archaeological site. When field walking, the surveyors were instructed to look out for material culture on the ground. The presence of more than two pottery sherds was recorded. Isolated pottery sherds were not recorded, as they were in the 2013 survey. This is because the provenance of them is questionable. Usually on an archaeological site there would be far more than one pottery sherd, even if the distribution was dispersed. This was an indicator of a site. A second was the identification of mound sites. These were usually prominent in the landscape so were not difficult to identify, apart from those which were very deflated and eroded, but the surveyors were aware of these. Cultivated areas required special care and attention as sometimes the pottery sherds would be churned into the ground, or wet from irrigation, therefore more difficult to see.

Site function is difficult to ascertain at this stage of the research where few excavation trenches have been dug in the landscape. Nevertheless, based on the excavations at Birnin Lafiya it is almost certain that the archaeology here consists of settlement habitation. The mounds consist of multiple phases of occupation consisting of mud architecture, which built up built up over time creating the elevated mounds. In some cases, the settlement shows evidence of other activities which are contiguous to daily life like iron smelting; and this is demonstrated archaeology by furnaces found on the ground surface. The flat and deflated sites probably had shorter occupation duration in comparison to the larger sites. Consequently, as exact functions of site have not been established other than ascertaining they are settlements, the sites were divided into categories defined on their present existence in the landscape. This classification system can later highlight those sites at risk. These categories will be explained in greater in the next chapter; however, consist of mounds sites, flat/eroded sites and cultivated sites.

3.8. Sampling Strategy

The following section will outline the ways in which the archaeological landscape was sampled during the survey and how information was collected within the confines of the research. It has already been discussed that the survey areas and transects undertaken were purposely located close to the fluvial systems. This means the sampling strategy is somewhat biased in obtaining full coverage of the landscape at this stage of the research. The collection and recording of artefacts in order to measure density and type will be discussed in relation to previous works.

3.8.1. Artefact collection

Collection of finds during systematic survey was implemented to gain an outlook on several landscape and settlement functions. Firstly, the spatial patterning of style and decoration of ceramics will indicate isolation or dispersal of traditions, highlighting different cultural groups in the landscape. Secondly, the quantity of artefacts on the surface and the weight will offer insight into fragmentation and indicate the amount of erosion that the surface has endured. Furthermore, it may be inferred that the higher the quantity of material culture, the more utilised that area was in the past, or that it was abandoned later, which is why artefacts are still found in dense quantities. Finally, the type of artefact collected offers an outlook on craft specialists and trade that may have taken place. For example, the presence of beads may signify long distance trade. Spatial awareness of where the finds occur will aid in establishing patterns of material culture, which will be indicative of the people who lived in the landscape.

The sampling strategy was based on a method undertaken previously on another archaeological project *Ghadames Archaeological Survey* (Mattingly and Sterry, 2010) where, similar to this project, the specialist team was helping to train individuals in the region, therefore a simple but effective method had to be chosen. This method involved consistently collecting from a $10m^2$ squared collection unit on every site that was encountered. The size was chosen as it was big enough to gain a relative understanding of the material culture on each site. Smaller sample areas mean less information gained and as the survey could only be conducted once, it was decided a large sample was preferable.

During the field survey the artefacts were collected from the centre of the site in every case, unless the centre was unattainable, then as close to the centre as possible. The site centre was ascertained by walking around and seeing how far the artefacts spread on the ground surface, which determined the limits of the site. If the site was particularly large, then it was split into two equal areas and a collection was made from the centre of these areas. The $10m^2$ collection unit was measured using a 30m tape and two stakes. One stake was placed in the centre of the site with the measuring tape end being secured by it, then the tape was extended 1.78m, which measured the radius and a second stake was used to score a circle in the ground. A GPS point was taken in the centre of the circle where the stake was, and all artefacts that could be lifted from the ground with ease were collected. No artefacts were excavated. Each circle was given a unique code dependent on the date and GPS used, the explanation of this can be found in the step-by-step guide in the appendix. The process can be seen photographed in Figures 3.6 and 3.7.

Figure 3.6 *A local surveyor measuring a collection unit circle on an archaeological site identified during survey.*

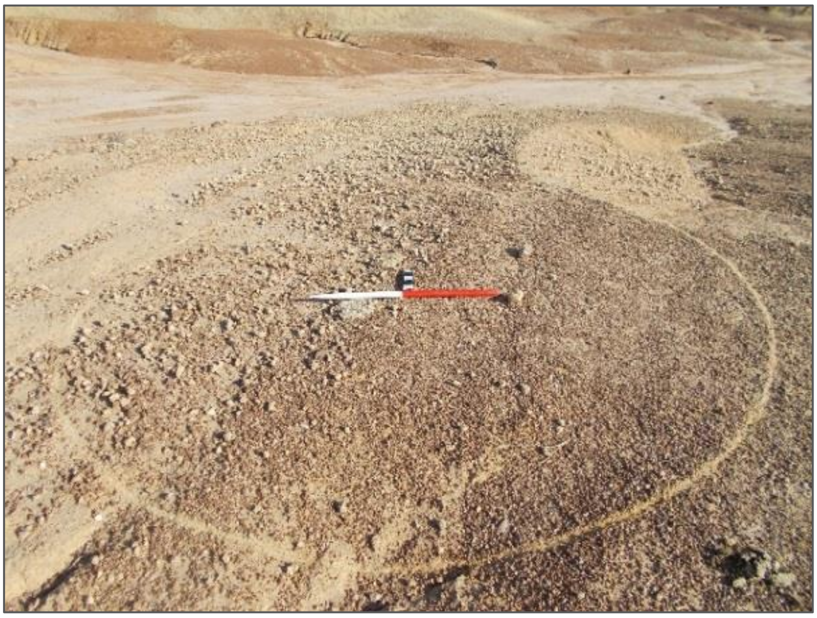

Figure 3.7 *The resulting collection unit before artefact collection with one metre scale in centre.*

3.8.2. Recording artefacts

All artefacts that were collected on the field from the collection unit were taken back to the base camp of the area where we were staying to be recorded. One collection unit at a time was processed by the team. There were separate record sheets for this process where each column was assigned for a collection unit bag. The processing first involved weighing the artefacts found in the collection unit by type, so all of the ceramic sherds would be weighed together, lithics, slag, and so on. Then the total amount of each artefact type recovered would be counted. The total weight and quantity of the artefacts were also written on the individual survey sheets that had been assigned to each collection unit. At this stage, anything that was not ceramic material was put to one side as these would not be subjected to further analysis.

***Figure 3.8** Students processing ceramic sherds that were collected during the field survey.*

Material culture decoration distribution is one of the indicators used to see culturally different distinctions in the landscape; therefore the pottery sherds underwent further detailed analysis so that potential patterns could be identified. After the sherds were weighed and the total counted, the smaller sherds were separated out; this is known as 'desampling'. These smaller sherds would not be considered for further analysis, which was consistent with the methodology of the *Crossroads* project, whereby any sherd that was smaller than the 25 CFA (West African Franc) was discarded. However, in the case of this survey, the desampled sherds were photographed, in case they were required for further information during the analysis and could be used in the future (beyond this research thesis) for an in depth analysis of the ceramic sequence. An example of the desampled sherds from one collection unit can be seen in Figure 3.9 and the process of desampling in the field can be seen in Figure 3.8. Once the smaller sherds were separated, the larger sherds were recorded. Firstly, the sherds were divided into rim and body sherds; the rim of the vessel, if large enough, can often allude to the shape of the overall vessel, which is why they were separated. Then, the sherds were laid out and grouped together by type of decoration. Decoration type groups are relatively broad and included: undecorated, eroded, Folded Strip Roulette (FSR), perforated, incised, and 'other' which included all other decorations including two and three decoration composites, and unusual decoration which was relatively rare (decoration will be discussed in greater detail in the next chapter). Once separated, the decoration types would be counted and recorded on the record sheet, for example, five perforated body sherds, or nine eroded rim sherds. A photograph of these individual groups was also required for two reasons, firstly this was an additional back up of data if the record sheets were lost and secondly, any additional detail that may be evident and missed in the field could be seen in the photographs. All of the photographs of the ceramic sherds featured a relevant scale bar and the original label of the bag featuring the date, the collector and the collection number. Many diagnostic sherds were bought back to the UK for further analysis; however, in-depth analysis of this ceramic material does not fit the realm of the thesis and will be used for a later study after the publication of the ceramic sequence by the *Crossroads* project.

Figure 3.9 *Example of desampled pottery from a collection unit.*

3.9. Summary

The methodology used for fieldwork outlined in this chapter was devised using a combination of survey methods defined in contexts out of Africa, and using the advantages of the methodology already established in the region by the *Crossroads* project. Additionally, the survey that was devised was distinct to the Niger River Valley area of West Africa, where certain challenges had to be factored in, such as lack of infrastructure and challenging environmental conditions including temperature, wildlife and terrain. Such obstacles would not traditionally be faced in other areas of the globe.

The next chapter will discuss the results of field survey undertaken, which was implemented using the methodology outlined in this chapter. This includes an in depth look at what types of site were encountered, their distribution and material culture types and decorations that were discovered.

4. Survey data: results and analysis

4.1. Introduction

This chapter will discuss the results and preliminary analysis of data obtained during fieldwork, which was undertaken using the methodology discussed in the previous chapter. The field survey was undertaken over 45 days and covered a total area of 25km^2 within four geographical zones in the study area. The four zones surveyed are illustrated in Figure 4.1, and include 7km^2 around the modern village of Birni Lafia, 12 km^2 by the Niger River tributary the Alibori, 3km^2 close to a small tributary the Sota River, and 3km^2 near the modern village of Kouara Tegui. As discussed in the previous chapter, these areas were chosen prior to the survey and broadly mapped out using satellite imagery. However, the pre-mapped areas were slightly modified when on the ground due to factors such as accessibility, logistics and time restraints. Despite this, transects were kept to the designated areas as much as possible.

The complete systematic survey undertaken in January and February 2014 over five weeks will be presented first within this chapter, highlighting the main trends in site distribution and material culture visible in the landscape. The appendices of this thesis will then be discussed, which include two comprehensive gazetteers detailing the precise information discovered on survey and two material culture catalogues detailing the finds from the sites within this survey. The first gazetteer is the information retrieved from survey undertaken by the *Crossroads* project; the second is the survey findings compiled from this research. Then the results from the four individual survey areas that were outlined in the previous chapter are detailed.

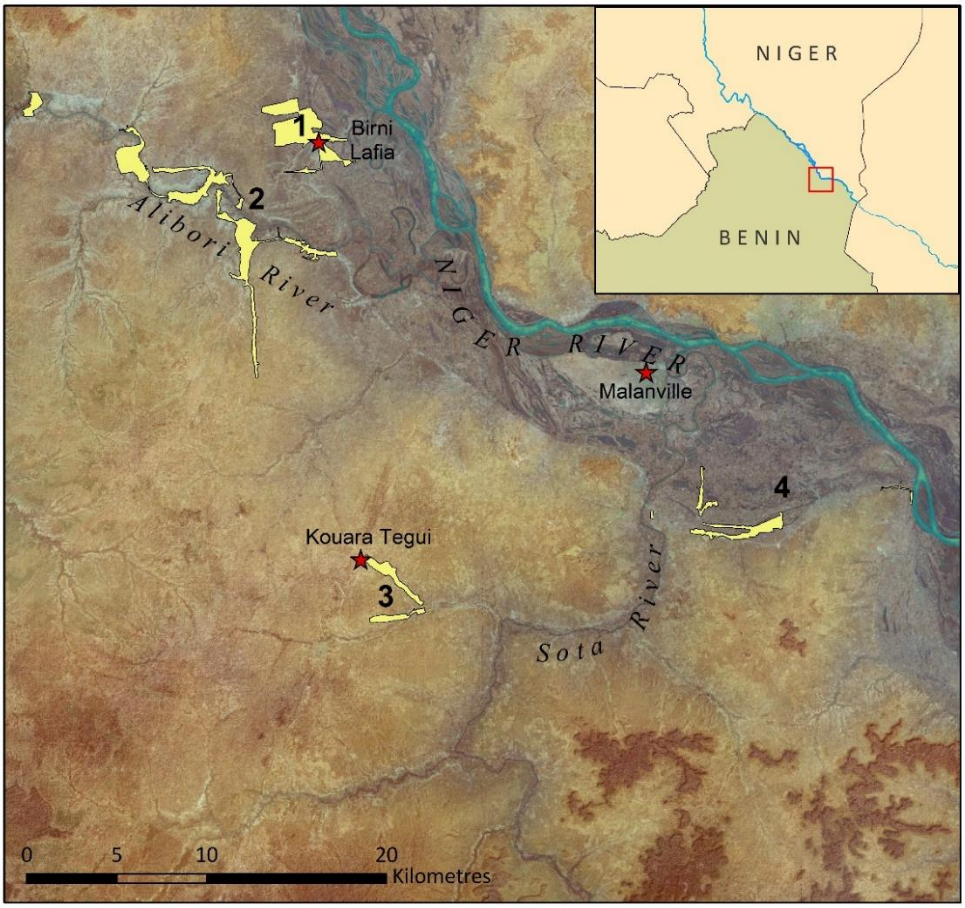

Figure 4.1 *Map showing the survey areas, depicted in yellow, within the study region. Area 1: Birni Lafia, 2: the Alibori River, 3: Kouara Tegui, and 4: the Sota River. Satellite image Landsat 8 and ASTER GDEM, courtesy of USGS.*

Overall, the field walking survey enabled the discovery of 320 archaeological areas of interest, where 317 artefact collections were made, throughout all of the survey areas. Figure 4.2, shows the distribution of the sites found. The individual details of these sites, including location, size of site, description and material culture present can be found in the site gazetteer in the Appendix (Gazetteer Two) and the particulars of this will be discussed in section 4.2.

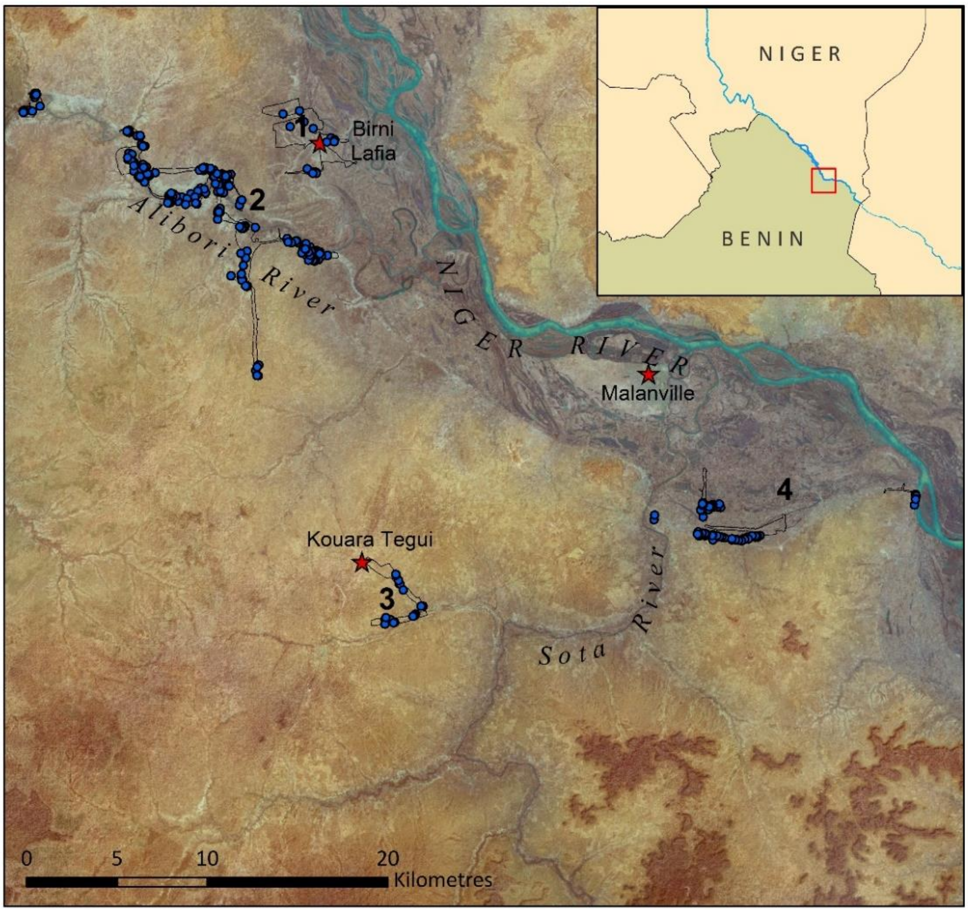

Figure 4.2 *Map showing distribution of all 320 archaeological sites within the survey areas in the study region. Satellite image Landsat 8 and ASTER GDEM, courtesy of USGS.*

As can be seen from Figure 4.2, sites were discovered in all the survey areas that were designated, and occur in varying densities. These sites can be divided up into three broad types, dependent on size and morphology/structure of the archaeological area seen on the ground. It is assumed however, due to the scale of most sites and the abundance and nature of finds, that the cultural occupation of these sites is related to settlement. For the purpose of this research, a threefold typology has been devised to best categorise the sites found in the landscape:

- Mound sites

The most frequent type of site that was discovered during the survey were mounds, which are common in West Africa, and are the easiest to identify. Mounds are elevated areas of ground that vary in size; some are subtle entities in the landscape, whereas others are very large with steep hills. The subtle mounds are shallow and deflated and usually have this appearance due to erosion. Eroded mounds will be discussed later in the chapter. Natural mounds also occur in the landscape and do not have any material culture present on the surface. These mounds were discounted during survey, as there was no material culture on the surface to indicate that they were sites. However, this could be because no erosion has occurred to reveal the material culture beneath the surface and this may be the case at the survey close to Kouara Tegui, this will be discussed later.

The morphology of mounds in this region can be compared to the well published tell sites in the Near East. The word *tell* dates back to early-Mesopotamia and simply means hill, which has taken on the meaning of mound built up from ruins of previous civilisations, where the mound stands higher than its environs due to ancient public buildings (Ernest Wright *et al*., 1974). The mounds found in northern Benin are similar in description; however, there is no evidence for the grandeur architecture such as that found in the Near East.

- Flat/eroded sites

Another type of site is the flat/eroded site; this type of site has material culture present on the surface only, and no other distinguishable topographical features. The flat/eroded area could potentially have been a mound in the past and has suffered extensive erosion, deflating and 'flattening' it, or could be an area that was only briefly settled, leading to little accumulation of the building material and artefacts that often create mound sites. This will be discussed further in Chapter 6.

- Cultivated sites

Finally, cultivated sites were another type that occurred. These sites have anthropogenic disruption by ploughing and sowing crops, which has disturbed the material culture on the surface. The configuration of the cultivated areas varies from mounds to flat sites, and has been singled out as a type of site as there is often severe disruption to surface assemblage, which can affect typology of artefact and density, both of which are under analysis in this thesis and will be discussed in the course of the present work.

The overall size of each site, seen either from the surface assemblage on the ground by the surveyor, or the overall shape and extent of the mound in the case of mound sites (as discussed in Chapter 3), was recorded using a GPS track. The results here varied greatly from site to site; the smallest site measured $4m^2$, whereas the largest was over $60{,}000m^2$ (six hectares). It is important to mention that the assessment of site size was made within a quick time period, as the priority of the survey was to identify as many sites as possible. Consequently site size should be used as a broad indicator. Site size was only recorded if there were two or more pot sherds on the surface, areas with isolated sherds were not recorded. The largest sites were recorded in the Sota region, where over two thirds of sites recorded here were mound sites. The smallest sites on average were the sites recorded along the Alibori River, where erosion frequently occurred; nonetheless, the biggest site discovered on the survey was found here.

In total, 49,057 pottery sherds were collected during survey and counted, weighed and photographed on the field. Of these, 6,641 sherds (14% of the assemblage) were kept for further analysis by noting the form and decoration. Diagnostic sherds, namely rim sherds and complete rims, were brought back to the UK from Benin, with permission from the Benin authorities. The average amount of sherds per collection unit is 153, and the median is 59, suggesting that there are sites with very large quantities of sherds.

For the purpose of this chapter, the results have been broken down into the geographical groups of the different survey area and illustrated in a set of maps. This chapter shows what was found on the survey and uses tables and maps to indicate trends in distribution, and show preliminary patterns, before spatial analysis techniques are conducted in Chapter Four.

4.2. Overview of Appendices

This section will discuss the tables that are presented in the appendix which detail all observations made during the survey between 2011 and 2014. Despite the potential loss of detail involved with working with data derived from other researchers during the primary surveys of the project, it was imperative that it should be included in order to give the results found in this research a broader context. Furthermore, record of all sites discovered is useful for cultural heritage management, and this will be discussed in due course. Thus, the appendices include two gazetteers; one details survey data obtained by different members of the *Crossroads of Empires* project obtained during the earlier surveys, and the other is a gazetteer of sites that were discovered in conjunction with this doctoral project using the methodology outlined in Chapter Three. The tables (1 and 2) also in the appendix show the finds that were recovered at the sites detailed in the second gazetteer, both of which will be discussed in this chapter.

4.2.1. Gazetteer One

The first gazetteer is comprised of data that was collected by various members of the *Crossroads* project team, using a range of methodologies which are discussed in Chapter Three. The table is divided by the year the information was collected – 2011, 2012, 2013 and 2014, with the largest quantity of sites recorded in 2013. This table directly derives information from the primary record and has not been modified from when the record was taken in the field; however, in some cases sites were duplicated between years and surveyors and in these cases the descriptions have been merged, but only one GPS point kept. Also, there were several cases of isolated sherds being recorded, particularly in 2011, which do not feature in the gazetteer. This is because it is difficult to tell if isolated sherds relate to archaeological sites or whether they found their way to that position through people moving around in the landscape.

Within Gazetteer One, each site has been given a unique identification number, so that in the following chapter (Chapter Five) the sites can be referred to, and one can consult the gazetteer for further details. Each site has the geographic coordinate is given, the elevation of the point in metres, and the date the point was taken and the person who recorded the information (shown by their initials). The survey reference is given, in some cases this is only a number relevant to the surveyor and in other cases this is the name of the place that was surveyed. Next on the table is the description of the site that the surveyor documented. The type of description varies between surveyors, as expected, some are brief and some are highly descriptive. Furthermore, some of the descriptions have been translated from French to English for the purpose of continuity in the gazetteer. There is a photo and other information section also in the gazetteer showing the additional data collected on the survey.

4.2.2. Gazetteer Two

The qualitative and quantitative results from the survey conducted within this research project have generated a comprehensive site gazetteer of findings, produced alongside Gazetteer One, listing sites discovered during the original surveys of the *Crossroads* project. The purpose of the second gazetteer presented in the appendix, is to detail the observations found on each site that were encountered during the systematic field survey undertaken in January and February 2014. One of the objectives of the thesis, as outlined in the introduction, is to create a geographical register of all known sites discovered during the time of the *Crossroads of Empires* research project. Again, the entries are presented in a traditional gazetteer style, and can be utilised in conjunction with a range of maps that are shown in this and the following chapters. The gazetteer is presented in tabular format and the columns are divided into different categories (an example of the gazetteer can be found in Figure 4.3). All of the details that fill the gazetteer are transcribed from observations made on the survey sheets during the field survey. The first column is the 'ID'; this is a numeric field where a unique number has been given to each collection unit (site) that was recorded and in nearly all cases, an artefact collection made. These site numbers are referred to in the thesis and can be cross-referenced in the gazetteer and pottery tables. The proceeding columns list the latitude and longitude in the coordinate system World Geodetic System (WGS) 84, which is one of the most widely used coordinate systems for earth navigation. The elevation of the site that has been recorded by GPS is detailed, giving each site an exact location and elevation (x, y, and z). The date that the site was discovered is specified along with the code that it was assigned. The geographic survey zone in which the site was recorded is detailed, so at a glance it is easy to locate a site. All of this information is generated by the GPS - the rest of the gazetteer is made up of subjective observations made by the surveyor apart from the final column of the gazetteer which details the total area, in metres squared, of the site that was calculated using the GPS track.

As discussed in the previous chapter the 'position of site' and 'current use' let the surveyors choose from pre-set words presented on the survey sheet (see appendix), or they could write their own description under 'other' section. Both of these columns state the exact description that was noted during the survey by the surveyor. However, not all sites recorded this detail as it was sometimes difficult to determine the position and use of the site when on the field.

ID	Lat	Long	Elevation	Date	Collection	Zone	Nature of site	Landscape Position	Current use	Clear limits	Area (m^2)
68	11.96687	3.129217	170.4	22/01/2014	P14-2201-3	ALIBORI	Medium sized settlement mound on the bank of the Alibori River, close to modern village. Found a worked piece of FSR in a circular shape. Not collected, not in unit.	River	Cultivated		1440.6
69	11.96573	3.130204	170.8	22/01/2014	P14-2201-4	ALIBORI	Relatively large area with disperse pottery on the bank of the Alibori River. Perhaps once a settlement mound but very eroded at the edges with pottery flanking in.	River	Abandoned		3613

Figure 4.3 *An example of the tabular layout of Gazetteer Two.*

The gazetteer is divided in two ways for ease of use. Firstly, it has been separated by geographical region, according to the different survey areas that were described in Chapter Three (also how the results in this chapter are divided) and shown in Figure 4.1. It is also split between the GPS that was used, which was dependent on the surveyor. The observations detailed using GPS 1 were made by me, whereas GPS 2 and 3 were conducted by students (Abbass Diallo, Samson Tokannou and Amour Ayibatin) from the Université d'Abomey-Calavi. The annotations made by the student surveyors have been translated from French to English and the English description is detailed under the 'nature of site' column. The qualitative/descriptive information in the gazetteer has not been modified from their original form written in the field; therefore these are the original, initial interpretations. A photograph exists of every site which may tell a different story, depending on who was interpreting it, but for the purpose of the gazetteer, the objective is to present the primary record of the sites, and different interpretations that contradict the initial findings may be made in the discussion of the results.

4.2.3. Summary of finds tables

The finds discovered on the survey are split between two tables in the appendix. The first table (Table 1: Ceramics and other finds) uses the same identification number for the sites detailed in Gazetteer 2, for cross-referencing, and includes the quantity and type of artefact found. The columns of the table are divided into artefact type, the first artefact type is ceramic sherds, which is separated into body sherds and rim sherds and includes how many of the total number of sherds were desampled (desampling is described in the previous chapter, where sherds smaller than a 25 CFA coin were discarded). The following columns show other artefacts and in what quantity they were discovered within each site including lithic and slag. The last column is for 'other' artefacts, which includes iron objects, beads and bone.

The second table, also divided by geographical region, goes into detail about the ceramic sherds that were found. The first part of the table gives information on the decoration of the body sherds that were found. This is divided into seven categories, which will be briefly described here but discussed in greater detail later in this chapter. The first column 'Undec', meaning undecorated sherds, then 'Eroded' meaning sherds with eroded decoration, thirdly 'FSR' standing for Folded Strip Roulette where the sherd only has evidence of folded strip roulette present on its surface, 'FSR/Plain' meaning a sherd that has folded strip roulette and plain (no decoration) design on it, 'perf' which stands for perforated sherd, also known as *cous-cousière*, which describes a sherd with holes pierced in it. Penultimately, 'Incis', which means a sherd that has had incisions/scorings made in it and, finally, there is an 'Other' section, this includes sherds that have decorations that cannot be categorised into these columns, this may be because they have 2 or more decorations, for example, folded strip roulette with incisions, or the decoration type does not occur frequently enough to justify its own category, for example, geometric designs or painted sherds. The description of the 'other' type of sherd can be found in the last column of this table.

4.3. Summary of all sites

This section outlines a summary of all of the sites found throughout the study regions. This includes an overview of the general distribution, type of site discovered, elevation of site, the size of the site, material culture type and density and ceramic decoration.

4.3.1. General distribution of sites and survey areas

Overall, the targeted survey areas showed substantial evidence of archaeological occurrences within them, which can be seen in the distribution map (Figure 4.2). These areas were initially chosen for several reasons, which are outlined in the previous chapter – Birni Lafia is the area where one of the largest settlement mound clusters is located and where the main excavation of the *Crossroads* project is located, the Alibori River, where many sites were discovered in the previous fieldwork seasons and further east, Kouara Tegui and the Sota River, which had limited or no investigation previously, making them all key target survey areas. Figure 4.2 shows the areas that were surveyed, defined by the black hollow polygons, and the sites that were discovered are shown by the blue points. At this scale, the distribution appears relatively uniform across the survey areas, with sites close together and clustered. In total 320 sites were located during the survey, to add to the additional 518 sites discovered during the previous surveys, bringing the total amount of sites discovered to 838.

The survey areas were adjusted dependent on where was accessible during the survey; topographical barriers such as vegetation and varying degrees of elevation, restricted roads and track ways making it difficult to get to places that were intended for survey. Transects within the survey areas were intended to be straight, following a particular bearing, but often went slightly off course due to these topographic obstacles. The survey agenda was to conduct a relatively quick survey of a broad area as systematically as possible within the circumstances that were presented, therefore time was not wasted with the removal of obstacles, and they were simply walked around. A plan of transects is found in the appendix of this thesis.

4.3.2. Typology of sites

The archaeologically unknown nature of this region prior to the surveys undertaken by N'Dah (2001) and the *Crossroads of Empires* project, mean that creating a site definition is difficult. The notion of an archaeological site can be construed in different ways (as alluded to in Chapter Two), and this research seeks to improve the criteria of the archaeological 'site' in this region based on the survey evidence. The type of site was categorised on the survey sheets under the heading 'nature of site'. As the description was reliant on the view of the surveyor, each surveyor was instructed to take a photo of the site, so the description could be verified by photo, to a degree. As discussed, some broad categories have been developed, which will be further interrogated in the discussion of this thesis to conclude with solid site definitions. It is important to recognise that although two or more sites may be categorised with the same definition, no two sites are the same in this region, and all are unique. It is also important to remember that the site is not being described by its use (although work on West African tell sites leads us to believe many of these sites are settlements), which is usually how a site is described, but simply by its morphological properties that can be seen on the surface. The use of a site can only be determined with further investigation such as geophysics or excavation.

The three main categories of site encountered during the survey are mounds, flat/eroded sites and cultivated sites (all described in section 4.1). The flat and eroded sites generally occur only in areas of the Alibori River. The badland topography, which features areas of severe erosion usually found in semi-arid regions such as the Sahel, have a lack of vegetation due to heavy rain showers washing plants away and causing the ground to erode. The Mékrou Valley in southwest Niger, around 200km southwest of the Niger Valley, exhibits a similar type of topography, where stone age artefacts were collected from eroded Pleistocene and Holocene sediments (see Idé *et al*., 2005). This type of landscape has revealed dense artefact scatters, which will be discussed in further detail later. Of all 318 sites located, around 26% were described as eroded and all of these are located in the Alibori region. Of the 318 sites discovered, 127 were described as 'mounds'. The other sites that appeared frequently were flat sites - 72 of these, and eroded sites, 61 in total. Sites that had cultivation present totalled 107 (33%).

4.3.3. Elevation of sites

The elevation of sites varied between the areas surveyed. The elevation generally in the region ranges between 49m and 347m above sea level, this is measured using the digital elevation model (DEM) provided by the ASTER satellite sensor. The landscape is generally flat with some natural escarpments not higher than 260m above sea level (see Figure 4.4). The areas surveyed that present archaeological evidence lie at 160m and 190m, with almost half of the sites lying at between 170m and 180m (see Table 4.1). Of all the sites, the average altitude was 174.1m. Around the Birni Lafia area, the sites were mostly below average, with a mean total of 166.4m. The sites around the Alibori River on average measured 174.8m, almost 10m higher than the sites at nearby Birni Lafia. In contrast, the sites in the east of the study region, close to the Sota River, had an average of 168.7m in elevation. The area with the highest average was further south around the village of Kouara Tegui, at 199.14m, but had the lowest density of sites.

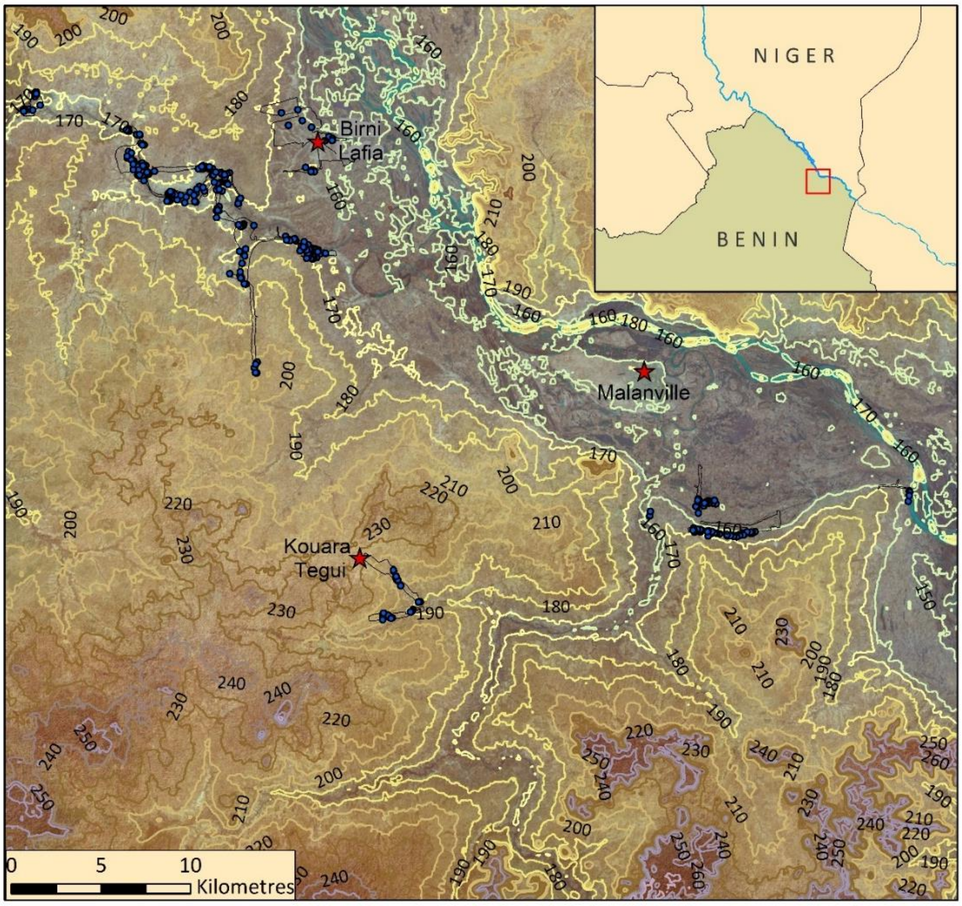

Figure 4.4 *Elevation of the study area. The archaeological sites are illustrated with blue points.*

Elevation (metres)	Number of sites	Overall percentage
<160-170	99	31.1%
170-180	157	49.4%
180-190	43	13.5%
>190	19	6%

Table 4.1 *Elevation of all sites in the study area and percentages.*

4.3.4. Site size

The average area of a site varied greatly, with the smallest site surveyed measuring 4.18m^2, to the largest site measuring 60,397m^2. As discussed in the methodology, the area of a site was measured dependent on the spread of material culture on the ground, without excavating each site it is difficult to determine the true extent (pros of survey over excavation discussed in Chapter One Introduction). The average site on the surveyed measured 4,771m^2 (0.47 hectares), with the largest sites taking the form of mounds located in the Sota River area, with the largest site being one site in the Alibori region measuring 60,397m^2 (6.04 hectares).

Figure 4.5 shows the area of sites in all regions. What can be seen from the map is two different stories evolving in the east and west. The differences in area of sites will be considered with a visual inspection in this chapter and further analysed using spatial analysis in the next chapter. From a visual inspection of the patterns it appears that in the west, the Alibori area, we see site clustering, where large sites are grouped with smaller sites close by. Further to the west we see a range of small sites cluster together, with fewer large sites. In the Birni Lafia region, very small sites are isolated toward the northwest, but two groups of large and small sites cluster together in the centre of the study area. One of the clusters is the periphery of the main site of ancient Birnin Lafiya settlement mound. In the Sota region in the east, the survey showed that very large sites cluster together in rows along the area surveyed, with one site neighbouring another. No sites in this area were described as eroded so finding large, intact mounds is not a surprise.

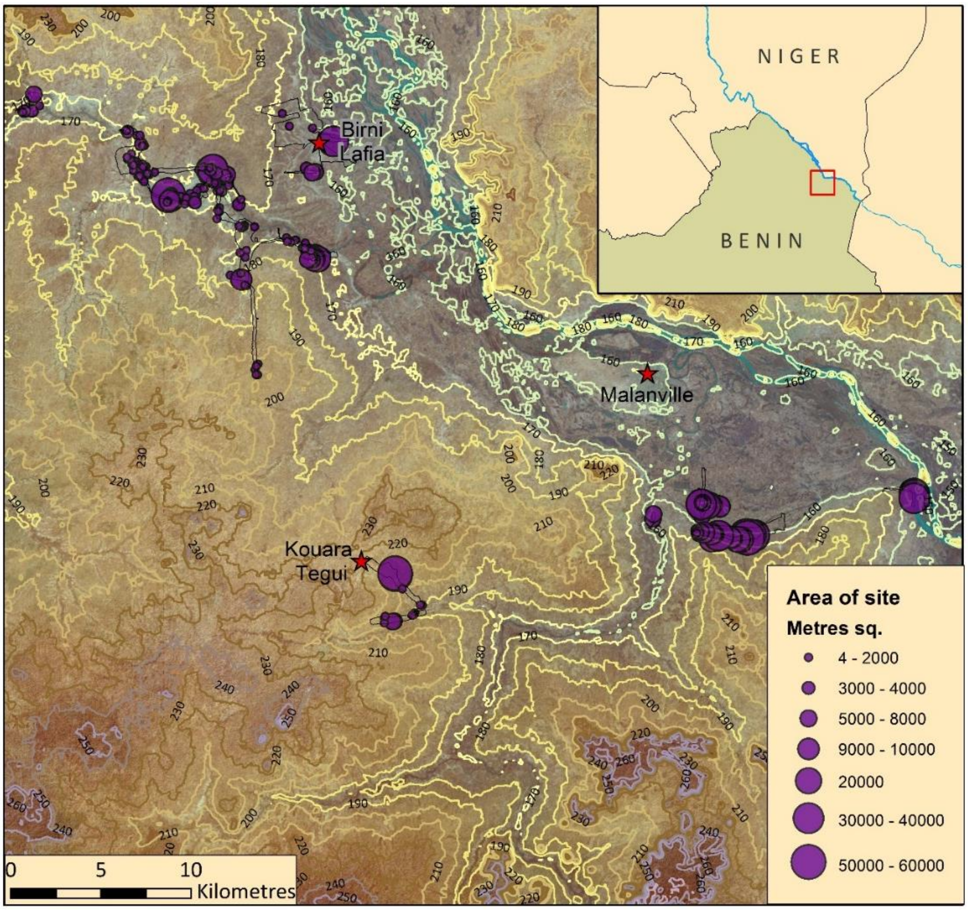

Figure 4.5 *A map showing the area of archaeological sites measured in metres squared throughout the study area using proportional symbols.*

4.3.5. Material culture densities

Overall the surface assemblage consisted of six material culture types, these were ceramic, lithics, slag, metal objects, bone and beads. 'Surface assemblage' is a term defined by Orton (2000) as material recovered from the surface during field walking. Ceramic sherds were found in the highest quantities, making over 97% of the corpus, totalling 49,057 sherds. Lithics totalled 981 individual artefacts and bone accounted for 127 of the corpus, however, 117 of these bone fragments were from one site, and as they were difficult to identify, they will be discounted from discussion in this thesis. The highest densities of material culture were found in the Alibori region, with sites averaging 184 sherds per site. The Sota region sites, on the other hand, averaged 115 sherds, however, this average is greatly increased because of the finds found at Djaboutchia in the far east of the survey area, on the banks of the Niger

River. Material culture densities will be broken down in the following sections of this chapter, but see the table below for an overall view across the study area. There are 122 sherds of the 6,733 that were not desampled where the type and decoration cannot be accounted for.

Slag was found in low densities, which is surprising due to the amount of furnace activity within the study region (this has been highlighted by C. Robion-Brunner *et al*., 2015). Only one site (Site 7) in the Birni Lafia showed evidence of slag smelting activity with 17 fragments collected from within the collection unit, which had a huge quantity of lithics (107 fragments) and no ceramic. There were 29 sites in the Alibori that had slag present within their collection unit; however the average amount from these sites was three fragments, which is insufficient to definitely say there was iron working evidence in the area. Kouara Tegui showed no evidence of iron working and the Sota survey area had one site with slag present within the collection unit. In some cases, furnaces were detailed within the survey sheet, though it is difficult to say if all cases were actually furnaces due to lack of expertise from the surveyors of their morphology.

All artefacts

Type	Ceramic	Desampled	(%)	Body	Rim	Lithic	Slag	Other
Total	49,057	42,294	86	5,888	753	981	252	221

Table 4.2 *All artefacts collected in the survey divided by type.*

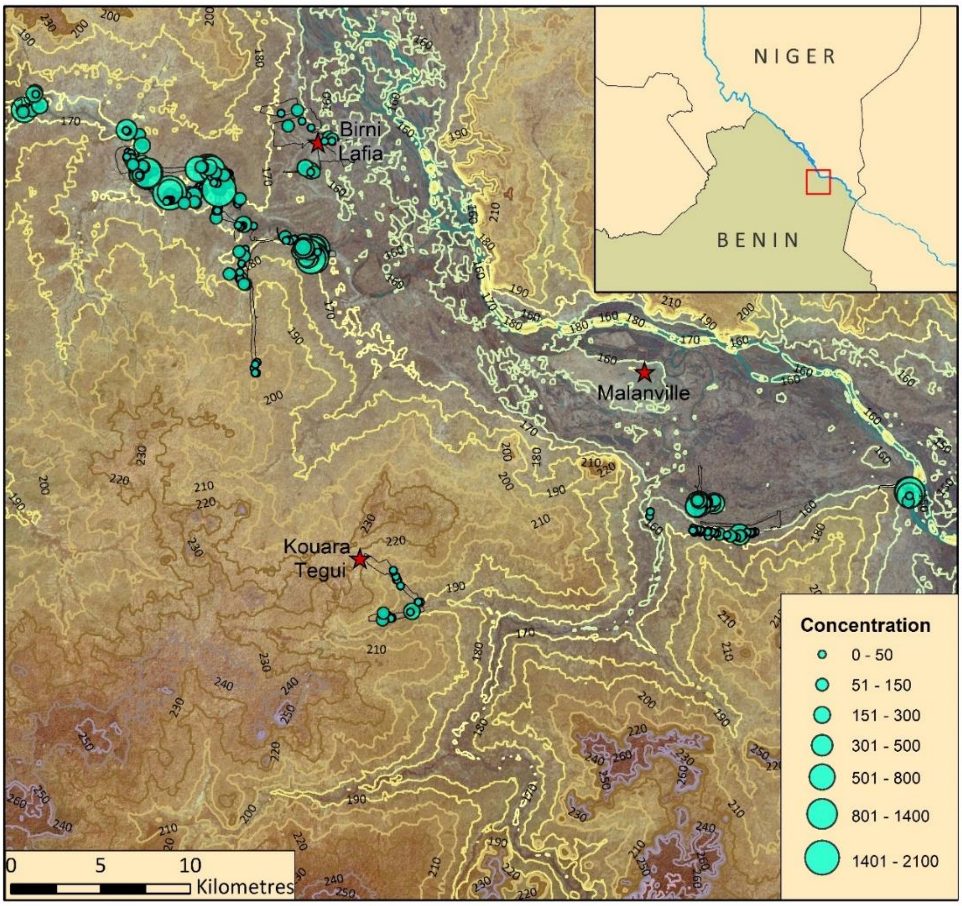

Figure 4.6 *Concentration of ceramic artefacts collected throughout the study area and illustrated using proportional symbols. Concentration has not been modified in relation to site size.*

4.3.6. Ceramic typology

A substantial variety of ceramic sherds were collected during the survey, which took many forms and decoration. As expected, the most common form of ceramic found were body sherds, but rims, bases and handles were also collected. As stated in the previous chapter, sherds that were smaller than a 25 CFA coin were only photographed and counted and then discarded, these are the 'desampled' sherds, and therefore this section only considers larger pottery sherds. In total, 42,294 (86%) of the sherds were counted and discarded, but a photograph of all sherds remains in the research archive. The remaining 6,548 (13%) sherds, have been looked at in further detail.

In total there were 57 styles of decoration recorded from the remaining 6,548 sherds during the survey, which includes two or three composites of pre-existing decorations on one sherd, e.g. folded strip roulette with incisions. Table 4.3 shows the overall types and decoration of the pottery sherds that were discovered during the survey. For this table, body and rim sherds have been grouped together; however, they have been split in the appendix.

All Sherds larger than 25 CFA

Type	Undecorated	Eroded	Folded Strip Roulette	FSR and plain	Perforated	Incised	Other
Quantity >25CFA: 6641	2,522 (39%)	2,206 (33%)	1,469 (22%)	88 (1%)	35 (1%)	46 (1%)	182 (3%)

Table 4.3 *Type and number of body and rim sherds found during survey*

The overall shape of body sherds is not taken into consideration or studied within this work, a high percentage of the sherds being too small thus undiagnostic, (see table 4.2.). Of the sherds that were kept, 89% made up body sherds and 11% made up rim sherds. There is an opportunity for future research to consider assemblage typology. Paired with this, further analysis on larger rim sherds may allude to the type of pot that it came from; this type of analysis will be considered for important sites, where occasional rims lie intact. The *Crossroads* project has created a typology of pottery which can also be referred to when the monograph is published.

Undecorated pottery (Figure 4.7) made up the largest part of the assemblage at 38%. These sherds are pieces of ceramic that have had no decoration, motif, paint or any other stylistic process applied to the surface of the pot, other than firing. The second largest group of sherds in the assemblage (33%) are eroded sherds (Figure 4.8.). These are pieces of pottery that have had a design/decoration applied to them but the type of decoration is difficult to identify due to the sherd being eroded by environmental processes such as weathering, and is to be expected from sherds that have been collected from the surface.

Figure 4.7 *Undecorated rim sherds from Site 142 in the Alibori region.*

Figure 4.8 *Eroded pottery from Site 136 in the Sota region.*

Folded strip roulette made up 22% of the assemblage, almost a quarter, forming a large quantity of the assemblage that was kept for further analysis. This figure does not including instances where folded strip occurs with another decoration type, this is where the entire exterior surface of the sherd has the decoration (shown in Figure 4.9). It appears frequently in excavations in the region, for example, in the Tin Tin Kanza excavation (see Khalaf and Haour, 2013) folded strip made up 45% of the assemblage. It should be noted that the pottery at Tin Tin Kanza came from excavated remains and many of the eroded sherds within this survey are potentially folded strip roulette. The decoration is made using two flat strips of material, usually of vegetal/organic origin, which is then folded or twisted over itself. This method is described by Gronenborn and Magnavita (2000:52), Wiessmuller (2001) and Livingstone Smith *et al.* (2010). This strip is rolled onto the pot whilst the clay is still moist enough to leave an impression on it. The size of the strip, the degree of tightness with which it is folded and the material used, all influence the final outcome of the pottery (Livingstone Smith *et al.*, 2010).

Figure 4.9 *Folded Strip Roulette pottery from Site 153 in the Alibori region.*

Forty perforated sherds were also discovered, 35 with perforations only, and a further five that are part of a two-composite decoration (mainly perforations with FSR). These sherds, also known as *cous-cousière*, have relatively large holes made in them and are very distinctive (Figure 4.10). In the pottery table found in the appendix, these are referred to as ‘cous’. Sherds with a perforated decoration were only found in the Alibori survey region. This is interesting as this type of pot was perhaps used for some type of food preparation, for example steaming or smoking or could have been used for industrial processes such as salt making. This is discussed in further detail by MacLean and Insoll (1999).

Figure 4.10 *Perforated sherds founds at Site 156 in the Alibori region.*

Incised sherds are another distinctive decoration, evident on a low quantity of sherds, but still present in the assemblage. These were found in every survey area, with the highest percentage in the Alibori. These are sherds that have had an incision scored in them with a pointed tool (examples of incised sherds can be seen in Figure 4.11). In the assemblage there are 46 sherds that had incisions and an additional 26 had incisions with another decoration incorporated.

Figure 4.11 *Incised sherds from site 10 in the Birni Lafia region.*

The 'other' category describes all other decorated sherds that were found. These include sherds that have two or three types of decoration on them, as discussed previously, and decoration types that occur rarely, for example, cross-hatching, sherds that have slip applied to them and stabbed, amongst many more. There were also a range of other sherds found, some are unique and will be discussed in more detailed within the following sections.

4.4. Results by area

The following sections outline the results in relation to the geographic survey area they were located. The areas will be discussed in order that they were surveyed starting with Birni Lafia, then the Alibori River area, Kouara Tegui and finally the Sota River area.

4.4.1. Birni Lafia

A 7km^2 area was covered, centring on the modern village of Birni Lafia (this is the modern day name for the village depicted on maps/Google Earth), in a survey that lasted three days. In total, 15 sites were recorded with artefact collections carried out, with a total of 1,228 sherds collected, with 516 items of a size over 25 CFA which were subsequently kept for further analysis. The survey area and sites found can be seen in Figure 4.12. The average size of site was 3,486m^2 (0.34 hectares). Within this area there are 2.2 sites per km^2 and this does not include the large site of Birnin Lafiya (this is the name given to the ancient site and used in the forthcoming *Crossroads* book). The average elevation of sites in this area was 166.4m, with no site lower than 166.1m or greater than 174.2m. With only two sites per km^2, the area presents a relatively low density of archaeology, but was surveyed due to the importance of the ancient site of Birnin Lafiya within the vicinity. The low density of sites could be attributed to the close vicinity of the Niger River, a very active river that often floods, and the low elevation that the area lies on, meaning there is a possibility that the archaeology was simply washed away. The average site size in the survey area here measures 3,466m^2. The Birni Lafiya survey area was the first area where the new methodology devised for this thesis was carried out.

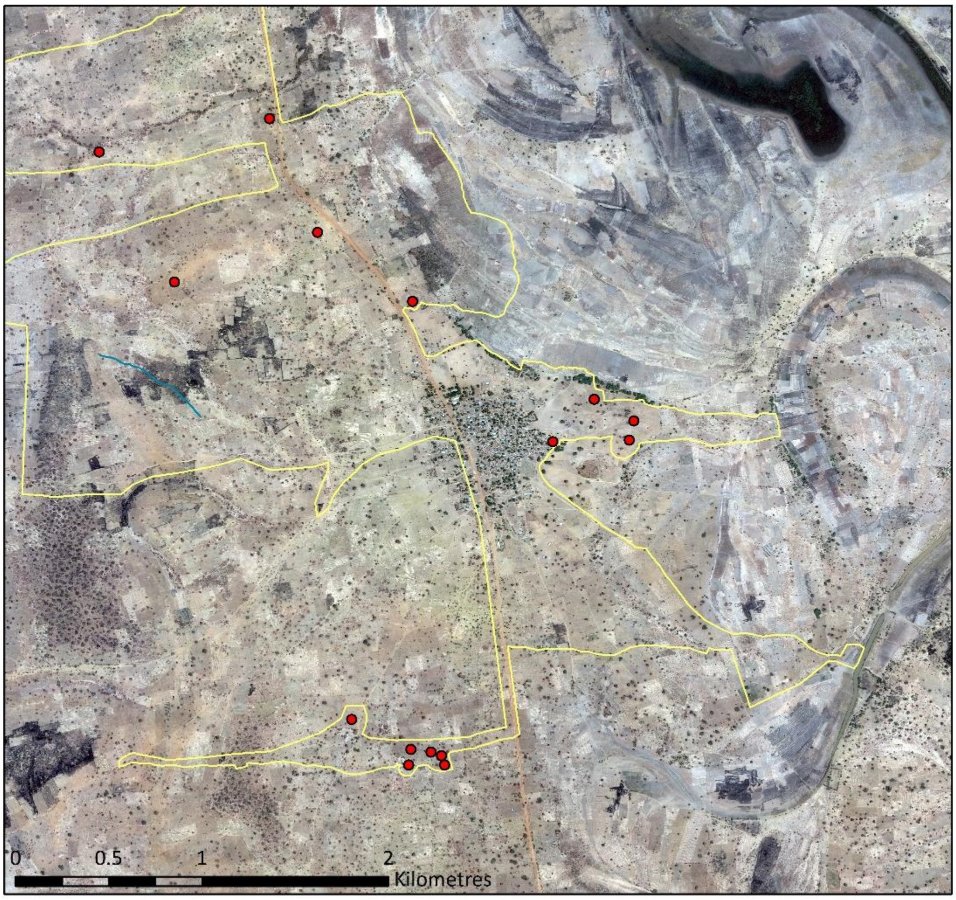

Figure 4.12 *High resolution satellite imagery centred on modern day Birni Lafia, yellow polygon indicates area surveyed and red points indicate collection units/sites. This does not include the large ancient site of Birnin Lafiya that is located southwest of the village in the gap that was not surveyed.*

The material culture varied from site to site in the Birni Lafia region, where objects found ranged from ceramic sherds, lithic and slag. Overall the highest occurring artefact type was ceramic sherds, 1228 in total, with 516 kept after desampling. Lithics were the second most frequent artefact encountered on survey here, 107 in total. There were only 17 fragments of slag found and this came from one site.

Of the 516 (42%) ceramic sherds kept, most were body sherds – 79% of the assemblage, with the remaining 21% made up of rim sherds. Of the assemblage found in this area most of the sherds were undecorated, see table 4.4. Folded Strip Roulette body sherds followed with 29%, however, 37% of body sherds found had folded strip roulette, which is only 1% (10 sherds) less than undecorated. This differs from the trend observed across the survey area as whole, where Folded Strip

Roulette usually makes up around a quarter of the assemblage (this will be picked up again in Chapter Six). The rest of the sherds in the assemblage were 24% eroded, and the remainder had very low percentages including; 1% Folded Strip/Plain, less than 1% with incisions and 2% were categorised as ‘other’. Perforated sherds did not appear in the assemblage that were kept for further analysis.

Ceramic assemblage Birni Lafia survey:

	Undec	Eroded	FSR	FSR/Plain	Perforated	Incis	Other	Total
Body	159 (39%)	90 (22%)	149 (37%)	1 (0.25%)	0 (0%)	1 (0.2%)	8 (2%)	408
Rim	66 (61%)	31 (31%)	2 (1.9%)	5 (5%)	0 (0%)	2 (1.9%)	2 (2%)	108
Total	225 (44%)	121 (24%)	151 (29%)	6 (1.2%)	0(0%)	3 (0.6%)	10 (2%)	516

Table 4.4 *Type and number of sherds found in the Birni Lafia survey area*

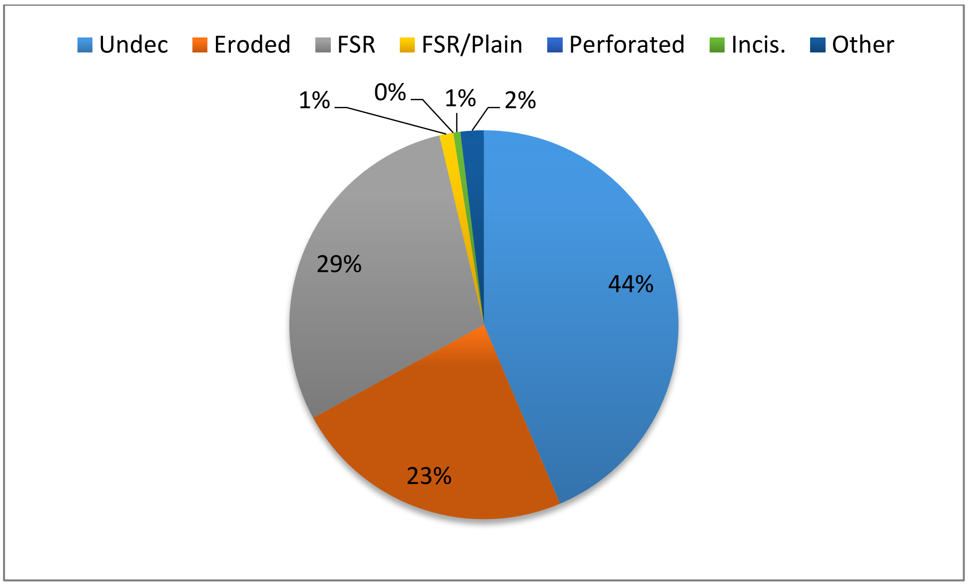

Figure 4.13 *Pie chart to show the ceramic decoration types found in the Birni Lafia survey. N=516.*

The site with the highest number of total artefacts within its 10m^2 collection unit was Site 10, which had 286 ceramic sherds (29 per m^2), see location on Figure 4.14. This site measures only 673m^2, which is the median site size with the Birni Lafia survey area. The sherds at this site were diverse in comparison to the other sites in this area, with one sherd with cross-hatching. Site 10 was among four sites that had over half of its total assemblage containing folded strip roulette.

Folded strip roulette decoration occurred at almost every site in this area, with the exception of four of the sites, and made up 11% of the total corpus from the Birni Lafia area. The folded strip roulette in this area was of good quality, with little erosion and clear detail. There were three sites (136, 10 and 11) that had sherds in the 'other' category. Site 136 (Figure 4.14 with locations) has examples of a variety of sherds that had unusual decoration, including two sherds that had twisted cord roulette, with multiple parallel incisions and one sherd that has folded strip roulette with V-shaped geometric incisions. This is unlike the other sites in this survey area. The other two sites that exhibited curious decoration were within the periphery of the ancient site of Birnin Lafiya. One site (Site 10) had a pot sherd with cross-hatched incisions, with 12 incisions on the sherd. There were also two sherds, one rim and one body sherd, which had folded strip roulette and parallel incisions. The third site (Site 11) had two sherds that had a two-decoration composite of incisions and folded strip roulette. A painted sherd was also retrieved, but outside of a collection zone and this was located close to the modern village at Site 3. Painted sherds are generally modern in context; therefore unsurprising it was found close to the village.

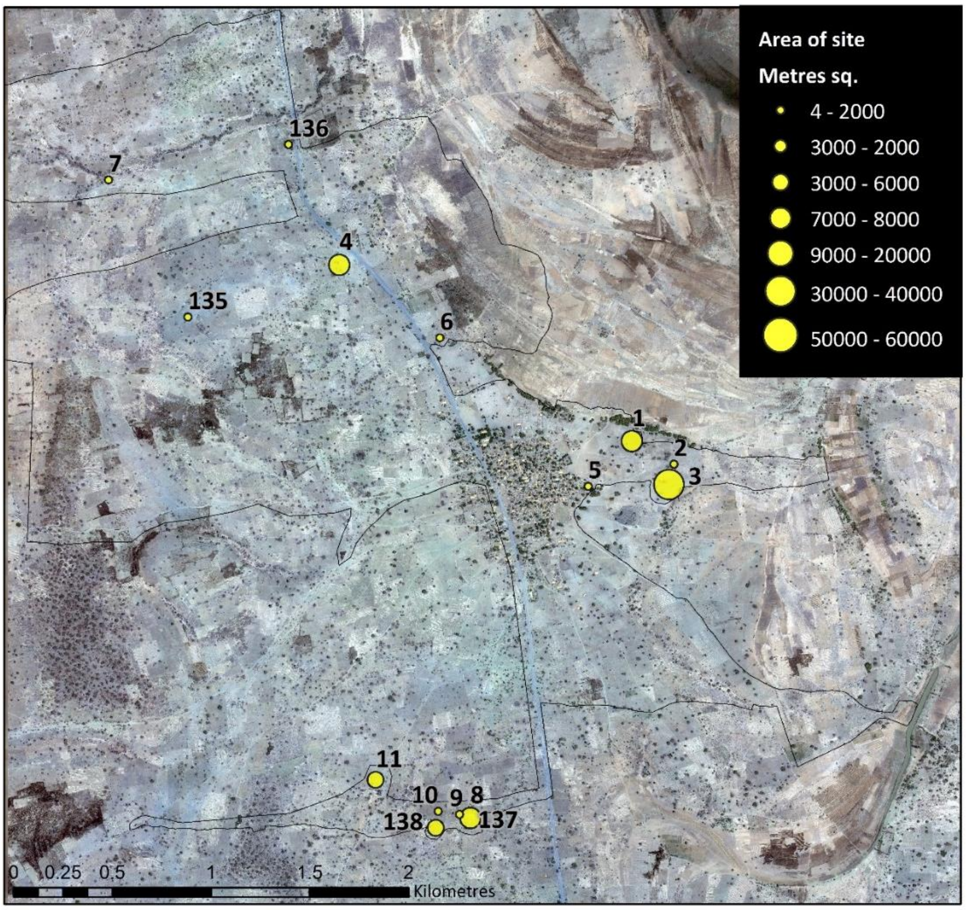

Figure 4.14 *A high-resolution QuickBird Satellite Image centred on the modern village of Birni Lafia illustrating archaeological site by size in m^2 shown by yellow proportional symbols, with the area surveyed shown in the polygon.*

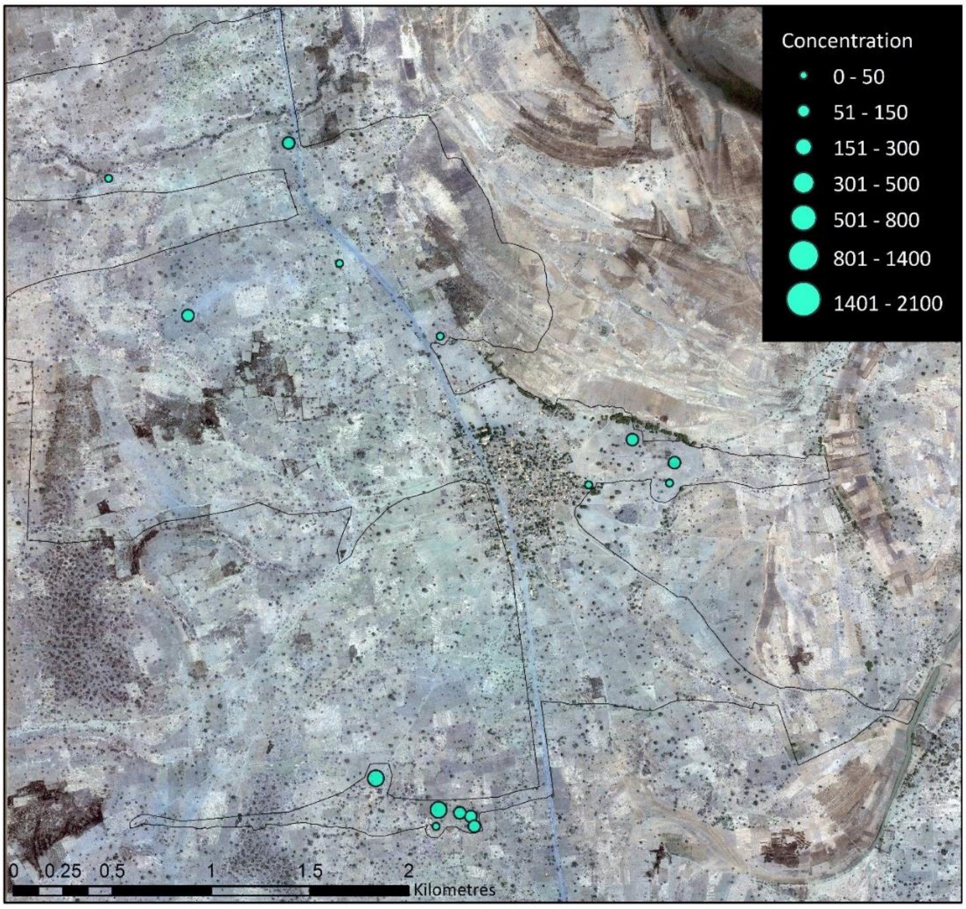

Figure 4.15 *A high-resolution Quickbird satellite image centred on Birni Lafia showing the concentration of ceramic sherds using proportional symbols found within collection units in the survey area which is illustrated by the black polygon.*

The site with the highest number of lithics from the whole survey, totalling 106 fragments, was found in the Birni Lafia region - the site with the next greatest amount was only 65 in the Alibori region. This site (Site 7 see figure 4.14 for location) also had many fragments of slag covering it.

Most of the sites in the Birni Lafia vicinity are cultivated; this is due to the close proximity of the river and the modern village. This would perhaps affect the preservation of archaeology present on the ground; however, sherds that were affected by erosion were low in quantity. Cultivation in this area is very prominent and east of the modern village the landscape and terrain is very flat and irrigated for crops. The area is also very water logged, and any sites situated on the periphery of the river system (this can be seen in the high resolution satellite image), if they existed, would not have survived the active river environment. A lot of time was taken walking the flat cultivated areas east of the modern village to see if any archaeological activity remains.

The morphology of the sites in this area varies between very large settlement mounds to flat, cultivated sites. Four of the 15 sites were defined as large mounds, two of which (Sites 1 and 11) were described as heavily cultivated and both of these sites presented a high number of pottery sherds, Site 1 with 102 sherds (8.2% of total assemblage of Birni Lafia survey area) and Site 11 with 246 sherds (20%). Sites were also described as a slightly elevated mound or a small mound, this description accounted for three of the 15 sites discovered here. The other sites discovered were flat or cultivated and could only be detected from the pottery sherds found on the surface.

The placement of the different sites varies and appears relatively isolated within the study area, apart from in the southwest corner, close to the ancient site of Birni Lafia. The notion of dispersed and clustered sites that were found during survey will be analysed using spatial analysis in the next chapter.

4.4.2. The Alibori

The Alibori River survey area had the highest density of sites within its landscape of all the survey areas mentioned. This survey area was examined over a period of 19 days and a total of 220 sites were discovered (Figure 4.17). There are 18 sites per km^2 in this survey area. The sites were mainly located close to the banks of the main river. The Alibori is an active river system and a tributary of the Niger River. Historic aerial imagery of the area shows that the river has shifted course over time. Furthermore, this area has encountered heavy erosion which can be seen in white on the multispectral satellite image bands 4, 3, 1 where the colour of the image has been adjusted for clarity. The Alibori River also has seasonal streams that flow from it, this can be seen in Figure 4.16 also a white appearance.

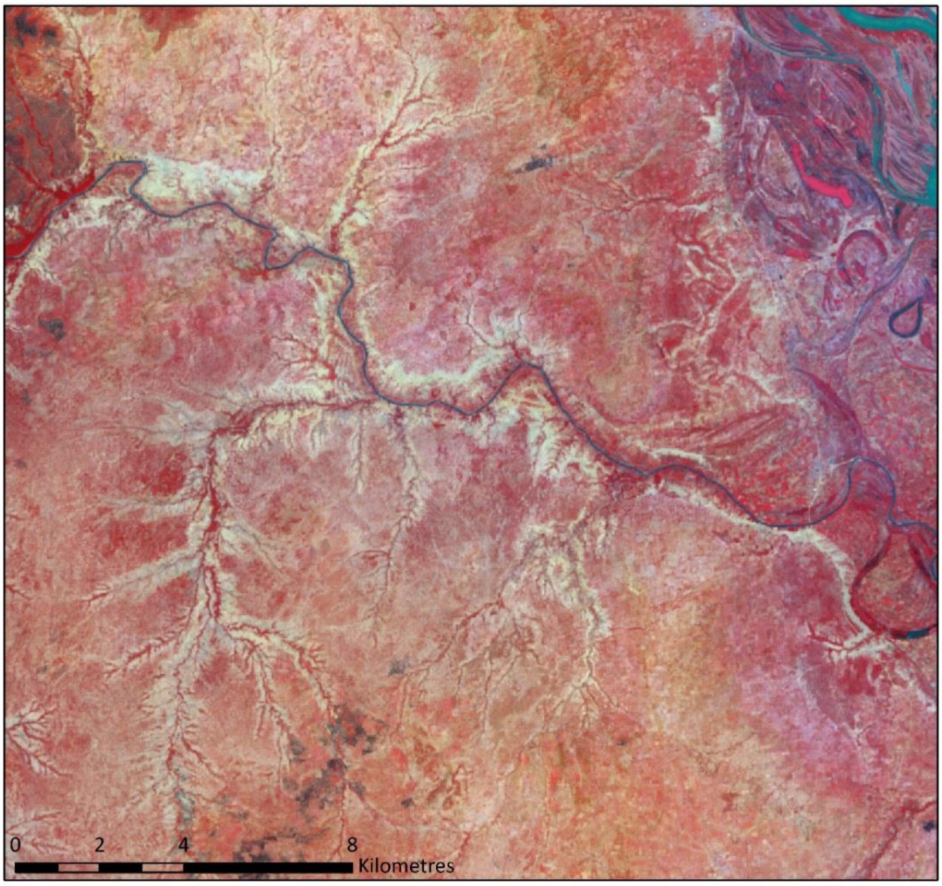

Figure 4.16 *Landsat bands 5, 4, 1 showing the modern Alibori River (blue) and white areas show dry river channels.*

According to Le Barbe *et al*. (1993) the Alibori covers 13,740m^2 and its length is around 422km. Some sections of the river, for example, the north east section, was not easily accessible; it was densely vegetated and cultivated, so this was not surveyed even though it was originally planned. There is a five kilometre gap between two of the survey areas, this can be seen in the far northwest, and was so the area of Kofouno could be surveyed. Kofouno exhibits substantial evidence of large, clustered settlement mounds on the bank of the Alibori and this had been identified by the *Crossroads* project during previous fieldwork seasons; therefore it was important to go back and analyse these sites in greater detail.

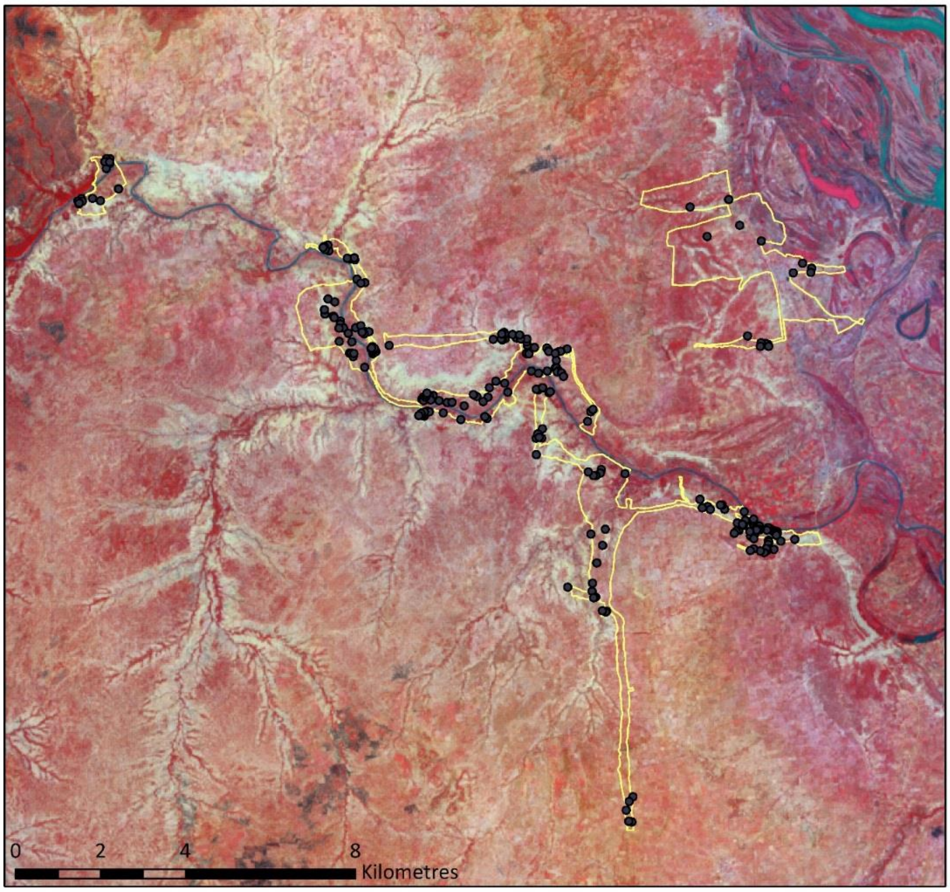

Figure 4.17 *Landsat image showing the Alibori and Birni Lafia survey regions with grey points to indicate collection units/sites.*

Site sizes show an interesting pattern in this study area. Figure 4.21 shows the distribution of site by size. It generally appears that large sites cluster together, with smaller sites close by that appear isolated and non-clustered. These smaller sites are in between four and 1,500m^2 in area. Large sites tend to cluster in the peaks of the meanders of the river, with smaller sites running close to the straighter section of the river.

The largest site on the survey here is Site 53 and measures 60,397 m^2 and is located at the bottom of the U-bend meander of the Alibori River, close to three large fossil channels/ non-perennial streams, which run south of the main river and it appears that there is a relic channel to the north of that, placing the site on an island (Figure 4.20). This placement of a large site between two water channels would have been useful for access to water; however, the flood of the river would have caused erosion, and this is present on the site today. Site 53 was described (by author) during the survey as 'probably the largest settlement mound area I have seen along the Alibori River. Possible evidence for stone building construction?' The site was made up of interlinked mounds rather than one large mound, like the other sites in the survey. The lowest elevation point taken on the mound measures 166.7m and the highest point on the mound measures 180.3m high, making this mound around 13.6m high. This site featured a large number of stones that were protruding from the surface of the settlement mound, generally a rare occurrence. It is difficult however to determine whether these stones were collapsed building material or whether they have occurred naturally, although this seems unlikely. This site was one of the few sites that had evidence of furnaces and iron smelting present, with a large amount of slag and tuyères on the surface of the mound. The pottery sherds here were very dense and several collections were made across the site due to its size. Over 1,000 pottery sherds were collected from this site from nine collection points dotted around multiple mounds. One of the collections was made where potential whole pots had been abandoned. The pottery consisted of mainly undecorated and eroded sherds.

Figure 4.18 *A photograph north facing showing the largest site discovered on survey, site 53, located close to the Alibori River.*

Figure 4.19 *A north facing photograph showing an area with a high concentration of slag located at the top of mound Site 53, close to the Alibori River.*

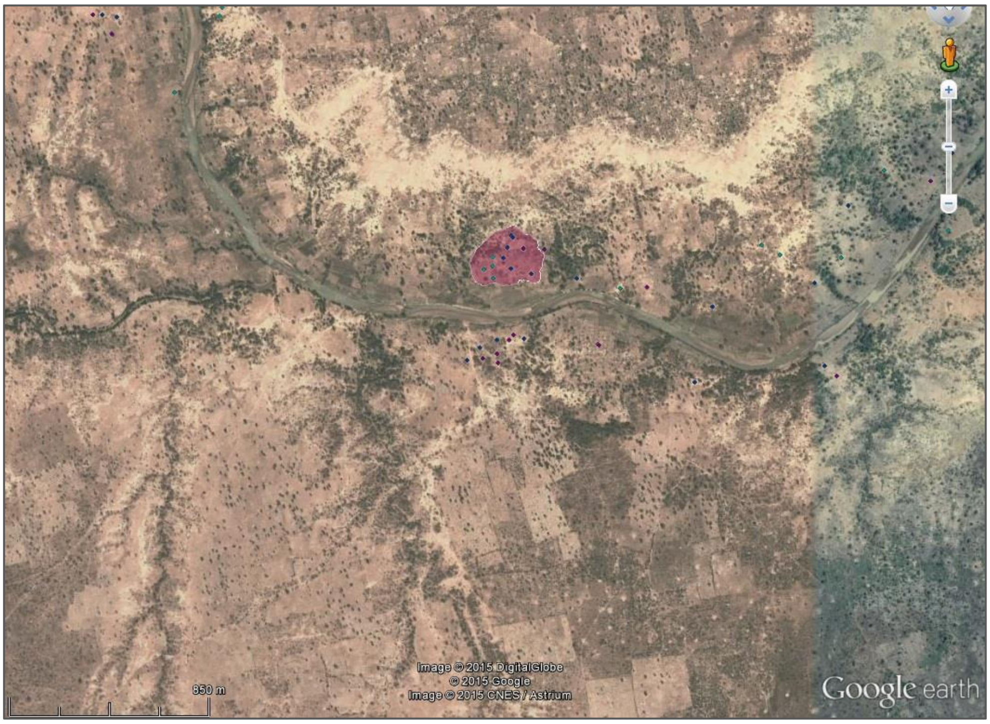

Figure 4.20 *A Google Earth image showing the extent of Site 53 on the banks of the Alibori River, the points represent individual unit collections.*

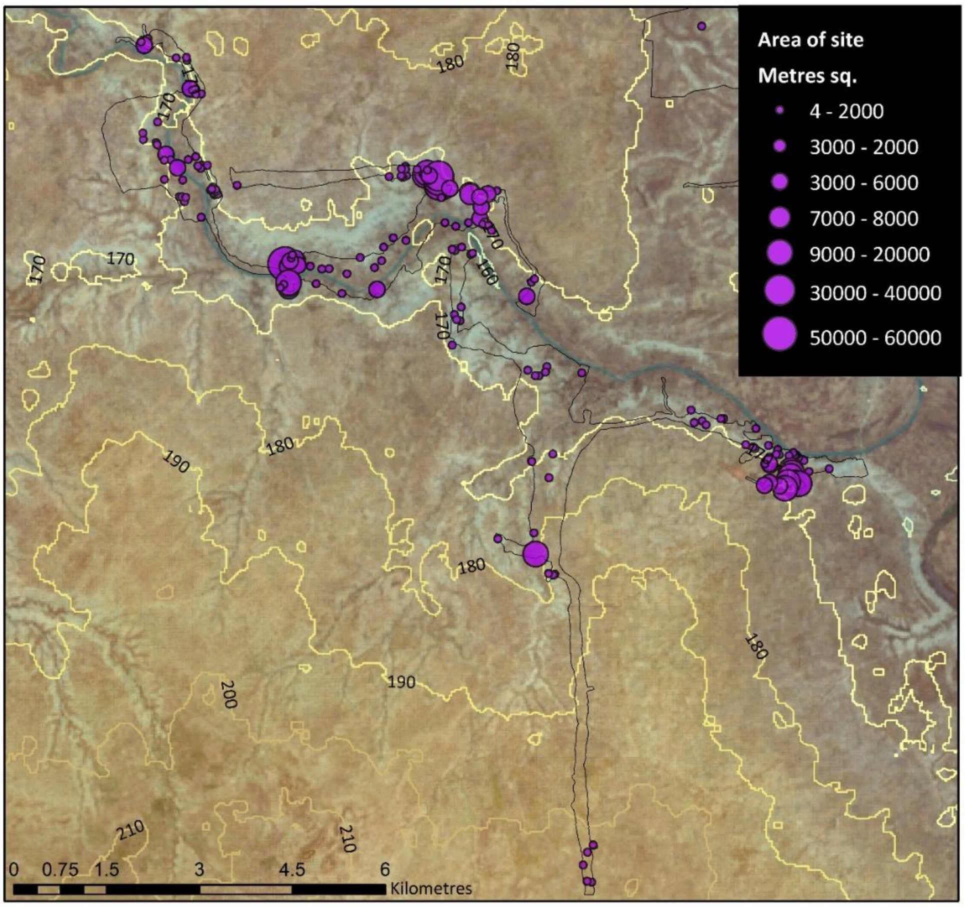

Figure 4.21 *Map (created by Landsat and ASTER satellite imagery) of the Alibori River survey area showing the size of site, measured in metres squares, depicted by purple proportional symbols and elevation depicted by contour lines.*

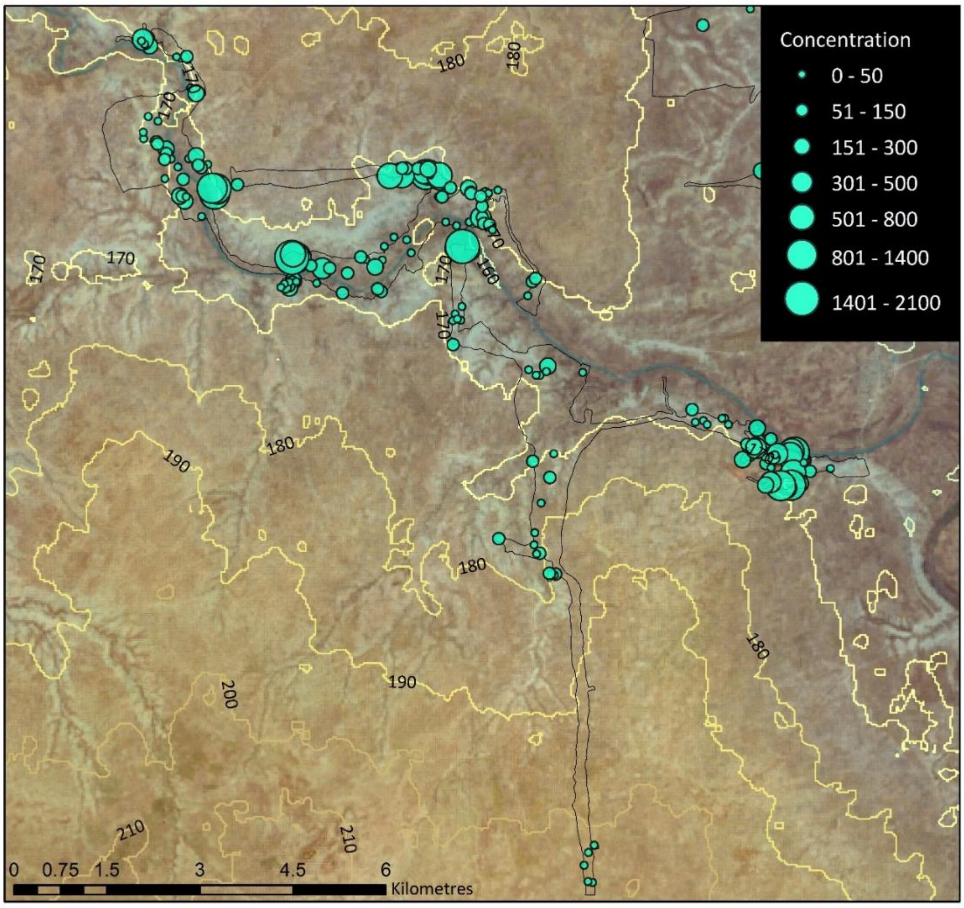

Figure 4.22 *Map (created by Landsat and ASTER satellite imagery) of the Alibori River survey area showing concentration of pottery collected depicted by turquoise proportional symbols and elevation depicted by contour lines*

Ceramic assemblage for Alibori survey area:

	Undec	Eroded	FSR	FSR/Plain	Perf.	Incis	Other	Total
Body	1691 (34%)	1879 (38%)	1229 (25%)	12 (0.2%)	33 (1%)	30 (0.6%)	107 (2%)	4981
Rim	353 (60%)	121 (20%)	18 (3%)	63 (11%)	2 (0.3%)	9 (2%)	27 (5%)	593
Total	2044 (37%)	2000 (36%)	1247 (22%)	75 (1%)	35 (0.6%)	39 (0.7%)	134 (2%)	5574

Table 4.5 *Sherd and decoration type of ceramic found in the Alibori survey area.*

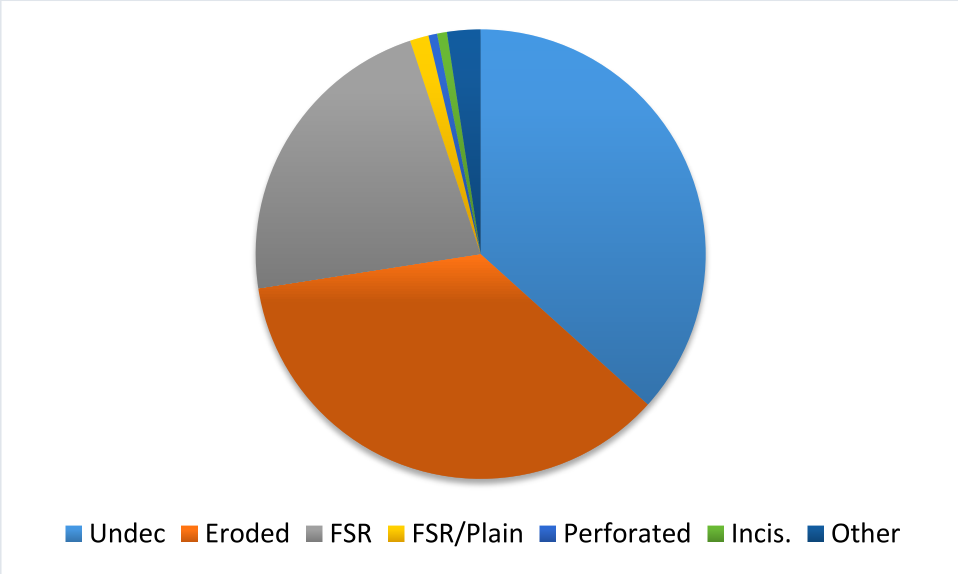

Figure 4.23 *A pie-chart illustrating the different types of ceramics discovered on survey in the Alibori River region.*

Another key area along the Alibori is an area of badland, close to the village of Kargui (cluster of points furthest east). In this area 53 sites were identified and site collections were made. The sites cover a total area of 1km^2 and had a high density of finds because of the considerable erosion of the landscape here. The topography in this area was quite different to the rest of the Alibori as it was yellow and dry, resembling a desert landscape. Pottery sherds were not hard to come across here. In this small area 10,688 pottery sherds were collected, equating to an average of 202 sherds per collection unit, in comparison to the Alibori in general which has 180 sherds on average per collection unit. Of these sherds, 8,636 were desampled (80%) of the remaining sherds (2,052), almost a quarter, exhibited the folded strip roulette decoration (22%).

It is also difficult to decipher whether these were areas where only one site that had been. One of the most important finds of the survey was discovered within this area and this was a copper alloy bead (small finds will be discussed in the next section). Many of these sites in this area were described as deflated mounds, with laterite that was present, which is caused by extreme weathering of underlying rock.

One site (Site 164) in this area had no collection but it was recorded because there were only lithics present on the surface.

The elevation of sites in the Alibori area showed some distinct patterns during the survey that can be seen in the contour map (Figure 4.24). Most sites sat within the red contour line, the 170-180m elevation mark. A transect was made straight across the 180m elevation and no sites were present, sites did pick up again around the 200-210m elevation band. The following chapter, which looks in depth at spatial analysis, will consider all of the sites that have been discovered by the *Crossroads* project to consider whether this pattern remains throughout.

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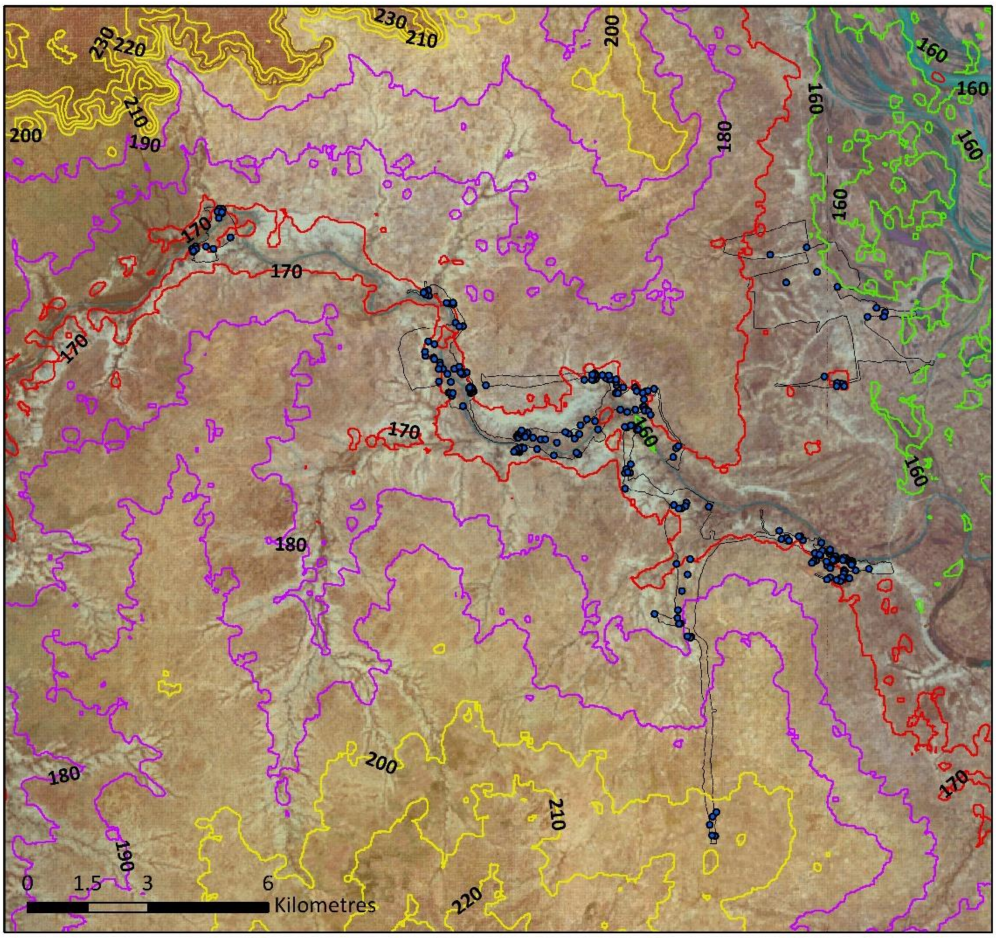

Figure 4.24 *A map to show elevation of the Alibori survey area illustrated by contour lines with the archaeological sites shown by blue dots.*

Small finds

The Alibori region was the only survey area that featured small finds, this is perhaps because it is more archaeologically exposed due to erosion. These small finds were encountered within collection units during the systematic survey, therefore found on the surface. The small finds can be seen in Figures 4.25 and 4.26. One is a copper alloy bead (Figure 4.25), which was the only copper alloy bead encountered during the time of the *Crossroads* project, and the other was a stone bead (Figure 4.26). These small finds illustrate that material culture in the area is not confined to ceramic and slag fragments and there is the potential to discover a greater wealth of material culture.

Figure 4.25 *Copper alloy bead found within collection unit during survey of the Alibori. Scale bar is in cm.*

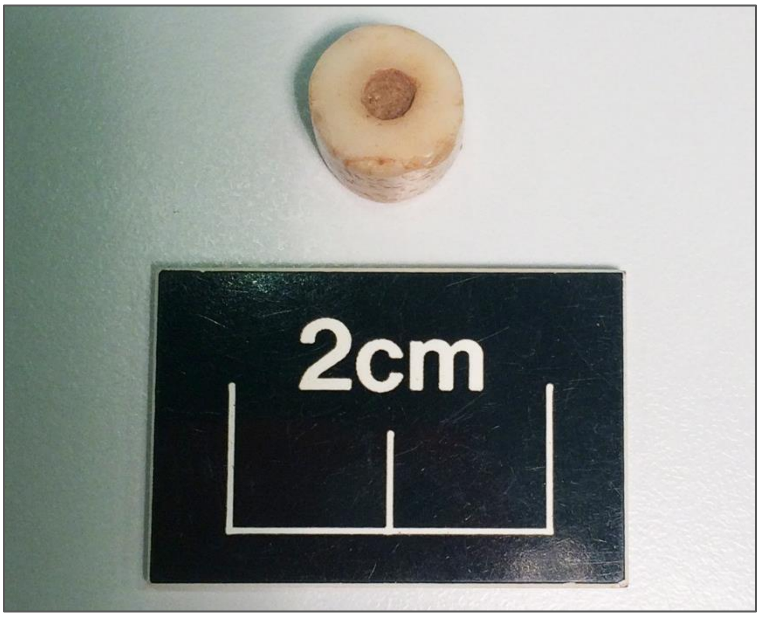

Figure 4.26 *Stone bead identified during survey of the Alibori region.*

4.4.3. Kouara Tegui

Kouara Tegui was the smallest survey area of the study region, it totalled 3km^2 and took two days to survey. As discussed in the previous chapter, the region was targeted due to the small, intermittent, non-perennial channel of the Sota River present in the landscape here. Also, the area had not been surveyed before. In total 19 sites were found in this area, and 750 artefacts found, which comprised 748 ceramic sherds and two lithics, no other artefact type were found here. The landscape in this area was very different to the Birni Lafia and Alibori areas, as there were no big variations in the elevation and although the area was higher in the landscape, averaging 200m above sea level, it was generally flatter than the other survey areas. Contour map is featured in Figure 4.33. Furthermore, the area had more vegetation and less erosion than the area surveyed in the Alibori, and this may implicate site visibility and be part of the reason why there were limited sites in this area. The field walking followed a dry river bed which did have some mounds flanking the sides of it; however, it was unclear whether these were natural or anthropogenic as there was no material culture present on them which may be due to lack of erosion. An example can be seen in Figure 4.27.

Figure 4.27 *Photograph of the dry river bed which was field walked along in the Kouara Tegui survey zone.*

Site size at Kouara Tegui varies between 286m^2 to 35,917m^2, but most sites (all but two) measured under 6,000m^2, making them relatively small in comparison to sites elsewhere on the survey. This might be due to lack of erosion in this higher area not revealing the full extent of sites. The largest sites were 216 and 217, these were two mounds making up a large site with many baobab trees present. Even though the site was large, there was dispersed and, relatively little material culture on the surface, the two collection units only had 76 sherds within them, before desampling. It is the smaller sites that had the most sherds, the fifth smallest site (209) measuring 486m^2 (0.05 hectares) had the most sherds, 181 in total within the 10m^2 collection unit.

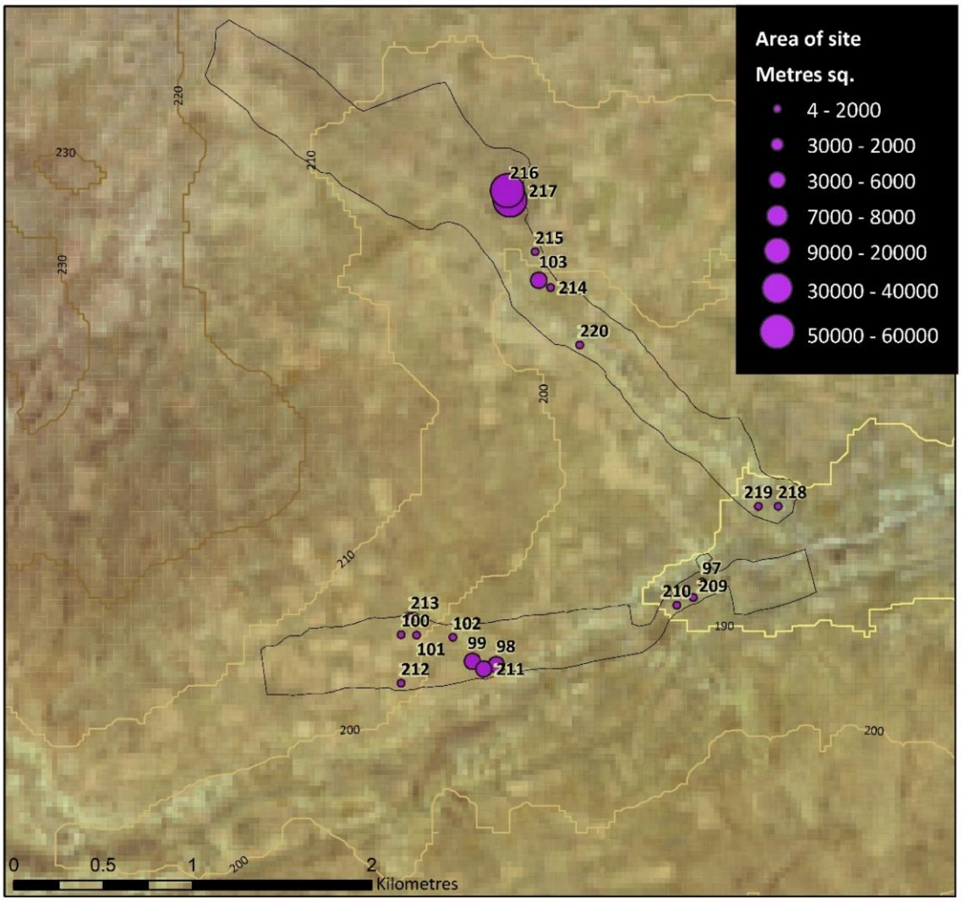

Figure 4.28 *Size of site measured in metres squared within the Kouara Tegui study region. The numbers show the unique ID the site was given, and can be cross referenced with gazetteer.*

Similar to the other survey areas in the study region, undecorated and eroded sherds occurred in the highest quantities. Most of the pottery was undecorated 102 sherds (63%), followed by eroded sherds which made up 20% of the collection. There was, however, a low percentage of the Folded Strip Roulette decoration, only 7% (11 sherds), which is unlike the other survey areas where Folded Strip made up over 20% of the assemblage.

The ‘other’ category of pottery in this area is interesting with six sherds (4%) having a two-decoration composite including twisted cord roulette; five of these sherds came from Site 220, which appears to be a small, somewhat isolated site (Figure 4.28 for site locations). The twisted cord sherds are shown in Figure 4.30. One site (Site 213) also had evidence for a complete vessel rim, which is a rare occurrence, and only seen again in the Alibori area. There were no sherds with perforations found within the survey area.

	Undec	Eroded	FSR	FSR/Plain	Perforated	Incis	Other	Total
Body	94 (64%)	31 (21%)	10 (7%)	0 (0%)	0 (0%)	2 (1.4%)	11 (7%)	148
Rim	8 (57%)	1 (7%)	1 (7%)	1 (7.1%)	0 (0%)	1 (7.1%)	2 (14%)	14
Total	102 (63%)	32 (20%)	11 (7%)	1 (0.6%)	0 (0%)	3 (1.9%)	13 (85)	162

Table 4.6 *Sherd and decoration type of ceramic found in the Kouara Tegui survey area.*

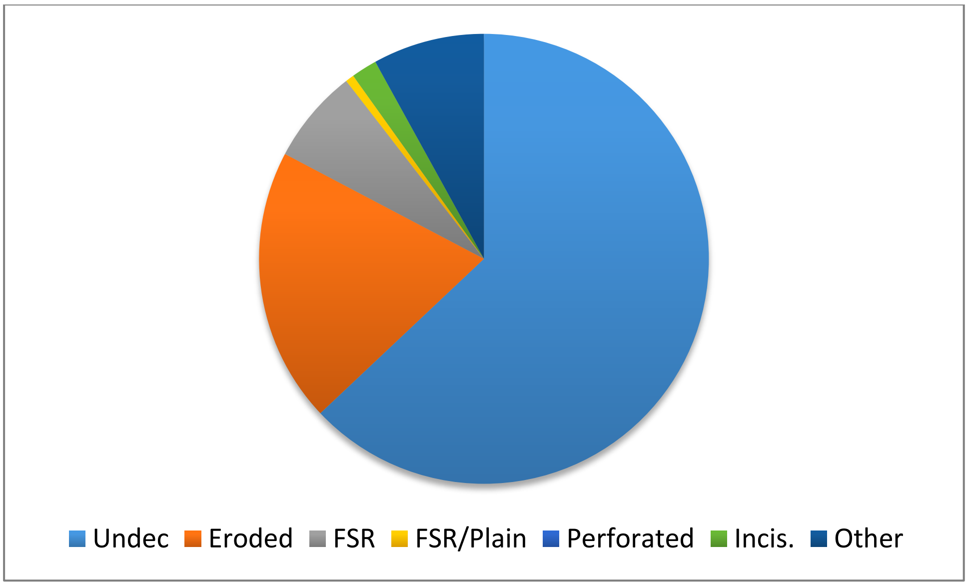

Figure 4.29 *Pie chart showing the types of decoration found in the Kouara Tegui survey region.*

Figure 4.30 *Twisted Cord Roulette with Folded Strip Roulette found at Site 220.*

Figure 4.31 *Complete rim sherds found at Site 213 in the Kouara Tegui survey area.*

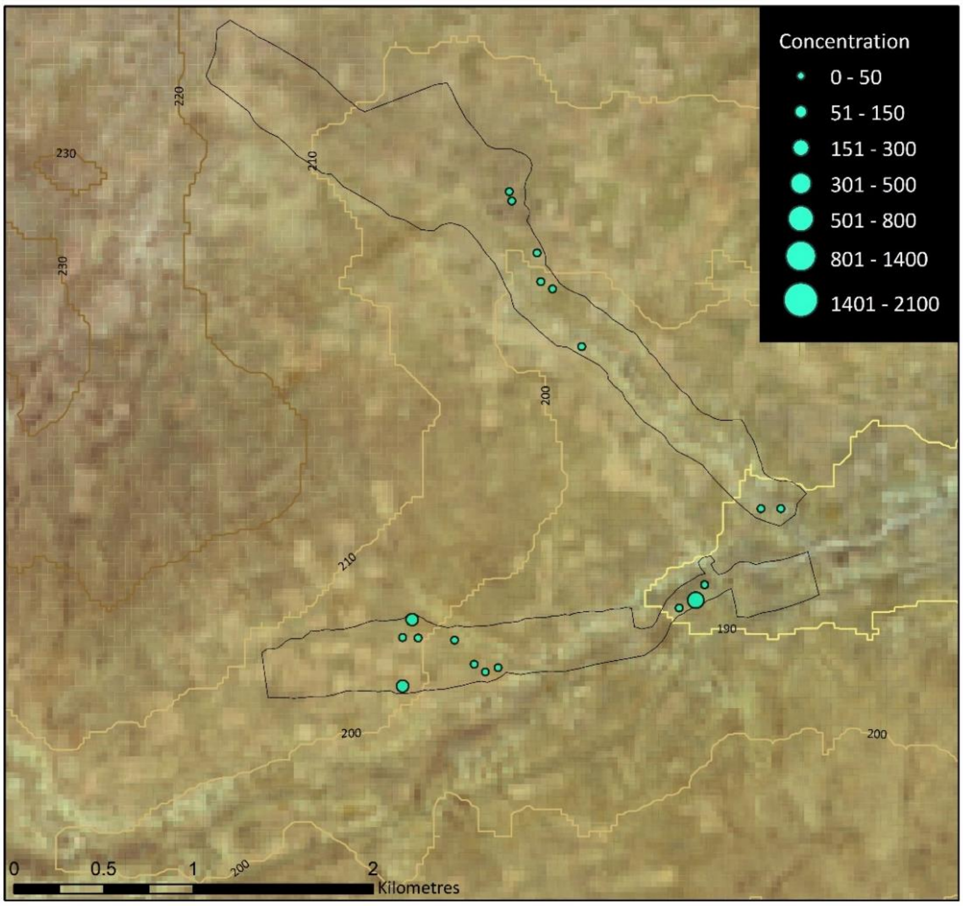

Figure 4.32 *A map showing concentration of ceramics discovered at sites within the Kouara Tegui study region, with elevation of the area depicted by contour lines.*

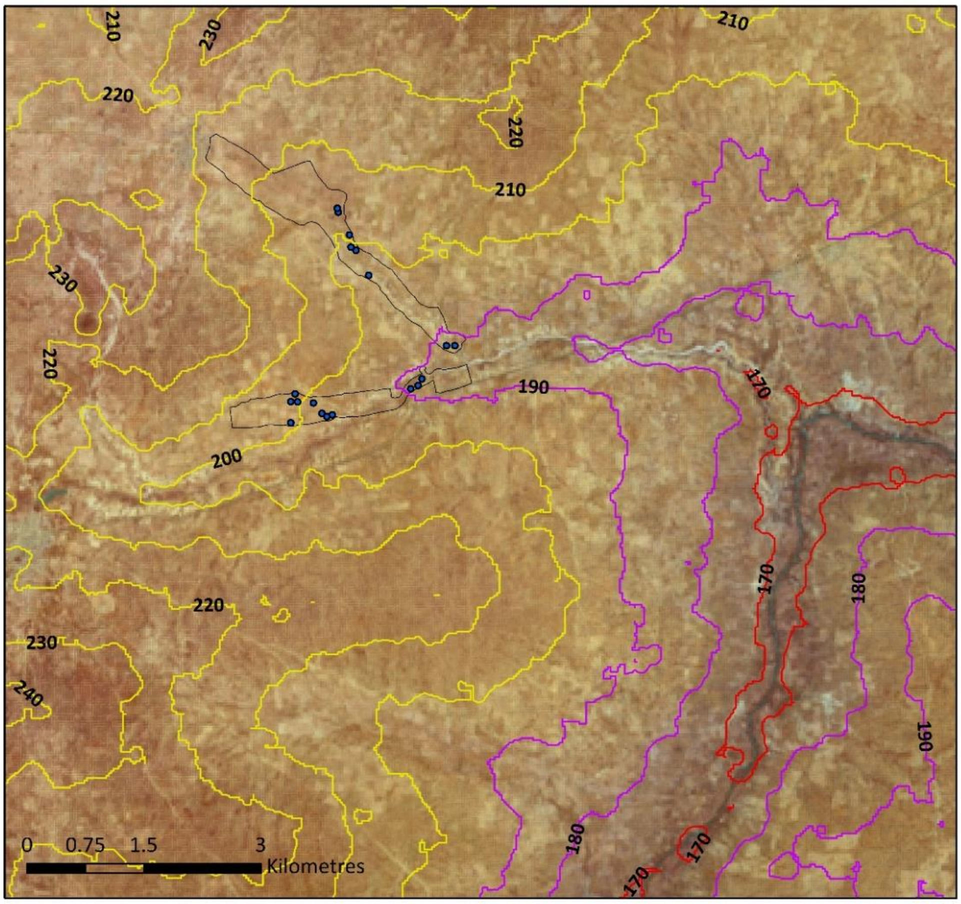

Figure 4.33 *A map showing the general distribution of sites within the wider Kouara Tegui study region, with elevation of the area depicted by contour lines.*

4.4.4. The Sota

It was the intention to survey the Sota River in a similar way to the Alibori River, where transects could be made close to the river in order to investigate the relationship the river has with settlement patterning. However, because the area in the immediate vicinity of the river is heavily cultivated it was very difficult to survey in these areas. The cultivated areas were heavily irrigated, meaning the ground was very water logged and any archaeological activity would not have been visible. Thus, the Sota study area was broadly divided into four survey zones (Figure 4.34) and 53 sites were discovered in this region.

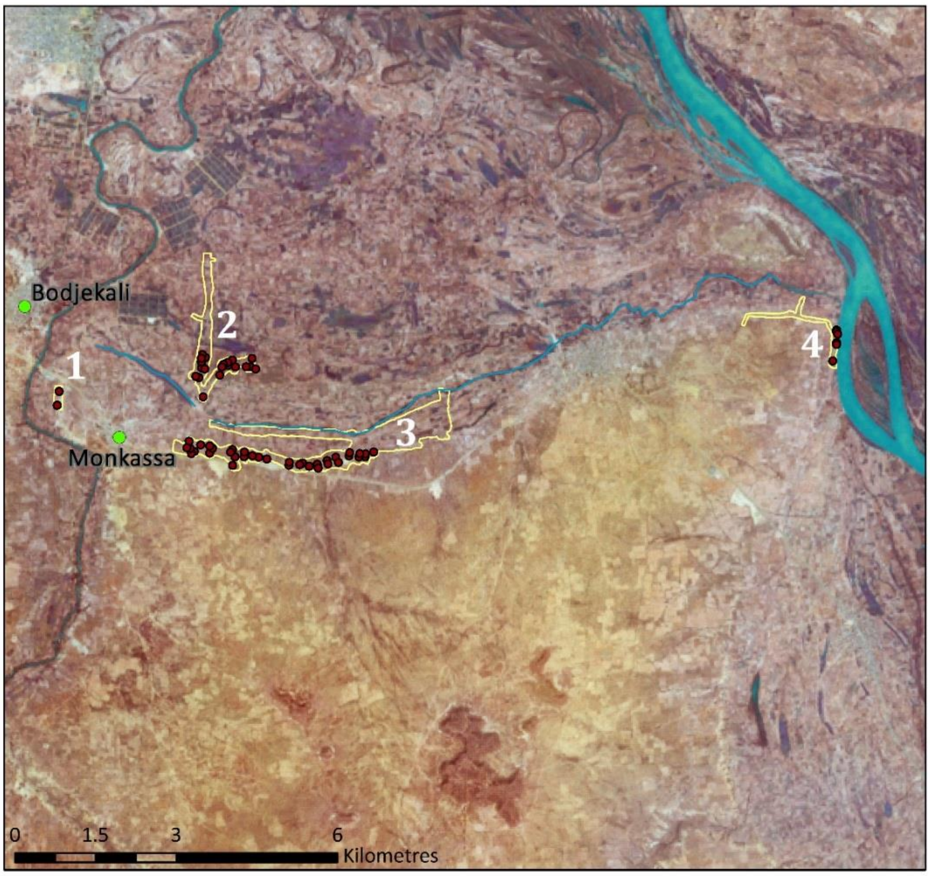

Figure 4.34 *Satellite image to show the Sota survey area. Burgundy points represent collection units (sites) and yellow polygons represent the area walked (survey zone).*

The survey initially started between Bodjekali and Monkassa (see area 1 on Figure 4.34) where the Sota River runs from north to south. There were only two sites discovered in this area of heavy cultivation, which can be seen in the far west of Figure 4.34. Even though in cultivated areas, both sites were large, one measuring 5,431m^2 and the other 5,021m^2. One of the sites was located on a mound with two large baobabs in the centre, whereas the other was heavily cultivated so the boundaries were unclear. The sites had a very low density of sherds on the surface with one collection unit totalling 11 sherds and the other 19, highlighting the effect of ploughing on sherd density. The time spent surveying the small area by the Sota River (totalling 600m^2) attracted some attention from locals who. These locals helped us collect pottery and informed us of grander sites slightly further afield. This information was used (although a diversion from the original methodology), and the survey area changed from the main Sota River to an area close to a non-perennial stream and a main road which runs east to west from the Sota River directly to the Niger River.

The second survey area, situated northeast of the modern village of Monkassa, was identified from the directions given by informants, and could be seen easily due to its extremely elevated settlement mounds which are very visible in the landscape. Again, the topography here was very different to that seen in the other survey areas, with a great deal of fluvial activity in the form of dried river/stream beds and very large, grander mounds. The survey area here totalled 728m^2 and part of the area was situated close to the non-perennial stream, with a transect heading away for comparison (this transect is shown in area 2 on Figure 4.34). Twenty sites were discovered in this small area, but no sites were found heading north of the survey area, away from the river. This is perhaps because the elevation of this section with no sites was around 150m, whereas the area where the sites were located had an average elevation of 163m.

This second area had a higher sherd count on average than the rest of the Sota study area with 158, which is slightly higher than the 155 average sherds for all of the sites, and much higher than the Sota region as a whole where the average is 115. The sites in this area only contained potsherds and did not have any other artefact type present. The average site size in this survey zone was 8,571m^2, which is almost 1,000m^2 greater than the average site in the whole survey. What was very interesting about the sites here, in stark contrast to many of the sites in the Alibori region, was that the morphology of these sites were all mounds and were very typical of the settlement mound structure, often described as 'average' and 'typical' mounds in the descriptions on the survey sheets.

Within this second survey area was the settlement of so-called 'Busa', which sat among the other 20 settlement mounds. This was one of the only sites in the entire survey of all regions that the local habitants informed us the name of. However, even though the local people know the site well, it is still unprotected. The site of Busa, which is 29,444m^2 (3 hectares) and 159.4m elevation, is heavily cultivated with a chilli field and even has a brick structure placed on it. The person that owns the mound and surrounding cultivated fields described the site of Busa as an ancient village of the inhabitants of Garou. Furthermore, he described the removal of hundreds of pottery sherds to make way for the chilli cultivation upon the mound.

A memorable artefact retrieved from the second survey area within the Sota was collected from Busa is a ceramic neck of a vessel. However, it was not found within a collection unit but was collected due to its rarity and a GPS location noted on the survey sheet, in the same way a small find would be. The neck is shown in Figure 4.35. It is of note as it is one of the only complete vessel necks found on the survey, the other being at site 150 of the Alibori, within a collection unit. Stylistically, this neck is very different to the one found at the Alibori (Figure 3.36).

Figure 4.35 *Ceramic vessel neck found at the site of Busa within the Sota study region, with 10 cm scale.*

Figure 4.36 *Ceramic vessel neck found at Site 150 in the Alibori region.*

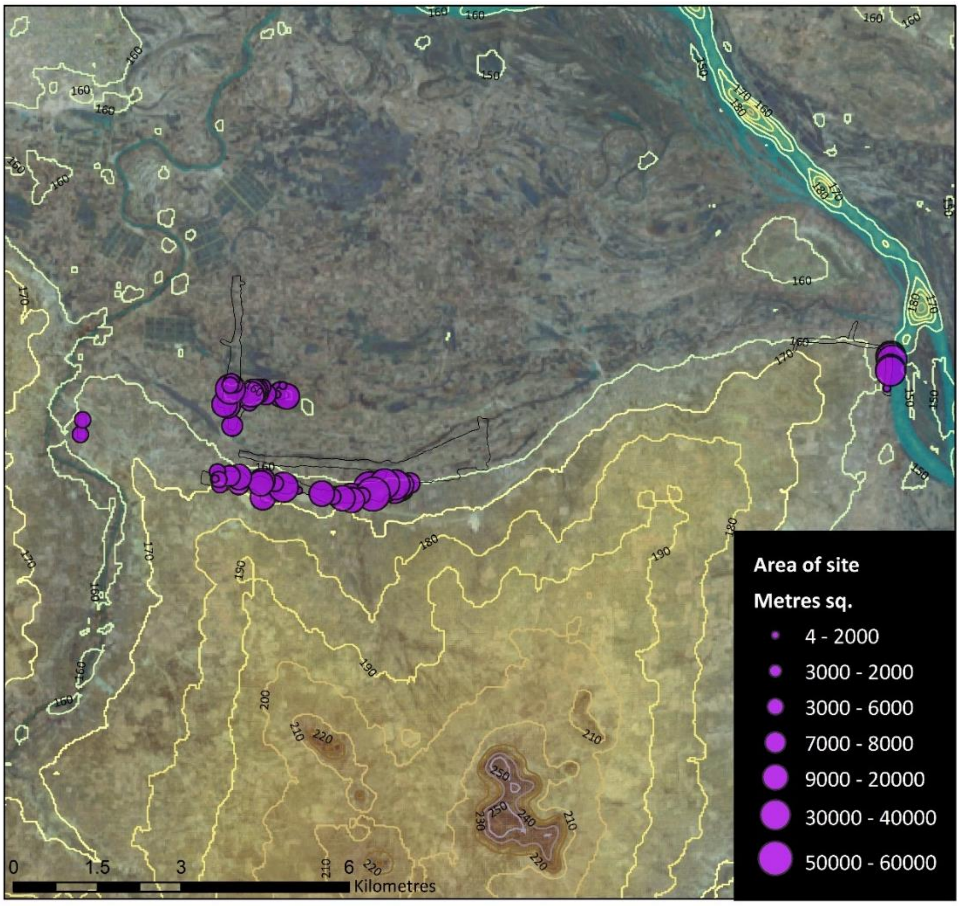

Figure 4.37 *A map showing size of site measured in metres squared within the Sota River study region. Elevation of the area is illustrated by contour lines.*

The third area of the Sota that was surveyed was close to the east-west road that runs from Bodjekali to Madekali. A total of 36 sites of interest were pinpointed here, some of which were discovered in previous surveys. Nevertheless, there was an increasing need to survey this area due to the encroaching widening of the main road. A large portion of this survey zone traced the small intermittent stream, in the same way as the Alibori survey, investigating whether there were sites in the immediate vicinity of the channel. However, as can be seen in Figure 4.38, there was nothing in the immediate vicinity of the stream. This is more than likely due to the fact that this river was much wider in the past and the remnants of this can be seen in high resolution satellite imagery (Google Earth) (see Figure 4.39). These landscape features and proximity analysis will be considered further in the next chapter, which will discuss how close sites are to the current river systems and how placement of sites follow ancient river systems. All of the sites in the third survey area of the Sota had a very close proximity to the main road instead, which has probably been built across many sites.

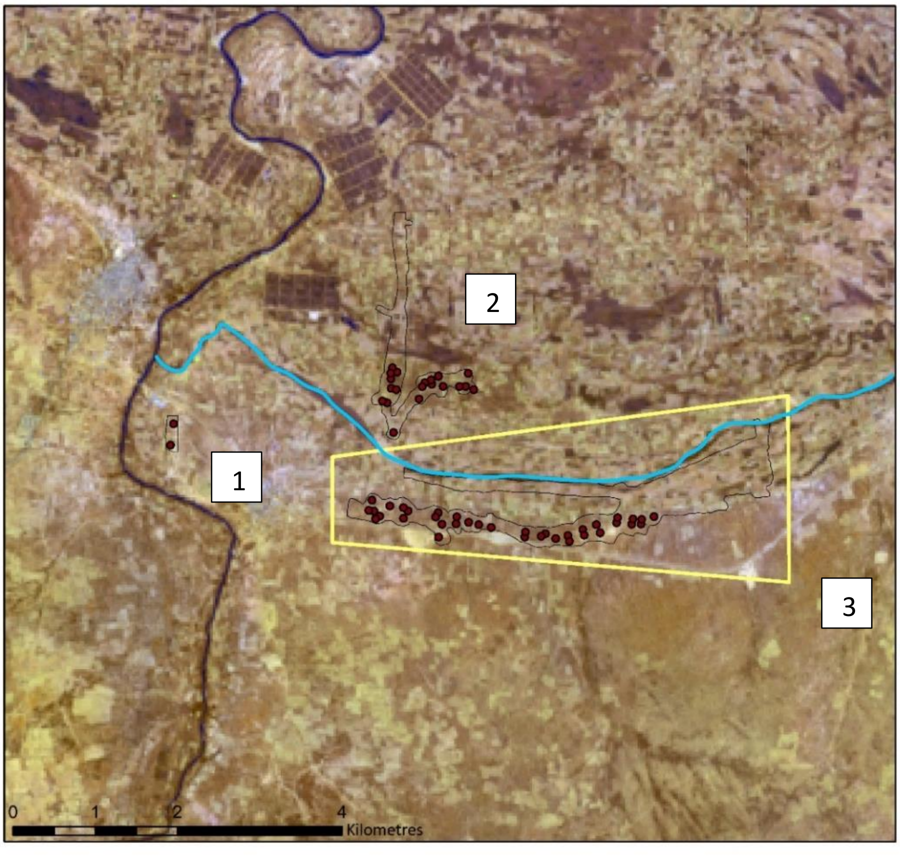

Figure 4.38 *The Sota River and its channel highlighted in light blue, the survey area is marked by the black polygon and the yellow box to show survey area three.*

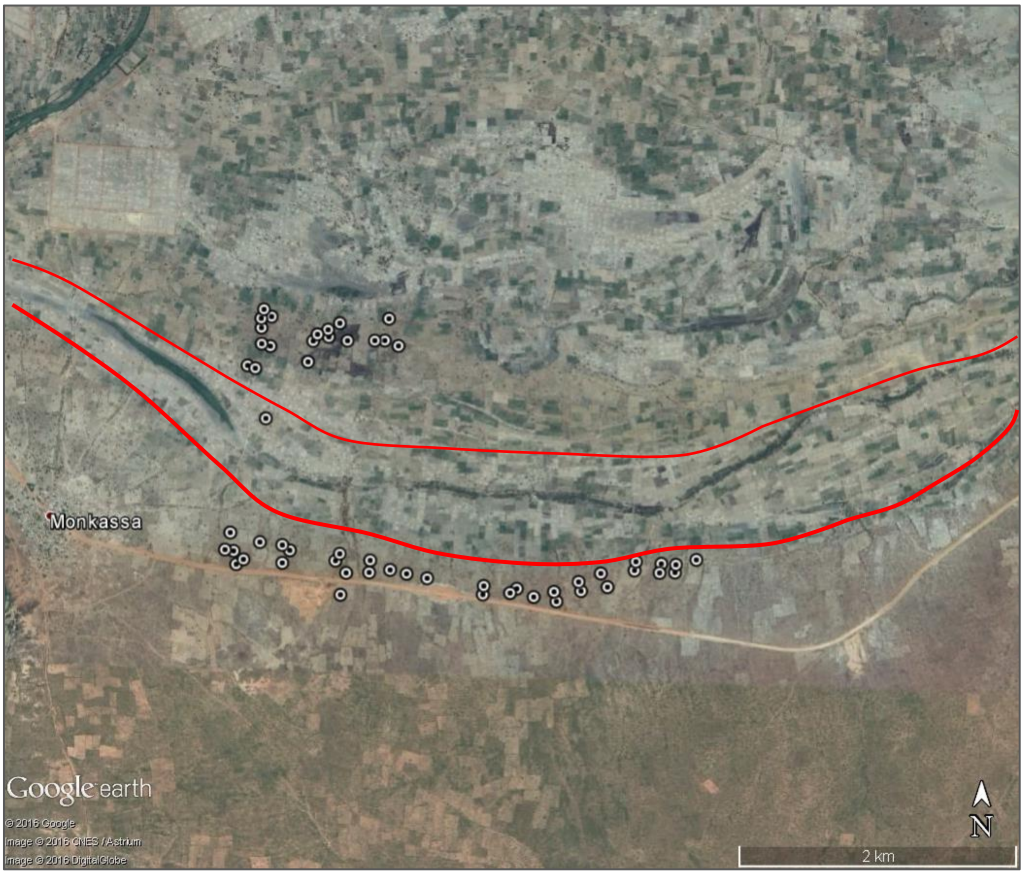

Figure 4.39 *Google Earth image with red line to show where the river could have run in the past, note the colour change of the landscape. Points illustrate archaeological sites discovered.*

The sites along the third area which measures 235m^2, and runs close to the road, consisted of very large settlement mounds - 23 of the 36 sites had the description 'very large' or 'large' within it. The total number of ceramic sherds found before desampling in this area was 1,866 and 166 after desampling. Of these, 36% were undecorated, 51% were eroded (which goes against the overall trend in the Sota area where undecorated and eroded have very similar percentages). Nine percent of the assemblage in this area was folded strip roulette and the rest (4%) was made up of 'other' sherds. Notable 'other' material here included a base, a sherd with wavy lines and two sherds with incised marks from two different sites, these can be seen in Figure 4.40.

Figure 4.40 *Sherd on the left from Site 113 and on the right from Site 120 in the 'other' category of decoration, collected in the third survey area of the Sota region study area.*

One of the sites in this third area, which is located very close to the road, was discovered to have been completely bulldozed during in the construction of the road. Furthermore, as we were surveying, other sites were also being destroyed in a similar manner. There was some very interesting pottery from the machined site which was found in the machined section. Because the site was a large crevice in the ground, a surface collection was not made, but a few sherds of interest were collected, including one geometric design piece and a complete rim with a narrow opening. These can be seen in Figure 4.41. The destruction of this site and the others, which can be seen on Google Earth, will be discussed in Chapter Six, the discussion chapter, with photographs of the destruction.

***Figure 4.41** Top, complete ceramic rim of vessel found at destroyed site 121. Rim has eight holes pressed into it with eight notches, perhaps used for hanging at some point in the past. Bottom left and right are two different angles of the same sherd which has two decorations, twisted cord and two geometric designs, one rectangular and one triangular (seen on the right).*

The final survey area featured the site of Djaboutchia, which sits on the edge of the Niger River in the far east of the study area. Six collections were taken from this area, however, this was more than likely one very large site. Because of this, rather than measuring the individual areas the entire site area was calculated by GPS and measures 24,919m^2 (2.5 hectares). It was important to survey here, as again the site is suffering from environmental erosion and is slowly collapsing into the main Niger River.

The material culture at Djaboutchia was very dense on the surface in some areas, one collection unit had 1,393 sherds, which makes up 19% of all the ceramics collected in the Sota region. There were some differences in the material culture here, distinctly the presence of lighter, burnished sherds, which were almost absent elsewhere (a small quantity was found in the Alibori region). This was perhaps signalling a change in clay and technique in this area.

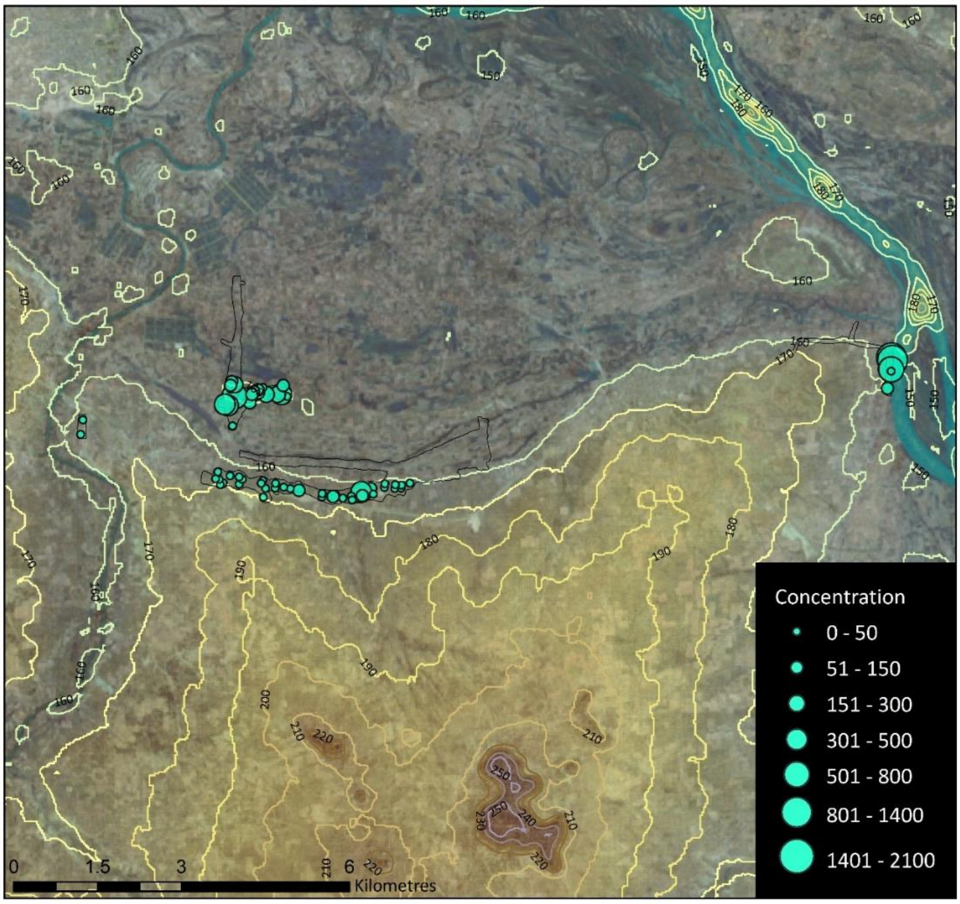

Figure 4.42 *A map showing the concentration of ceramic finds from within the Sota River study area shown using turquoise proportional symbols.*

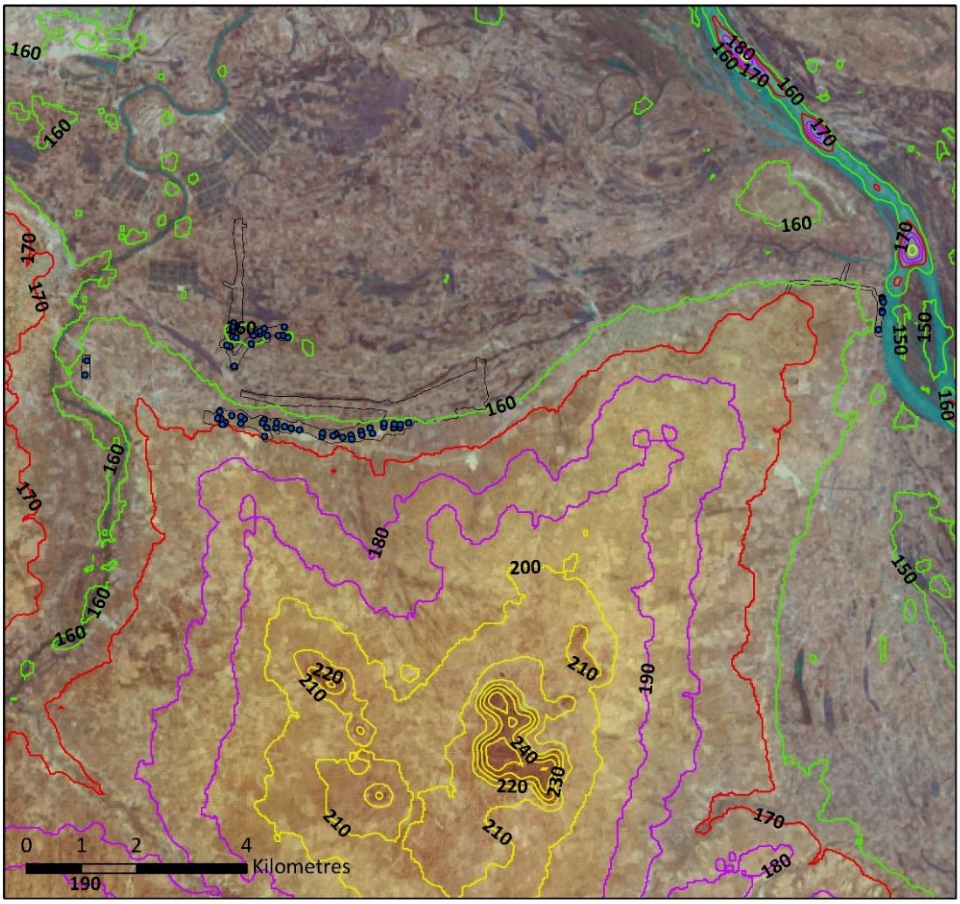

Figure 4.43 *A contour map showing the general distribution of sites within the Sota River study region, with elevation of the area depicted by contour lines.*

	Undec	Eroded	FSR	FSR/Plain	Perforated	Incis	Other	Total
Body	129 (37%)	141 (40%)	59 (17%)	5 (1%)	0 (0%)	1 (0.3%)	16 (5%)	351
Rim	22 (58%)	5 (13%)	1 (3%)	1 (3%)	0 (0%)	0 (0%)	9 (24%)	38
Total	151 (39%)	146 (38%)	60 (15%)	6 (2%)	0 (0%)	1 (0.3%)	25 (6%)	389

Table 4.7 *Sherd and decoration type of ceramic found in the Sota survey area.*

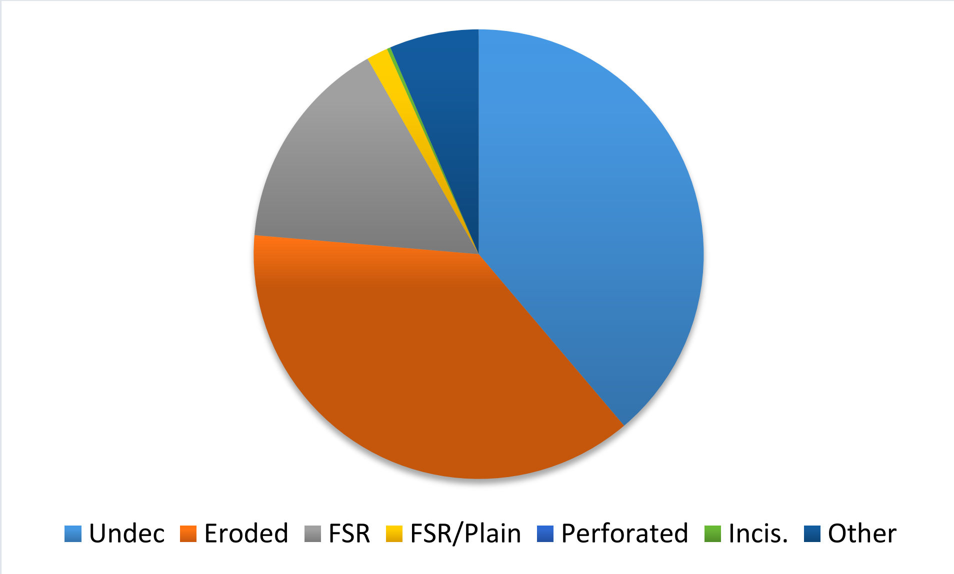

Figure 4.44 *A pie-chart illustrating the type of ceramic discovered with the Sota River study region.*

There was a distinctly low number of lithic and slag found in the survey in the Sota region. There are small non-perennial streams that run in between some of the mounds. These topographical aspects of the landscape will be discussed in the next chapter.

4.5. Summary

This chapter has outlined the findings of the field survey that was carried out in the Niger River Valley over five weeks in January and February in 2014. Already, before spatial analysis using GIS tools has been carried out, there are some distinct patterns emerging, particularly between the east and the west of the region. The Birni Lafia and Alibori survey areas exhibit a large degree of erosion, particularly close to the banks of the Alibori River. This erosion has increased archaeological visibility and there are a dense quantity of pottery sherds found on the surface. There are many flat sites in the Alibori area also, which is a stark contrast to the Sota and Kouara Tegui survey areas, which exhibits large, elevated settlement mound sites. The material culture in the region also differs between the individual survey areas, which may suggest some social diversity in the landscape, this will be discussed in Chapter Six. The spatial patterns in the landscape will be analysed further in Chapter Five.

Chapter Five: The landscape and spatial analysis

5.1. Introduction

This chapter will examine the landscape that forms the backdrop to the archaeological sites found in the Niger River Valley, Benin, and consider how the environment may have affected the placement and distribution of sites. Two research questions outlined in the introduction of this thesis will be considered here: the first concerns settlement patterning and the involvement of the environment in settlement preference and human activity, and the second, examines the usefulness of satellite imagery and GIS in analysing landscape processes. The case made here is that using GIS significantly enhances our understanding of settlement organisation and substantiates patterns already apparent visually as seen in Chapter Four. GIS will be used in conjunction with analysis of satellite imagery to examine the topographic and geomorphological features of the landscape and create varying maps of the area showing change in water and vegetation over time. As discussed in Chapter Two, GIS and remote sensing offer a range of possibilities providing a quick and effective way of analysing an area such as this large hinterland of the Niger River Valley. Using this information in combination with the survey data will give an informed exploration of the region and lead to hypotheses on how past settlers were using this area and the potential to discuss how society functioned here.

We already know that the Sahel, which sits between the southern Sahara's edge and the wet Savannah, is predisposed to climatic instability, which currently affects present day populations. Hydrological dangers mean that flooding affects agriculture, homes and properties, and enables the spread of disease. Flooding of the Niger River Basin is the most common natural disaster in this area to impact human security and the livelihood of people (Okpara *et al.*, 2013). This notion was discussed in further detail in Chapter One, but the present chapter draws on modern satellite imagery to understand landscape processes further that may be affecting the preservation of the archaeology, and help us to understand why we encounter so many abandoned sites.

The chapter is divided into several sections in order to classify and understand what processes are occurring in the landscape. The first part of the chapter considers remote sensing. High resolution satellite data, a tool traditionally used for site identification, is used to ascertain whether archaeological sites can be detected using this imagery. Two algorithms were used for this, as discussed in Chapter Two, and they are panchromatic sharpening and Normalized Difference Vegetation Index (NDVI). Then, the general geomorphology of the area has been classified from medium-resolution remotely sensed satellite imagery to map and show the context in which the sites are situated. The imagery has been further classified again to show the Normalized Difference Vegetation Index (NDVI), to illustrate how much lush, green vegetation is present in the study area over two different time periods, this is discussed in Chapter Two. The Normalized Difference Water Index (NDWI) is also considered to detect changes in areas of open water. The general distribution of all of the sites found during all fieldwork seasons between 2011 and 2014 will be discussed, including distribution of different site typology across the entire survey. The chapter will then go on to use spatial analysis techniques to consider the degree to which spatial patterning occurs, particularly looking at clustering of different archaeological phenomena including types of site (namely settlement mounds and flat sites) and will go on to look at material culture patterning. There are hundreds of variables that could be considered when analysing spatial distribution and patterns in the landscape as a wealth of data and information has been collected. There is not scope within this thesis to consider every pattern variable, so the most important ones have been identified and highlighted in this chapter. These are, the proximity of sites to fluvial channels and surface water and the degree to which sites cluster together, which denotes evidence for urbanistic qualities of settlements within this space.

Overall, all the combination of methods used in this chapter will give a reconstruction of the landscape processes of this region in the past and give insight into human/environment interactions.

5.2. High resolution satellite imagery

Remote sensing using aerial and satellite imagery in archaeology has been used for many decades for the identification and mapping of sites in the landscape. This section considers the results of high resolution imagery analysis in the Dendi region. Currently in West African archaeological contexts there has been no published research undertaken using satellite imagery, so this part of the thesis will demonstrate how it may be used in these Sahelian contexts. As examined in Chapter Two, in many landscape archaeology situations it is possible to identify archaeological remains from the air through the use of high resolution satellite imagery, this is generally in areas where there is still standing architecture on the surface, or where the ground surface (vegetation and soil) has been modified because of the underlying remains. The area of northern Benin has no evidence of standing architectural remains, but, change in soil spectral reflectance as a result of sub-surface archaeology can be used to identify sites. There are settlement mounds however, which do extend beyond the natural surface of the landscape, with some as high as eight metres. Yet, the mounds are undetectable from standard high resolution aerial imagery, such as Google Earth, because the surrounding soil and vegetation exhibits similar spectral qualities.

The imagery used for this analysis comes from the satellite sensor *Quickbird-2*. As discussed previously, the most useful satellite remote sensing data that can be used for extracting archaeological features is that from a sensor that provides a resolution of less than one metre per pixel. For this project, a 25km^2 area was purchased from Infoterra Ltd., and comes courtesy of DigitalGlobe, Inc. The centre coordinate for this image is 11.978252°N and 3.220944°E with a 2.5km radius, producing a polygon image (see Figure 5.1). Table 5.1 shows the characteristics of the sensor and the acquisition information of the imagery used for this research. This metadata is important as it shows the time of year the imagery was taken.

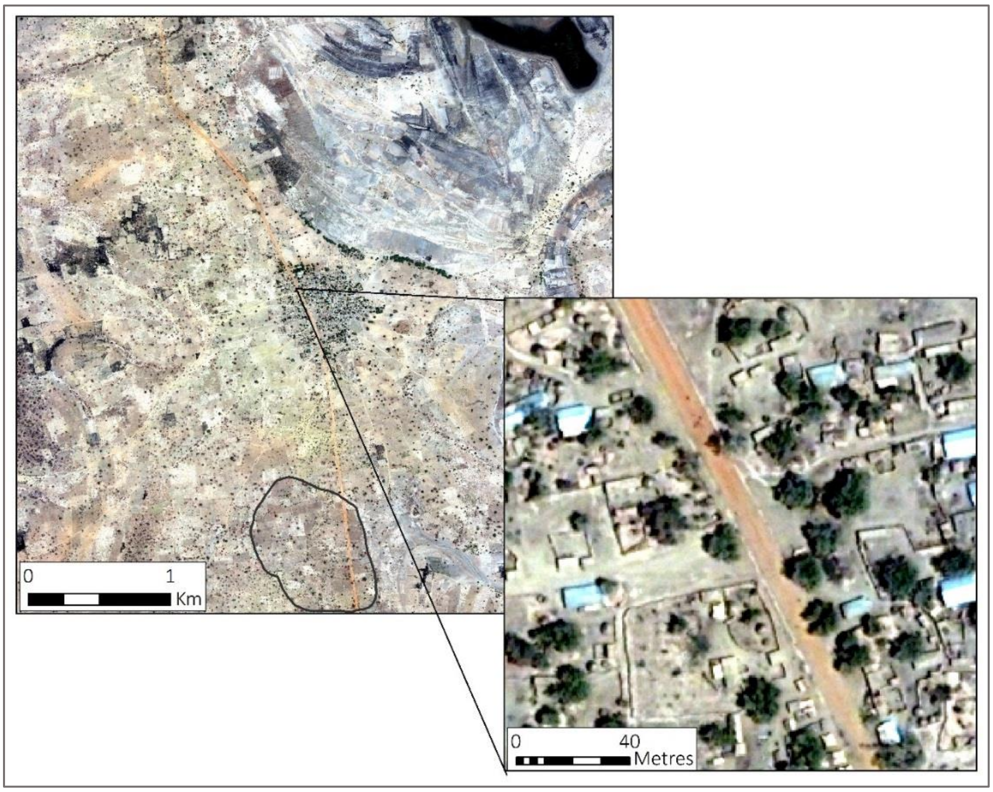

Figure 5.1 *On the left is the 25km^2 image centred on the modern village of Birni Lafia. The polygon to the south is the settlement mound complex of ancient Birnin Lafiya. Inset on the right is a zoomed in area of the village to demonstrate the clear aerial image produced from panchromatic sharpening that can be obtained from high resolution imagery.*

Satellite	Spectral Bands	Resolution	Acquisition Date
Quickbird	Pan: 0.45-0.90 µm Blue: 0.45-0.52 µm Green: 0.52-0.60 µm Red: 0.63-0.69 µm Near-infrared: 0.76-0.90 µm	0.61 metres 2.44 metres 2.44 metres 2.44 metres 2.44 metres	18/03/2003

Table 5.1 *Quickbird-2 sensor characteristics and metadata taken from the image*

Panchromatic sharpening of the image was undertaken in an effort to reveal differences in the earth's surface by showing potential earthworks and subsurface remains of archaeological sites (an approach developed successfully by De Laet *et al*., 2007; Masini and Lasaponara (2007)). Figure 5.2 shows two images both of which have undergone panchromatic sharpening. The first image (left) shows the results of a differential GPS survey undertaken by the *Crossroads* project, which accurately outlines the full extent of the site that is visible from the surface. The second image (right) shows a mapped polygon outlining the distinct change in spectral reflectance of the landscape, which fits the outline of the site.

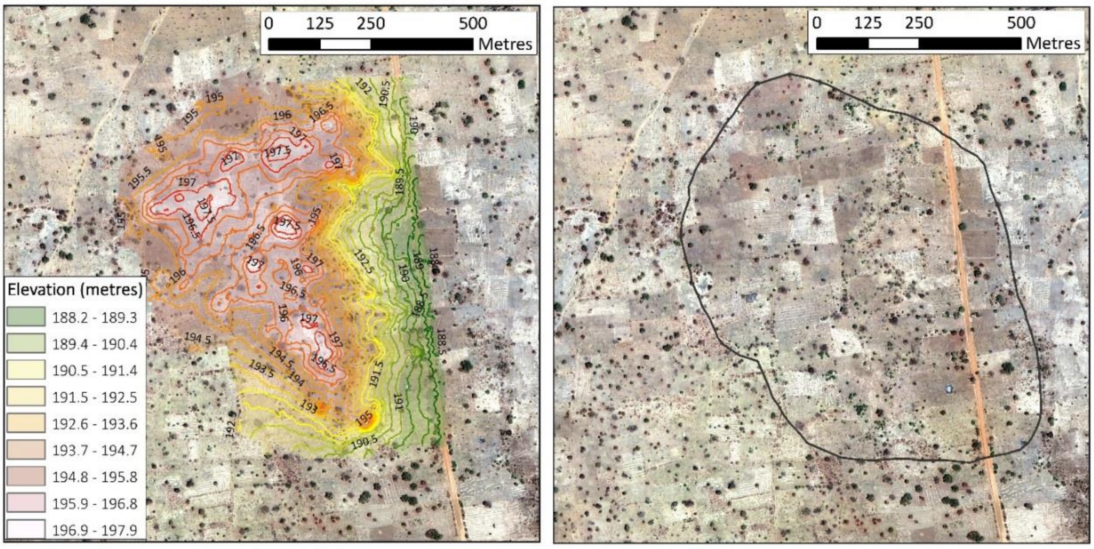

Figure 5.2 *Pan sharpened Quickbird-2 images: Left, shows a digital elevation model of the site of ancient 'Birnin Lafiya' produced using a differential GPS device. Right, shows the outline of the site.*

Applying the pan sharpening algorithm to the Quickbird-2 data revealed a distinct change in spectral reflectance, which can be seen in the darker tone of the soil, thus proving this method successful for identifying archaeology from the air. As can be seen from Figure 5.2, the spectral response of the settlement mound complex is clearly different from the surrounding landscape. There is one difference between the two images; the outline of the site in the image on the right shows that the site extends to the other side of the road where the spectral response of the soil extends. During the geophysical survey of the Birnin Lafiya settlement mound, undertaken by Carlos Magnavita, it was noted that were anomalies under the road and because the area beyond the road was cultivated, it was difficult to survey the full extent. This demonstrates that the result obtained from pan sharpening the satellite imagery is not only promising for the identification of archaeological sites in the region, but can also reveal the true extent of the site, where survey may not be possible.

Looking to other high resolution analysis to extract archaeological information by using methods such as those described in Chapter Two, which consider the differences in vegetation in indicating archaeology on the ground, we can consider the example of NDVI. This method was carried out successfully by Lasaponara and Masini (2007) on images in the south of Italy, where non-vegetated and vegetated terrain was considered. The archaeological sites that were present in the non-vegetated areas were revealed on satellite imagery by merging the red spectral band with the panchromatic band. However in the vegetated area, applying the NDVI algorithm was most successful in revealing archaeological sites because the near-infrared is more susceptible to picking up changes in spectral response of vegetation. Because the area of Birni Lafia is semi-vegetated, both algorithms were applied to the pan sharpened image to consider the best result (Figure 5.3).

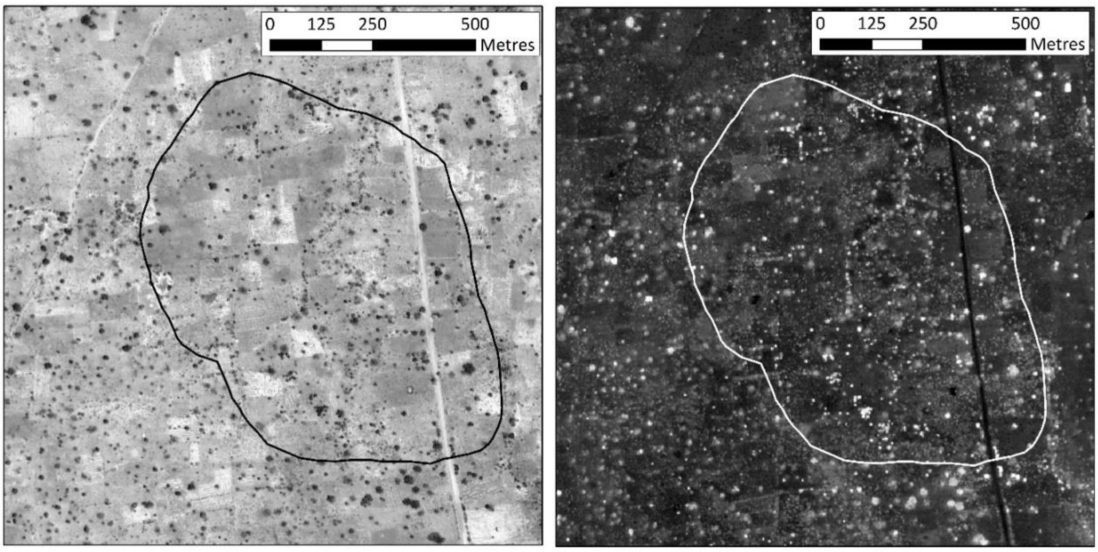

Figure 5.3 *Image on the right is the results of the red band and subsequent panchromatic merger and the image on the left is the results of NDVI after panchromatic sharpening. Both images show the polygon of the site that was created from the panchromatic sharpened image.*

The results of this process differed from the result of carrying out the panchromatic sharpening alone. Merger of the red and panchromatic band shown on the left of Figure 5.3 shows a very slight variation in the spectral response of the archaeology compared to the surrounding landscape – this is illustrated by a slightly darker grey colour of the ground in comparison to the surround. The NDVI process on the other hand, unfortunately shows no variance in the spectral response, this is because the vegetation cover is not dense enough to display the variation needed to identify the archaeology. As the image was taken in March, which is the beginning of the rainy season, the process of NDVI may work better when there is more vegetation. Furthermore, testing the algorithm on imagery of different time scales may illustrate different results (this will be discussed further in the conclusion for future considerations).

Overall, manipulation of the high resolution Quickbird-2 image obtained of the Birnin Lafiya settlement mound was relatively successful in illustrating the outer boundaries of the ancient site. Panchromatic sharpening of the image was the most effective algorithm applied, which revealed a distinct difference in colour of archaeology compared to the natural surrounding landscape. Merging the red spectral band with the panchromatic band showed a slight difference in ground colour, but not to the same degree as the panchromatic sharpening, and the NDVI image showed no difference. This method was also useful as the site could be mapped accurately and quickly from the image with no time on the ground; however, ground truthing is needed. This will be discussed in further detail in the discussion chapter (Chapter Six). The next section will address the analysis and results of medium resolution imagery in studying the archaeological landscape.

5.3. Medium resolution satellite imagery

This section will outline how medium resolution data from Landsat and ASTER GDEM was utilised to consider the environment in the Niger River Valley.

5.3.1. Overview

The advantages of using medium resolution imagery were highlighted in Chapter Two. Such imagery is available free of charge and can be used as a tool for mapping large landscapes, not only two-dimensionally, but also in elevation. This section will outline the techniques and results derived from remote sensing methodologies to show the topography of the landscape through the different spectral characteristics and elevation data of imagery across the study area. As discussed, spectral differences in the earth's surface recorded by satellite sensors have the ability to show the general topography and geomorphology in the region from space. Furthermore, the satellite sensors record a range of multispectral information, beyond the visible spectrum, which can go further in highlighting different properties on the earth's surface, such as water and vegetation changes, which may not have been detected by the naked eye.

The satellite imagery used for this analysis of the landscape comes from Landsat 5 Thematic Mapper (TM), Landsat 8, and ASTER Global Digital Elevation Model (GDEM) (ASTER GDEM is a product of Ministry of Economy, Trade and Industry (METI) and National Aeronautics and Space Administration NASA). All pre-processing of imagery data, including stacking of multispectral layers, geographic transformations and subsets of imagery, were carried out in the context of the present doctoral research in ERDAS Imagine Professional package. All visualisations of data presented were produced in ESRI ArcGIS.

Satellite	Spectral Bands	Resolution	Acquisition Date
Landsat 5	Blue: 0.45-0.515 µm Green: 0.525-0.605 µm Red: 0.63-0.69 µm Near Infrared: 0.75-0.90 µm Shortwave IR: 1.55-1.75 µm	30 m 30 m 30 m 30 m 30 m	15/06/1999

	Thermal IR: 10.4-12.5 µm Shortwave IR: 2.09-2.35 µm Panchromatic: 0.52-0.9 µm	120 m 30 m 15 m	
Landsat 8	Coastal aerosol: 0.4 -0.45 µm Blue: 0.45-0.51 µm Green: 0.53-0.59 µm Red: 0.64 - 0.67 µm Near Infrared: 0.85-0.88 µm SWIR 1: 1.57-1.65 µm SWIR 2: 2.11-2.29 µm Panchromatic: 0.50-0.68 µm Cirrus: 1.36-1.38 µm Thermal Infrared (TIRS): 10.60-11.19 µm Thermal Infrared (TIRS): 11.50- 12.51 µm	30 m 30 m 30 m 30 m 30 m 30 m 30 m 15 m 30 m 30 m 30 m	06/06/2015
ASTER GDEM	N/A	30 m	17/10/2011

Table 5.2 *Sensor characteristics and metadata of medium resolution satellite sensors*

5.3.2. Data Acquisition

As discussed in the previous section, the satellite data comes from two different satellite programmes, both of which have global coverage. One is the Landsat Programme which captures data using a multispectral platform recording between eight and eleven spectral bands (Table 5.2). The other is dataset ASTER GDEM which captures not only horizontal data points, but vertical ones showing elevation. Landsat and ASTER GDEM data both have a 30m resolution and the downloaded data comes courtesy of the United States Geological Survey (USGS) and NASA. The imagery was acquired from the Earth Explorer website (http://earthexplorer.usgs.gov/).

Multi-temporal imagery from the Landsat Programme was downloaded and comes from two different Landsat satellites that were in orbit around the earth and capturing imagery at during different timescales. The first image was taken in June 1995 and comes from Landsat 4 TM, which was one of the first Landsat sensors that took imagery at a 30m resolution, the same as present day Landsat 8, which captured the second image in June 2015. Both datasets are free to download from the USGS website and are georeferenced for accurate automatic mapping, making it invaluable for landscape research. These images were chosen due to lack of cloud cover in the area in both scenes during this time. Imagery captured at other points in time have substantial cloud cover meaning the general topography of the region is concealed, which is useless for analysis. Furthermore, June is the rainy season, and as fieldwork takes place in the dry season (January), these images were also useful to contrast the landscape at a different period during the year.

The ASTER GDEM product has estimated accuracies of 95% confidence at 20m for vertical data and 95% at 30m for horizontal data. The data were projected in the World Geodetic System (WGS 84) in decimal degrees, however to match the Landsat imagery projection system, they were reprojected using a rigorous transformation method, to Universal Transverse Mercator (UTM) Zone 31.

5.3.3. Pre-processing

The Landsat imagery downloaded consisted of two tiles (path 192, row 51 and path 192, row 52), these tiles were mosaicked together using the mosaic function in ERDAS Imagine software; a subset was then taken of the chosen area. At this stage, the multispectral bands are separate therefore the process of image fusion was undertaken in order to create a colour composite image. This process fuses together the different bands that are collected at different wavelengths of the electromagnetic spectrum to form a colour image. This image can be visualised in different ways, highlighting the topographic features of the landscape. For example, when the red, green and blue bands are used, this will display 'real' colour as the eye sees it. This process was undertaken in ERDAS Imagine using the 'Layer Stack' tool. This step is necessary for visualisation and classification of the landscape, which can be easily understood in colour rather than greyscale, which is how the image is downloaded. Also, the Landsat image is orthorectified by combining it with the ASTER elevation imagery, as they are the same resolution. Figure 5.4 shows the resulting images after the pre-processing stage. This pre-processing stage has the overall aim of producing a single, easily read image that can then be more fully analysed.

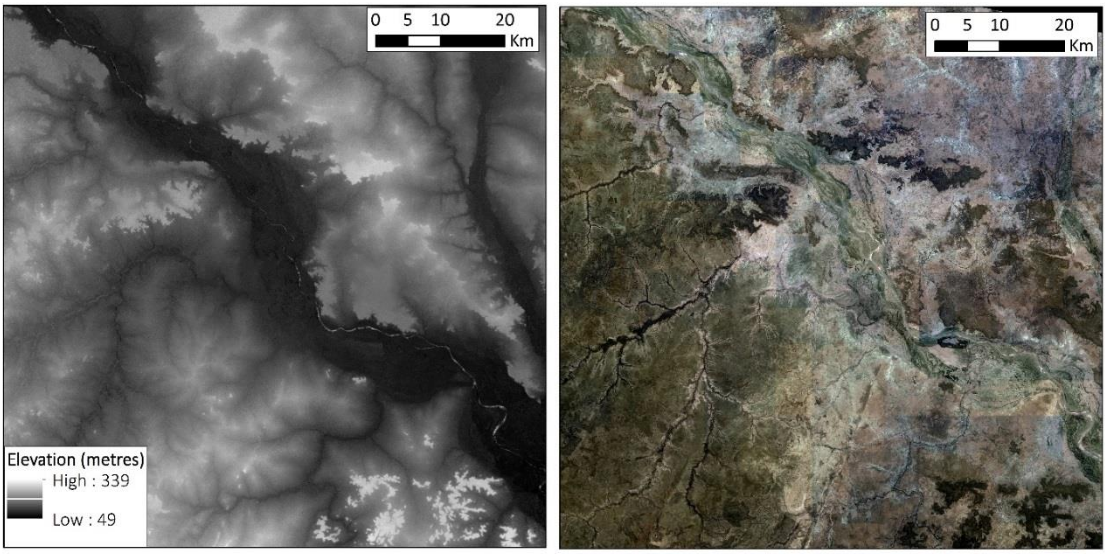

Figure 5.4 *Image on the left is the ASTER GDEM image of the region and the image on the right is a Landsat 8 image (bands 1, 2 and 3).*

5.3.4. Landscape mapping for the historic environment

Once the data had been prepared, base maps were produced these can be seen throughout this thesis. It is sometimes difficult to obtain a high resolution base map of the terrain for some parts of Africa (and other regions of the world), so producing a map such as this, using free satellite imagery, is invaluable for several reasons. Chapters Two and Three noted that understanding the topography of terrain before the fieldwork is undertaken is important for the application of the survey methodology. This shows a clear advantage of using this tool.

One useful map to prepare from the free satellite imagery is a contour map. Figure 5.5 shows a contour map of the Niger River Valley and its tributaries, derived from the ASTER GDEM data. This map was made using the 3D Analyst Tool in ArcMap 10.2.2. Preparation of an elevation map prior to archaeological fieldwork is important for two reasons, firstly; steep elevations may hinder mapping delimited survey zones as some areas may be too high to access. Secondly, as was alluded to in previous chapters (Two and Four), and will be discussed later in this chapter, settlement patterns do correlate with elevation, thus play an important role, particularly for predicting where sites may occur.

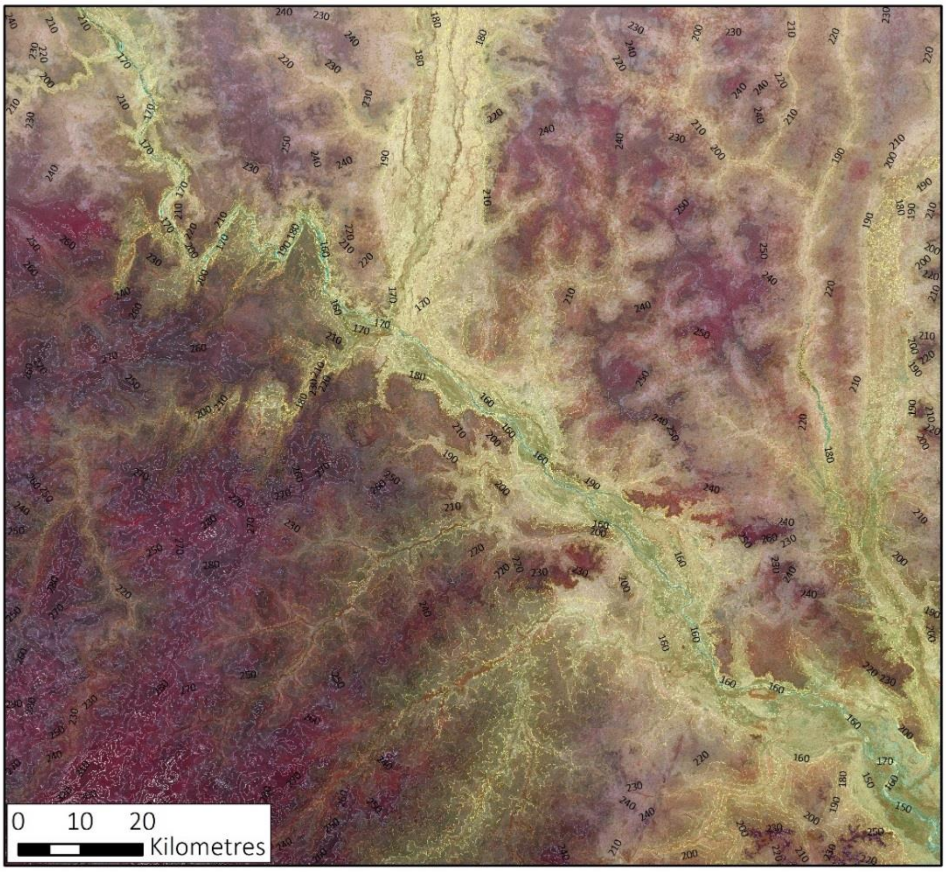

Figure 5.5 *Map of the study region showing contour lines, elevation and geomorphology. Created by combining ASTER GDEM data and Landsat 8 data, with hillshade affect.*

The preparation of a base map is essential for mapping the sites discovered during survey. Within this project, satellite imagery maps of the landscape have been created, and all of the sites mapped on discovery. This is essential because when collecting GPS points as there may be an error in the handheld device which means the coordinates are wrong, therefore validating and cross-referencing them on the map are a must. As discussed in Chapter Three, the *Crossroads* project conducted a field walking survey between 2011 and 2014, during which 514 sites were recorded. The exact details of the sites that were discovered can be found in the first gazetteer in the appendix of this thesis. An additional 320 sites were discovered on the survey that was undertaken within this doctoral research project. Figure 5.6 shows the 834 archaeological points of interest discovered since 2011. The sites span the Niger River over some 120km, covering a vast area of the river valley, illustrating that large proportions of this landscape were inhabited at some point in time. This map, for the first time in the history of research in the Niger River Valley, reveals the sheer density of archaeological activity, with clusters of archaeological sites in almost every area examined.

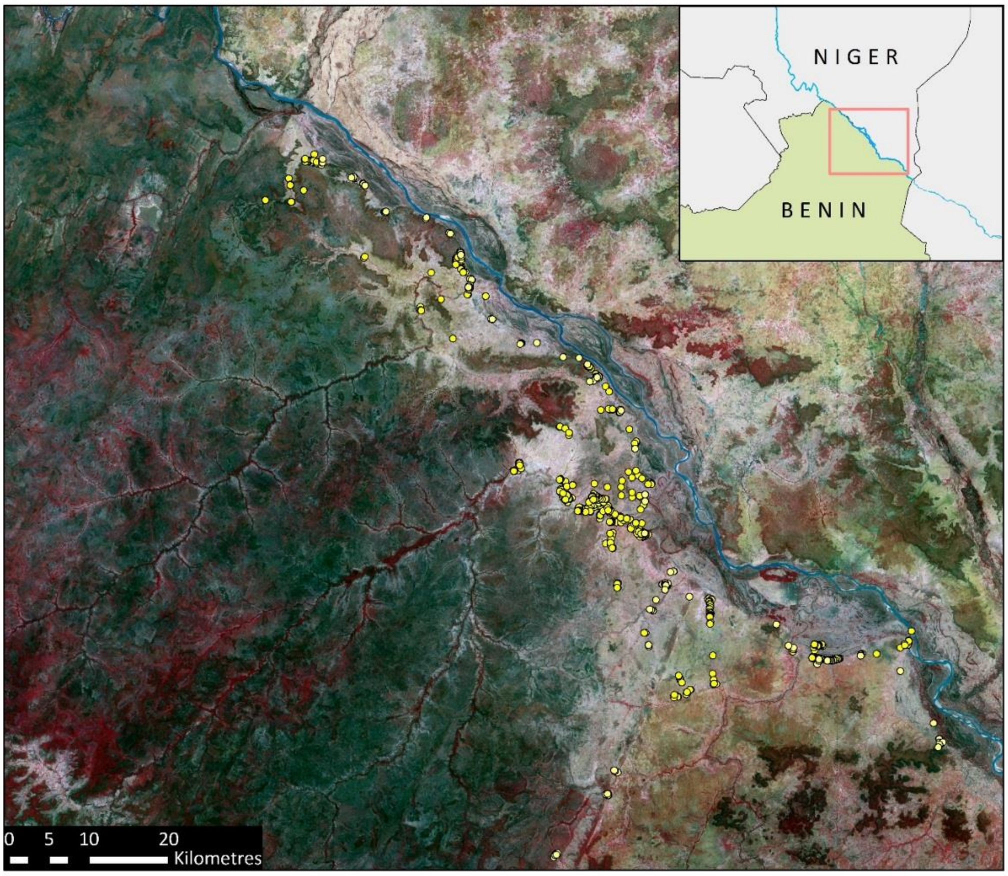

Figure 5.6 *Main image:* Landsat 8 image taken 6th June 2015, bands 5, 4, 3 shown here shows colour infrared to illustrate vegetation. The yellow points represent every site discovered in the region since 2011 from survey. Inset: Red box indicates the study area shown in the satellite image.

The first immediate observation about the placement of archaeological sites in the region as a whole, is their position close to the fluvial channels, either the main Niger River or its perennial and non-perennial channels. This is shown in greater detail in Figure 5.7 which shows the Alibori River region. In this Figure, the course of the river has been mapped by hand using the satellite image as a guide (another advantage of using freely available satellite imagery). From a visual inspection, the sites appear to cluster and group together close to the river systems, whereas isolated sites appear further away from the channels. Furthermore, the sites are located on the lighter colour terrain, corresponding to eroded areas close to the river. These questions will be developed further later in the chapter.

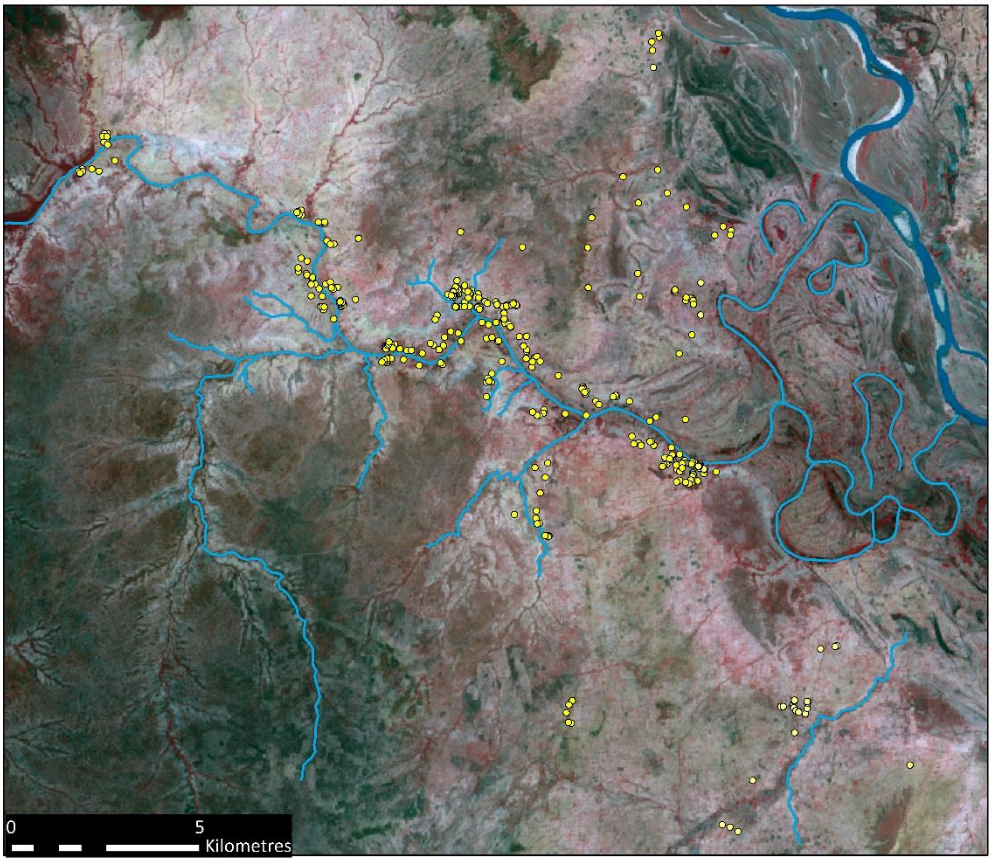

Figure 5.7 A close up of the Alibori River area; some of the fluvial systems have been digitised to show clearly on the map. The yellow points illustrate 358 archaeological areas found during surveys between 2011 and 2014 in this area.

The Sota study area however, tells a slightly different story. The sites that are identified here are morphologically very different, consisting mainly of large mound sites (see Chapter Four) and they are distributed differently. They appear to be very ordered in a linear distribution following the river stream, and groups of paired mounds appear common (Figure 5.8). The landscape in general here is also noticeably different, with a lesser impact of fluvial systems in the landscape. That is, the Alibori area looks quite 'veiny' with the fluvial systems of the Niger penetrating the landscape. Fluvial activity does exist in the Sota area, but consists of subtle fossil streams, coming from a non-perennial river system and can be seen in Google Earth. Thus, this less dynamic landscape is less eroded then that of the Alibori region and this most probably affects the visibility of sites.

Figure 5.8 Arrangement of sites in the Sota survey area, using Google Earth imagery to show the river system running east to west between the Sota and the Niger River.

5.3.5. Geology

This section will briefly consider the underlying geology of the region, which potentially has an impact on the degree of erosion. There is a geological difference in the landscape between the east and the west, as shown in Figure 5.9 in an inset of the USGS geological map of Africa courtesy of Persits *et al*. (2002). This variation is apparent when analysing the satellite imagery, as shown by the diagonal line in (Figure 5.10). This is known as the Kandi fault line. This change in geology may partly account for the lack of erosion in the Sota and lack of exposure of archaeological sites there. According to the geological map, the underlying geology in the Sota area originates from the Mesozoic and Paleozoic (MzPz) eras. The dominant rock type of in the Alibori area is gneiss, a high-grade metamorphic rock that is resistant to erosion. The Niger River Valley is also covered with alluvium, consisting of quartz sands and clays (N'dah and Laibi, forthcoming). Badlands, however, are formed in the Alibori region illustrating that the alluvial formation must be weaker than the zone further to the east for the high degree of erosion to occur. Furthermore, the differences in the river flow rate between the Alibori and the Sota also would affect the topography of the landscape. The erosional effect on the archaeology further west of the study region has been discussed by Haour et al. (2004) and Ide, (2009) in the Mékrou River valley, which exhibits a similar landscape to that found close to the Alibori River.

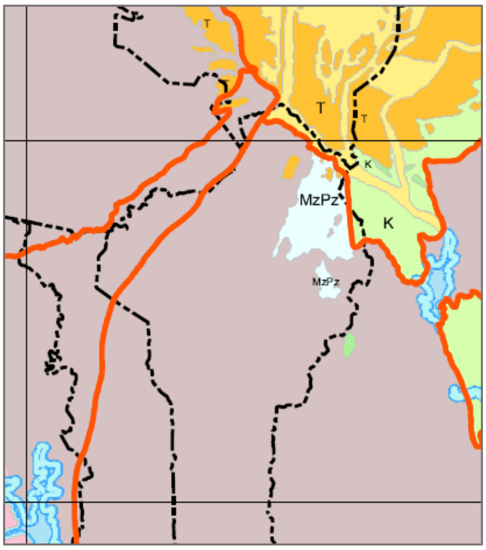

Figure 5.9 *USGS geological map of Africa showing Northern Benin study area.*

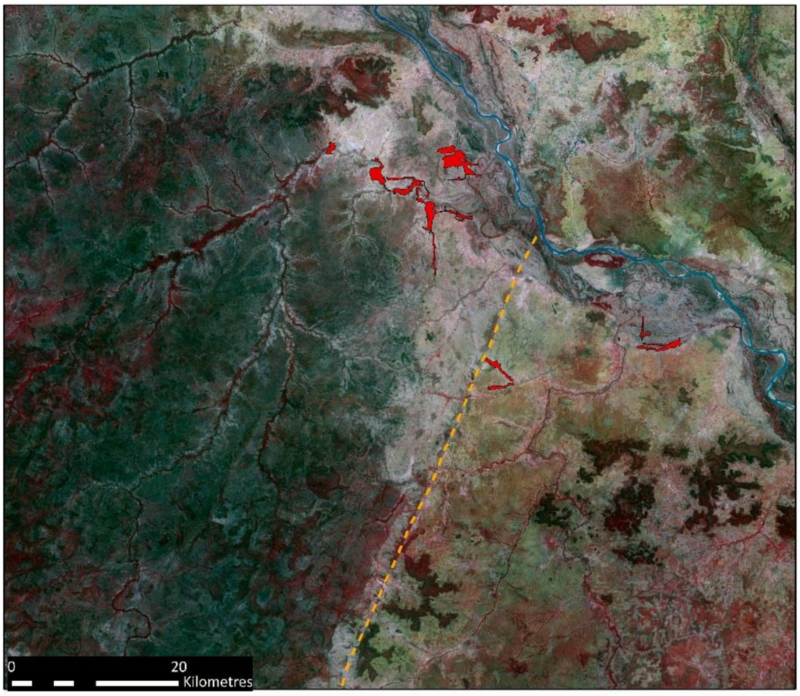

Figure 5.10 *Landsat 8 satellite image illustrating the geological shift shown with the orange dashed line and the survey areas are shown in red.*

5.3.6. Vegetation detection and change

Medium resolution imagery is not only used for mapping, and as discussed in Chapter Two, it can also be used to give us insight about the landscape which may not be obvious from visual observation alone. Pixels that make up the image taken by the satellite can be classified to represent the different topography of the Earth's surface. The classification process groups together pixels with the same reflectance (i.e., the same topography). For example, all pixels where water is present on the land surface will be represented in the image by the same pixel number, and the software will represent this pixel in the same colour on the map; similarly vegetation of the same type will be represented in the same colour, urban areas another colour, and so on.

The process of NDVI using high resolution imagery was used in the first section of this chapter to ascertain whether archaeological sites could be detected from it on the micro-scale. As we saw, this had limited results. Nevertheless, on a regional scale, the NDVI can be calculated to understand vegetation patterns over the last 20 years and give clues into archaeological visibility, and how the area is being affected by the increase of population in recent years (noted in Chapter One) which will give insight into the environmental dynamic and sustainability of the region.

In order to understand how the vegetation has changed in the region, a 20 year period has been chosen for analysis. Healthy vegetation is calculated using the NDVI algorithm (Chapter Two) and classifies the pixels in order to demonstrate healthy vegetation. This was undertaken in ERDAS Imagine Professional Software, using the unsupervised classification method. In general, vegetation is an important feature to track in the landscape; we can assume that the presence of healthy vegetation means healthy soils for cultivation. Landsat tiles from 1995 and 2015 were chosen, as explained in an earlier section, due to their lack of cloud cover (important that pixels of the landscape image are not concealed by cloud), and the fact that they were both taken around a similar time in June. The results of NDVI classification can be seen in Figures 5.11 and 5.12, carried out on both Landsat scenes from 1995 and 2015.

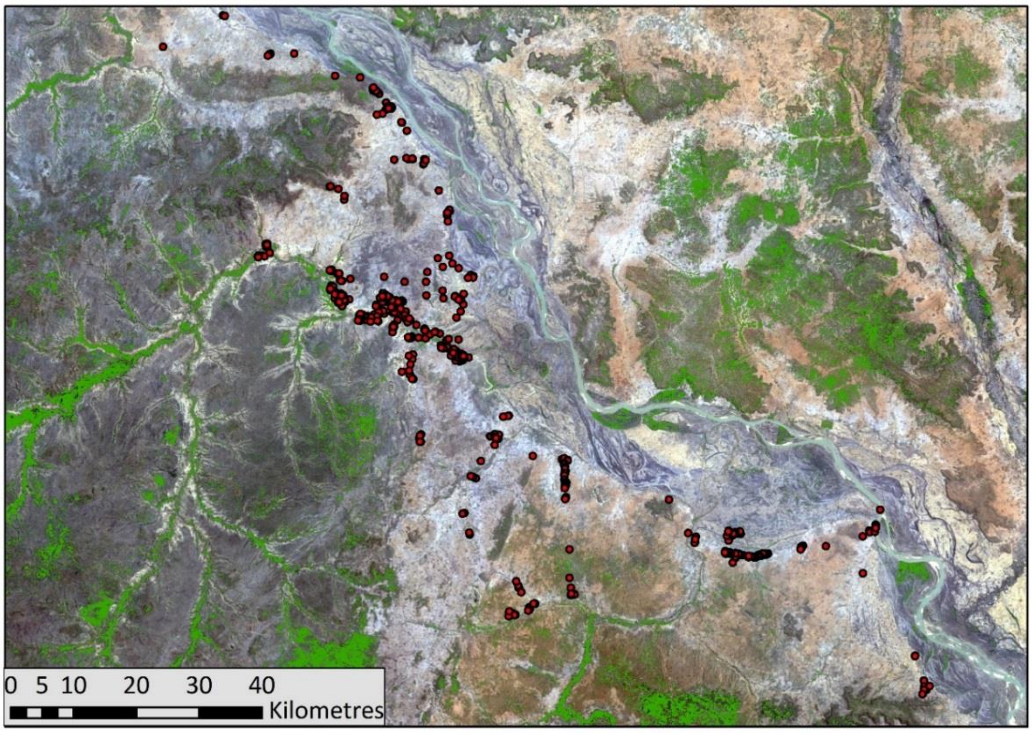

Figure 5.11 Landsat 5 TM image captured on the 15th June 1995 showing the healthy green vegetation generated using the NDVI algorithm. Red points illustrate the archaeological sites in the region.

Figure 5.11 shows the Dendi landscape in 1995 and the bright green areas represent healthy vegetation at the time the image was captured. Healthy vegetation appears to centre on the fluvial systems, which is unsurprising as water is readily available there. From this we can infer that there is limited flourishing cultivation elsewhere, and thus limited irrigation. This comment seems in line with the fact that the population in this region at the time was half of that today. Vegetation will still grow close to river systems where there is access to water regardless of the population in the area, which makes this a prime location for inhabitants to settle close by.

The image taken in 2015 can be seen in Figure 5.12. Here, there appears to be an abundance of green areas in the image, showing a distinct rise of healthy vegetation present in the landscape. Again unsurprisingly, vegetation is mainly concentrated around the river systems. But this vegetation is denser in appearance, particularly close to the Niger River itself, where it seemed to be lacking in the 1995 image. The increase in vegetation reflects the increase in population, with the development of agricultural and cultivation.

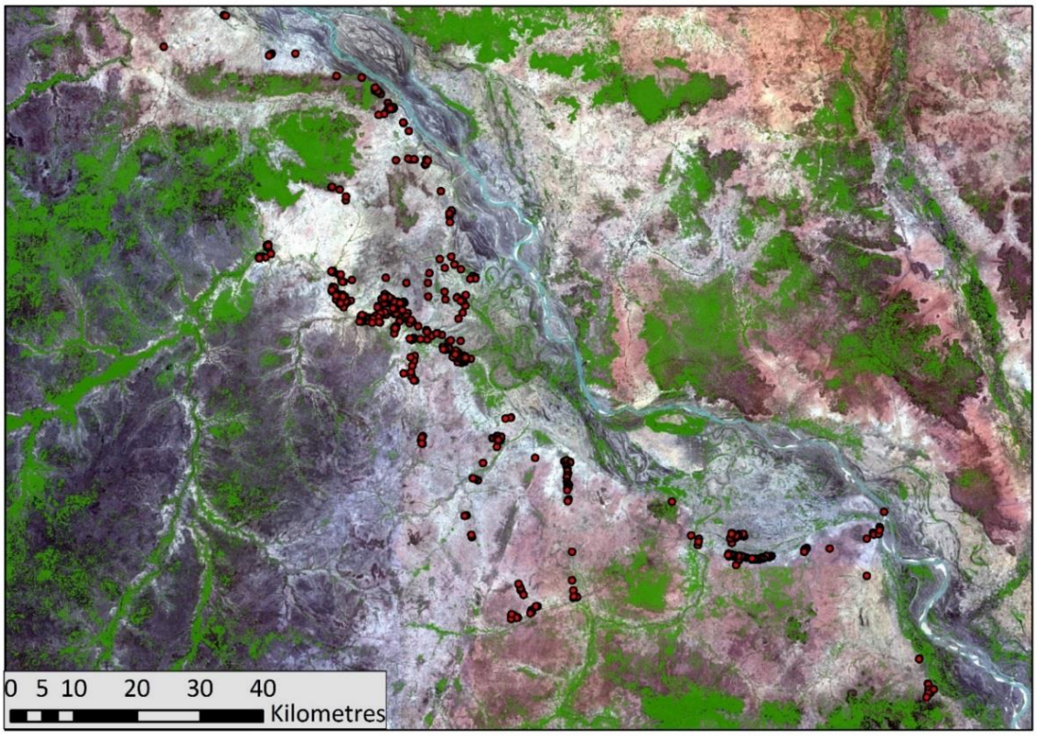

Figure 5.12 *Landsat 8 image from 6th June 2015 showing NDVI - green shading illustrates healthy vegetation, red points show the archaeological sites discovered.*

5.3.7. Change detection

Visual analysis of both Landsat images clearly distinguishes the differences in the vegetation in the area. However, by using a simple algorithm, remote sensing software can detect change over time more accurately (Chapter Two). In the course of this doctoral research topographical change in vegetation was analysed between two different Landsat images. As discussed in Chapter Two, change detection highlights pixel reflectance changes in two different images over a period of time. It basically subtracts the pixel values in the earlier image from the later one. The algorithm calculates brightness changes in the pixels that have increased or decreased by over 50% between the two sets of data. The resulting image shows whether there is an increase or decrease in healthy vegetation. Brighter pixels in the satellite image mean healthier vegetation when using the NDVI algorithm. The results of the NDVI change detection can be seen in Figure 5.13.

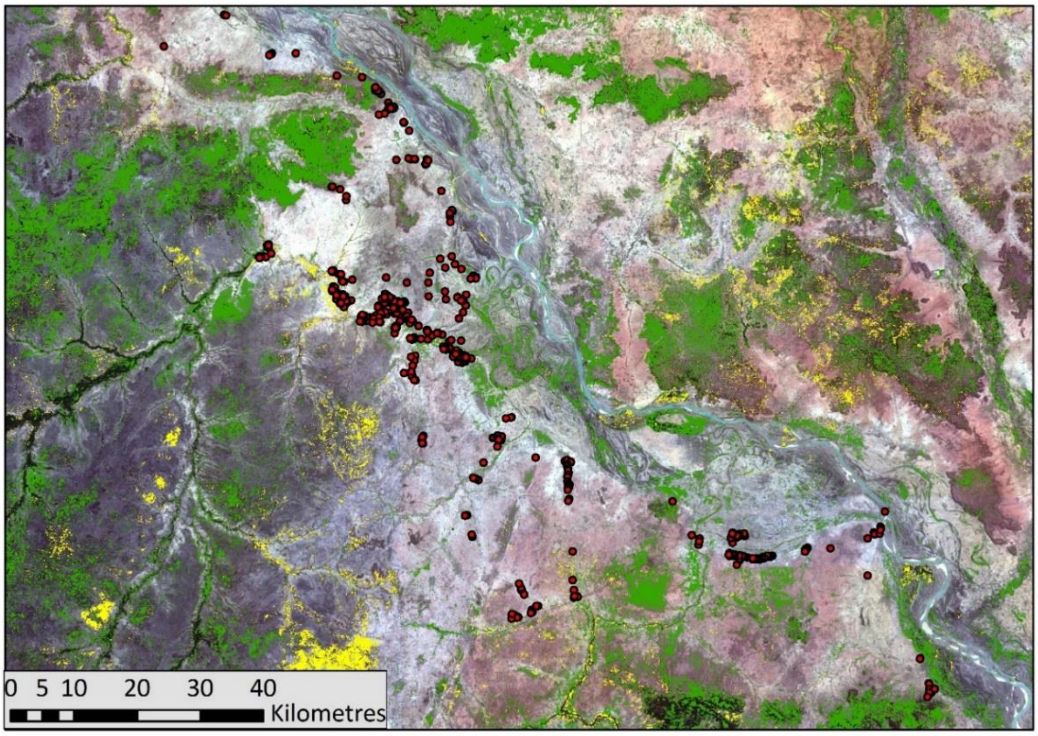

Figure 5.13 *Landsat image illustrating change detection between the 1995 and 2015 satellite images. Green illustrates where healthy, green vegetation has increased and yellow illustrates where there has been a decline in vegetation over the 20 years.*

Overall between 1995 and 2015 there has been an increase of healthy vegetation in the region; however, there are also decreases in some areas. There is a notable lack of healthy vegetation within the Alibori study area where the majority of the archaeological sites were discovered, clustered together as seen in Figure 5.13. The yellow shading in the area shown, illustrates the decline in vegetation over the 20 year period. However, the analysis shows that in the Sota study region in the east of the image, there has been an increase of vegetation. The effects of these vegetation changes are also clear on the ground, the Alibori region has undergone extensive erosion, offering an unfavourable environment for vegetation to flourish, and this is perhaps also why the archaeological sites and the artefact density are more apparent here as there has been more exposure. The Sota region features much larger mound sites and there are fewer sites; there is little erosion and pot sherds per site are not as dense (see Chapter Four). The differences in the landscape at ground level can be seen in Figure 5.14 and 5.15. This will be discussed further in Chapter Six.

Figure 5.14 *The dissected landscape of the Alibori River survey area.*

Figure 5.15 *View of the landscape in the Sota River region.*

5.3.8. Surface water detection and change

Remote sensing imagery is not only useful for calculating where there is healthy vegetation, it can also be used to examine changes in moisture, which is also imperative to human life. Reliable information about the spatial distribution of open surface water is critically important in various scientific disciplines, such as the assessment of present and future water resources, climate models, agriculture suitability, river dynamics, wetland inventory, watershed analysis, surface water survey and management, flood mapping, and environmental monitoring (Desmet and Govers, 1996, Zhou and Wu, 2008, Du *et al*., 2012 and Sun *et al*., 2012).

Pixels of a satellite image can be classified to show areas of water, in a similar fashion to vegetated expanses. The algorithm used for this process is called Normalised Difference Water Index, as discussed in Chapter Two. This analysis was carried out on the Landsat image tiles from 1995 and 2005, and the results can be seen in Figures 5.16 and 5.17. The image from 1995 (Figure 5.16) shows that, predictably, surface water is concentrated in river contexts and it is apparent that there is little other surface water away from these fluvial systems. Again, it can be inferred that there is a lack of irrigation channels for crops, demonstrating a deficiency in agricultural activity.

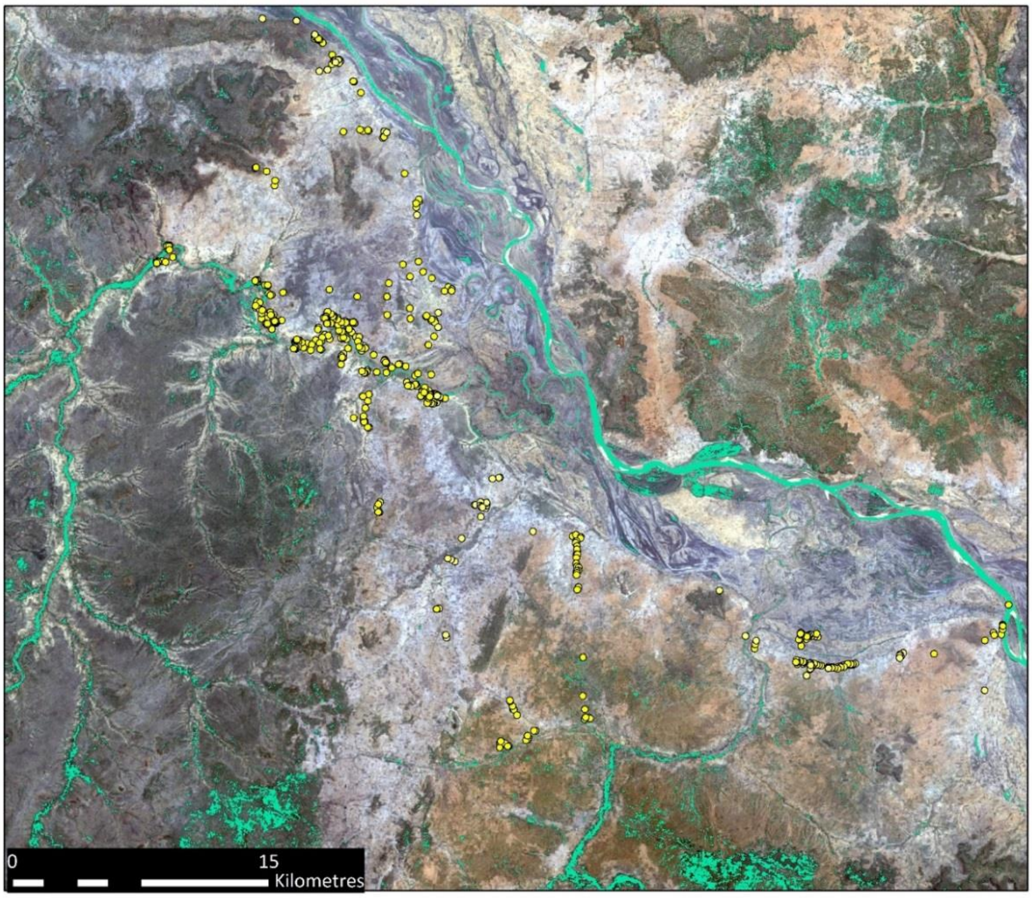

Figure 5.16 *Landsat 5 image illustrating surface water (turquoise) detectable in the region during June 1995. Yellow points show occurrences of archaeological sites.*

Figure 5.17 shows the surface water present within the Niger River Valley in 2015. There is a distinct increase in surface water overall within the region, shown in the NDVI image. The major areas of water are still located in the river zones, but they also occur elsewhere. In the areas located away from the river however, we can assume water occurs because of anthropogenic intervention. For example, crop irrigation and agriculture has probably caused the moisture increase. Areas close to the main course of the Niger River have also seen an increase in surface water. This is probably due to two reasons; one being the increase in the flood zone in recent years and secondly, there has been an increase in cultivation practice close to the river edge, due to its ease of irrigation. Figure 5.18 shows an example of the cultivation by the Niger River edge photographed in 2014.

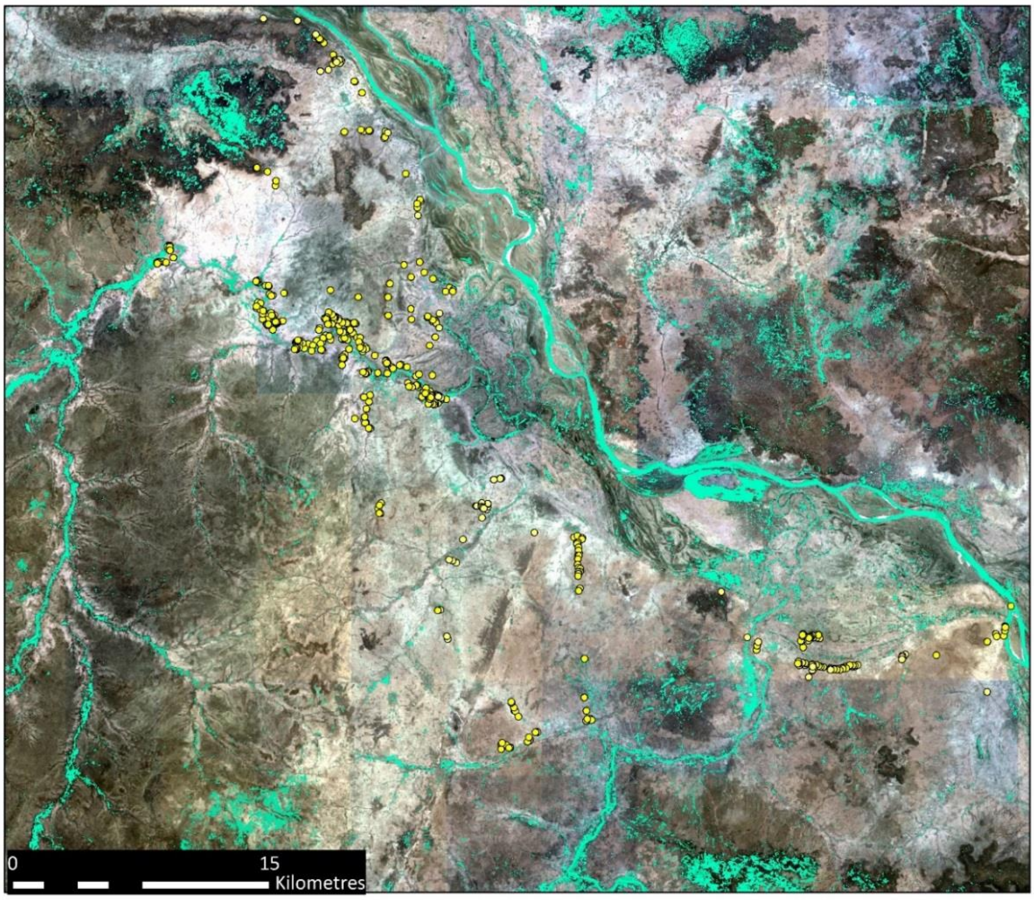

Figure 5.17 *Landsat 8 image illustrating surface water (turquoise) detectable in the region during June 2015. Yellow points illustrate occurrence of archaeological sites.*

Figure 5.18 *Photograph taken during survey in 2014 of the edge of the Niger River close to Birni Lafia modern village.*

The change detection algorithm, as discussed previously, was also carried out on the surface water classification imagery, to establish areas where there was an increase in surface water over the 20 year period, and as expected, the data shows that there is a large increase of surface water in the region. This was particularly apparent in the Sota survey zone. This rise is illustrated in Figure 5.19, where the red coloured pixels show areas that have seen an increase of surface water over 20 years.

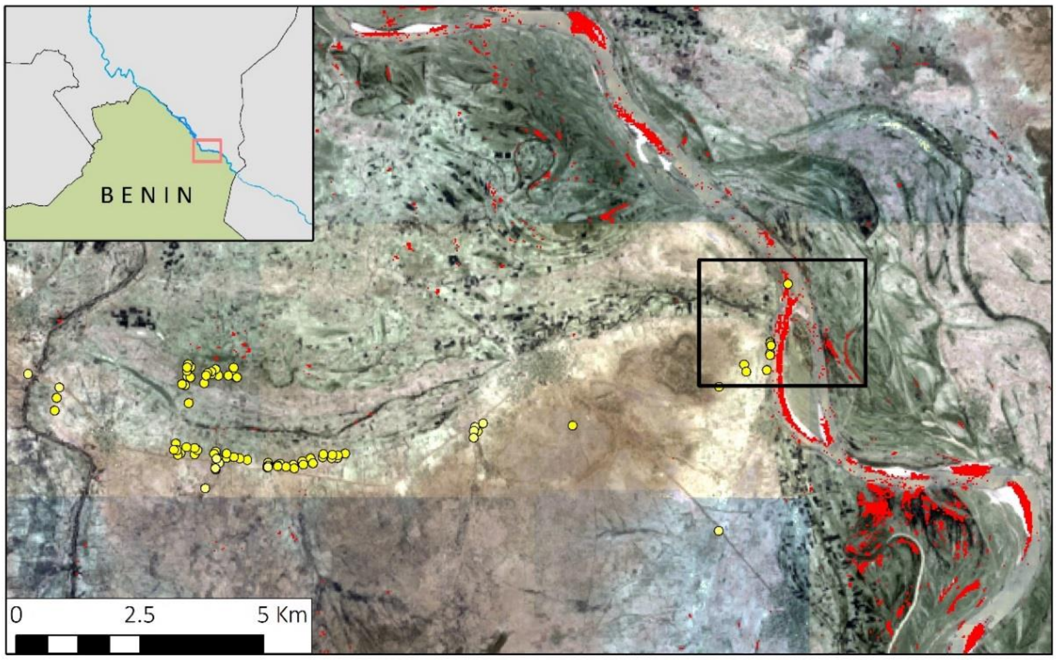

Figure 5.19 *Landsat base imagery with red areas showing where surface water has increased over the past twenty years. Area within polygon is where the large settlement mound of Djaboutchia is located.*

This increase in the overall amount of water in the landscape seen in the satellite image can be realised first-hand at the site of Djaboutchia, which was mentioned in Chapter Three, and can be seen within the polygon in Figure 5.19. Here, there is an increase in the surface water of this river area, suggesting that the riverbanks are eroding making the river wider. This is very obvious when looking at the historical aerial imagery using the Google Earth time slider (Figure 5.20). In the course of just under an 11 year period, the edge of the river has eroded by around 10 metres. This rate of erosion is a metre per year. Furthermore, Figure 5.20 illustrates the increase of field usage and cultivation close to the river, another reason for surface water increase and encroachment on the archaeological site.

Figure 5.20 *Google Earth image on the left dated 27th April 2003 and image on the right dated 7th February 2014, green marker pinpoints the site of Djaboutchia.*

When on the ground, the site of Djaboutchia, is visibly subsiding into the river as it is located right on the banks of the Niger (Figure 5.21). It is important to note that the site was not excavated but two charcoal samples were taken from the exposed section facing the river in association with an apparent burial. They yielded two identical dates of Cal AD 650 to 690 (Cal BP 1300 to 1260) Beta-345493/4.

The placement of Djaboutchia indicates that the river is much wider now than it was in the past, as a site of this size (during the survey it was recorded as 25,000m^2 in size) and with a high density of pottery (one collection unit here had 140 sherds per m^2), would indicate it was inhabited for a substantial amount of time, presumably unaffected by the environmental impacts of the river, if the settlement was long sustaining. However, heavy utilisation of the land, in terms of cultivation and habitation, so close to the river may have led to substantial erosion and later its abandonment. It is well documented archaeologically that soil erosion has been associated with the rise and fall of early societies, for example, in the Maya Lowlands (Beach *et al*., 2006), Rome, Italy (Judson, 1968) and Prehistoric and Historical Greece (van Andel *et al*., 1990). This will be considered further in Chapter Six.

Figure 5.21 *The settlement mound Djaboutchia flanking the banks of the Niger River.*

5.3.9. Medium resolution satellite imagery overview

This section of the chapter shows that use of freely available medium resolution satellite imagery is invaluable in providing insight about the landscape which would otherwise remain undetected. Basic and accurate mapping of a large area was undertaken quickly, areas of erosion were pinpointed, geological differences in the landscape identified and vegetation and water changes over the past 20 years have been mapped.

Once the various base maps and analysis of satellite imagery is established, leading to an understanding of some of the environmental processes that are occurring in the region, the different types of site that were discovered during survey will be discussed in relation to the landscape setting in the next section.

5.4. The archaeological site in the landscape

Placement of archaeological sites in the various survey areas has been briefly discussed in relation to a visual inspection of the satellite imagery. In the course of this research many different aspects of the archaeological sites in this region were classified, creating the basis of a site typology (see Chapter Four). For the purpose of this section, the maps and results will be divided into categories highlighting the distribution in the landscape of certain types of archaeological site. The sites that will be exemplified in this section are settlement mounds, or *tells,* which have been chosen due to their importance in West African archaeology, as they are widespread. Flat sites will also be shown, as they have suffered from either erosive processes or were settled for a limited time period, which meant a lack of accumulation of architectural and surface remains that create mounds. Finally, the distribution of sites that demonstrate potential iron working and furnace remains have also been mapped, to see if there are any patterns which may allude to how these past settlements functioned. All maps produced in this section use a multispectral Landsat 8 image taken in June 2015, and the layers presented are near-infrared (band 5), red (band 4) and green (band 3), which highlights green vegetation. The sites illustrated in this section are all of the sites discovered throughout the duration of the *Crossroads* project, in order to get a complete regional perspective.

5.4.1. Settlement mounds

Mound sites were present in all of the surveys that were undertaken across the four field seasons, and have been discussed in some detail in the previous chapters of this thesis. Settlement mounds are a common feature archaeologically in the West African landscape, particularly close to the Niger River and its tributaries; for example, in the IND (Chapter One). Of the 834 sites recorded in our survey area, 325 sites were recorded as mounds, which equates to a minimum estimate of 39% of all sites. Mound sites recorded by GPS during field survey have been identified as such in the written description given at the time of discovery. However, methodologically it is important to consider that all of the surveys used different procedures when field walking, therefore some of the sites discovered could be mound sites but the surveyor did not mention this in their description. Firstly, the findings of the other surveys and how this affected the discovery of mound sites will be discussed. Figure 5.22 shows the distribution of settlement mounds across the entire study area.

The 2011 survey focused much of the site account on the material culture, particularly ceramic decoration, present on the surface and less on the morphology of the site itself. Of the 174 sites discovered during this season, 38 were described as mounds, but 68 were defined as possible settlements and no other comment made. This is due to objectives of this survey; briefly discussed in Chapter One, where the rapid approach to get as much information as possible in a short amount of time meant that only a sentence was written about each site. As these 38 sites were described as a 'settlement mound' with 'pottery concentration' we can identify them as archaeological features rather than natural mounds. The survey in 2012, which uncovered very few sites, revealed one mound. Moving onto the 2013 survey (Chapter Three), which revealed the location of 156 mounds in total, which were generally all located in the Alibori River region, and the number substantially added to our knowledge of the location of mound sites in the area. Furthermore, this led to the identification of the Alibori River region as an archaeological hotspot. During this survey the descriptions of the mounds varied, some descriptions simply state the word 'mound', whereas other descriptions go into greater detail. This approach encouraged the need for a systematic approach to be put in place.

The somewhat unsystematic nature of the previous surveys led to the more systematic 2014 survey conducted for this research, where a substantial number of settlement mounds were discovered, and their size was measured using GPS. There were 126 mounds identified in total, and they are among those that can be seen in Figure 5.22. Settlement mounds were frequent in all survey areas, as stated in the previous chapter, with the highest concentration visible in the Alibori River area (centre right area of Figure 5.22). Although the Alibori survey area showed substantial evidence of settlement mounds, many flat and eroded sites also existed here; this will be discussed in the next section. The Sota region on the other hand only presented evidence for settlement mound sites (some however are eroded to a partial degree) and no other site types were seen here. This is perhaps due to the lack of erosion in this area, which is a key theme highlighted in this chapter and conceivably explains why there is a high density of sites in the Alibori region, versus the Sota in the east.

Spatial distribution of mound sites varies between east and west regions of the study area. The settlement mounds in the west of the study region appear to be somewhat more dispersed than the mound sites in the east, which are seemingly on top of each other with close neighbours. Spatial analysis will be used in a later section of this chapter to test the degree in which mound sites cluster overall, and in the different survey zones.

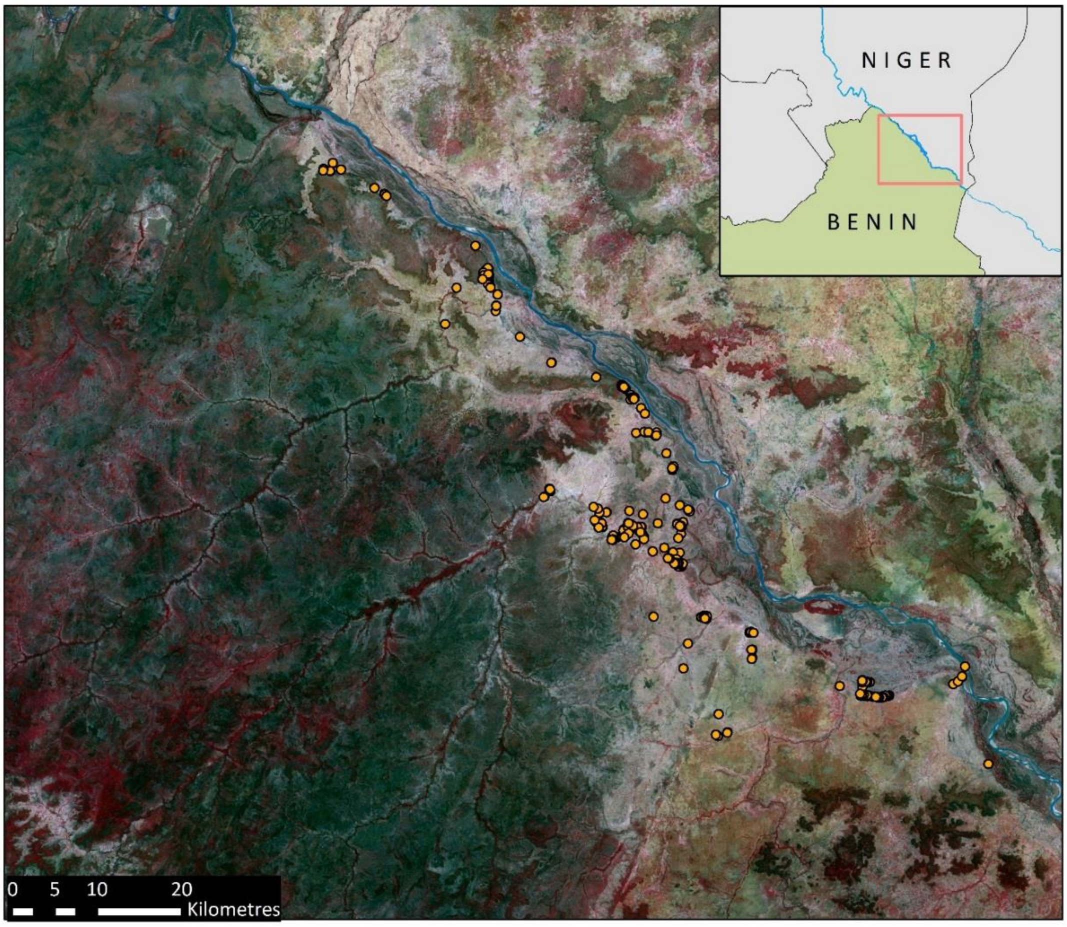

Figure 5.22 *Distribution of sites regarded as 'mounds' during field walking survey over four seasons between 2011 and 2014.*

5.4.2. Flat and eroded sites

The notion of flat and eroded sites is discussed in Chapter Four, and they are frequent within this landscape. Combining the results of all of the surveys a total of 158 flat sites were discovered and their distribution can be seen in Figure 5.23. What is starkly obvious from this distribution map, compared to one of settlement mounds, is that flat and eroded sites are more frequent in the Alibori zone, with 130 (83%) of all the eroded and flat sites occurring within this area of the survey.

There were no flat or eroded sites recorded in the 2011 surveys; however, there is a mention of eroded pottery scatters, but these have not been included within the distribution map as it is unclear as to whether the whole site was eroded or just the surface assemblage. The 2012 survey presented no evidence for eroded or flat sites but again, the survey objectives were such that the type of site was not mentioned in the description.

The Alibori flat/deflated sites exhibit a high density of pottery sherds; this is because these sites have been eroded down and only the pottery sherds from various occupation phases of the site remain, because they can withstand the erosion. Already discussed is the different geology found in the east and west, and the light coloured, eroded alluvial terrain that can be seen in the satellite image where the sites lie. All of these factors contribute to the fact that more sites and pottery sherds are witnessed in the west of the study area, centred on the Alibori River.

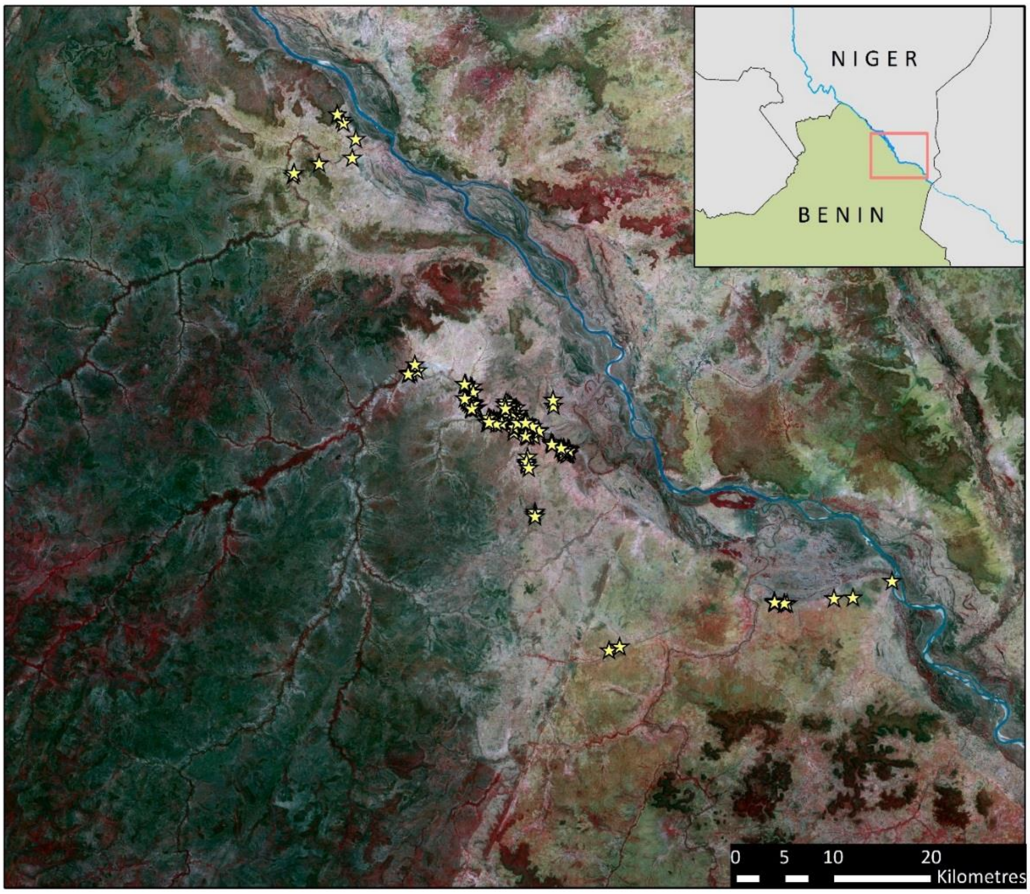

Figure 5.23 *Yellow stars represent 158 flat and eroded sites that were documented in the field surveys between 2011 and 2014.*

5.4.3. Iron working sites

During all of the surveys, sites showing evidence of iron working, such as the presence of furnaces, tuyère or fragments of slag were recorded as these displayed signs of craft specialists, which was an objective for identification in the *Crossroads* project. In the case of the systematic survey undertaken within this research, the slag fragments were collected and counted. This was not the case with the other surveys, so the density of finds is unknown and data from these must be considered with caution. Nonetheless, a distribution map of iron working happenings that were discovered can be found in Figure 5.24. The first season in 2011 revealed 45 of the 174 sites had some form of iron working evidence on the surface, and the very small 2012 survey, exposed a further two more sites. A great number of iron working remains were recovered in the 2013 survey when the archaeometallurgy specialist, Caroline Robion-Brunner, joined the *Crossroads* project and conducted targeted surveys to establish the location of furnace remains. The majority of these remains were found in the northwest of the study region close to the modern settlements of Pekinga and Kompa.

During the 2014 survey which was undertaken within this research, 31 sites were found with slag or tuyère present and 10 possible furnaces were noted. The details of these sites can be found in the appendix of this thesis. Figure 5.25 shows the distribution of iron working remains in relation to the size of sites recorded for this research. Interestingly, around the Alibori survey area, it seems that iron and slag remains cluster together around areas with large and smaller sites, which would suggest there is not a hierarchy in iron production and/or usage that correlates with site size.

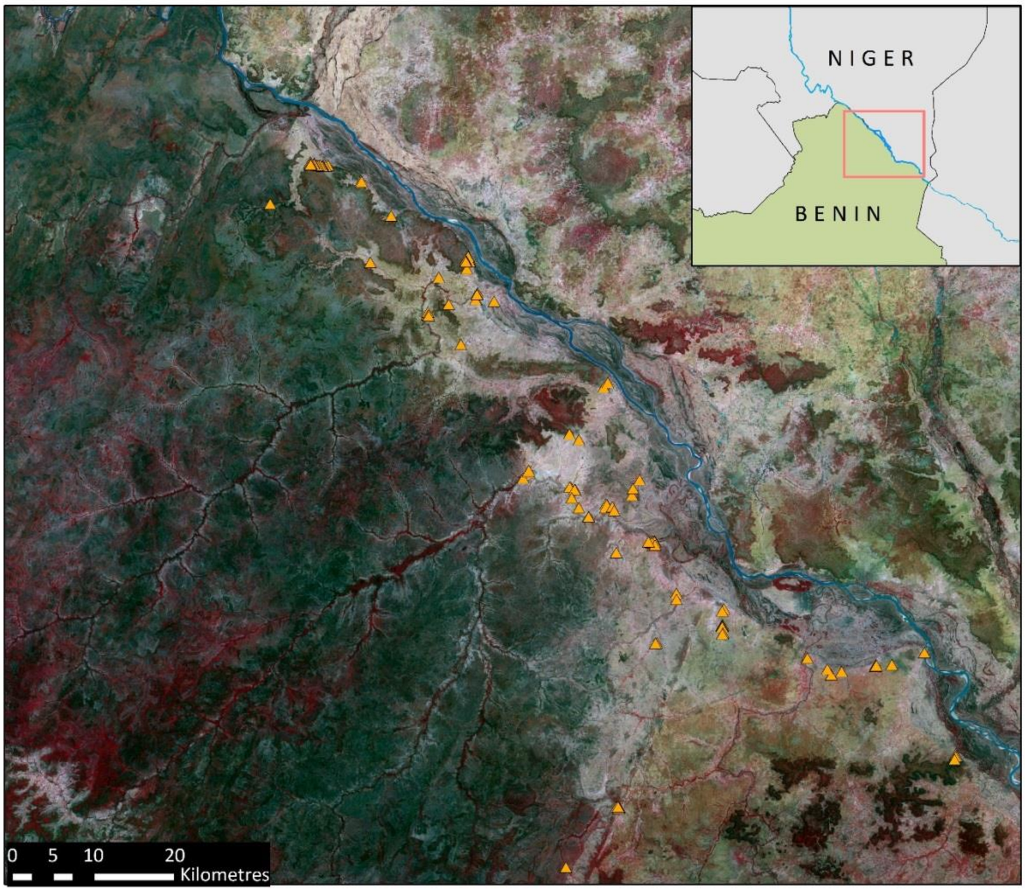

Figure 5.24 *Distribution of sites where slag, iron working or furnace remains were reported during survey over four seasons between 2011 and 2014.*

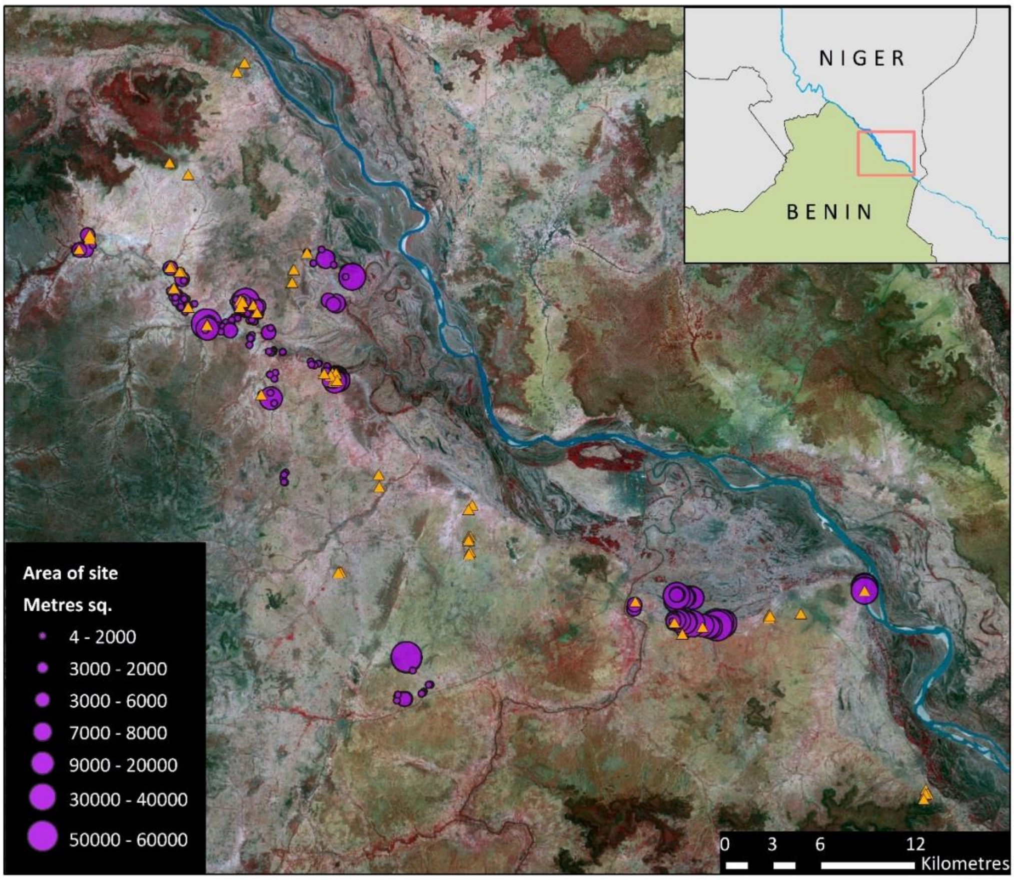

Figure 5.25 *Size of site recorded during systematic survey undertaken for this research project in 2014, in relation to iron working events discovered over the course of the Crossroads project.*

5.5. Material culture in the landscape

This section will briefly consider the material culture types and densities found within the landscape and map them spatially. Firstly, it will consider the distribution of undecorated sherds and FSR sherds, then the density of sherds that were desampled and finally, the distribution of potsherd pavements, which is one of the only examples of architectural evidence found on the surface.

5.5.1. Decoration type

The ceramic assemblage collected during survey that consisted of over 49,000 sherds consisted of several decoration types. In the previous chapter the prevalence of decoration type in the survey areas respectively was discussed; however this section will spatially illustrate the distribution of different decoration types, to see if there are any dominant spatial patterns. For the purpose of this section body sherds and rim sherds have been grouped together to represent decoration trends throughout the survey areas. Here, undecorated and FSR decorated sherds are considered as FSR occurred in the highest density as a type of decoration. Figure 5.26 shows the density of undecorated sherds across the region. The distribution of undecorated sherds looks relatively homogenous throughout the entire region, with no striking patterns evident. Table 5.3 illustrates the percentages of undecorated and decorated sherds below, and further reinforces what is shown spatially on the map. Decorated sherds are defined in the previous chapter, but refer to any sherd that has had its surface modified; this also includes eroded decorated sherds. The next chapter will discuss the relevance of pottery decoration.

Survey Area	Undecorated %	Decorated %
Birni Lafia	44	56
The Alibori	37	63
Kouara Tegui	63	37
The Sota	39	61

Table 5.3 *Percentage of decorated and undecorated sherds per survey zone uncovered during the 2014 survey.*

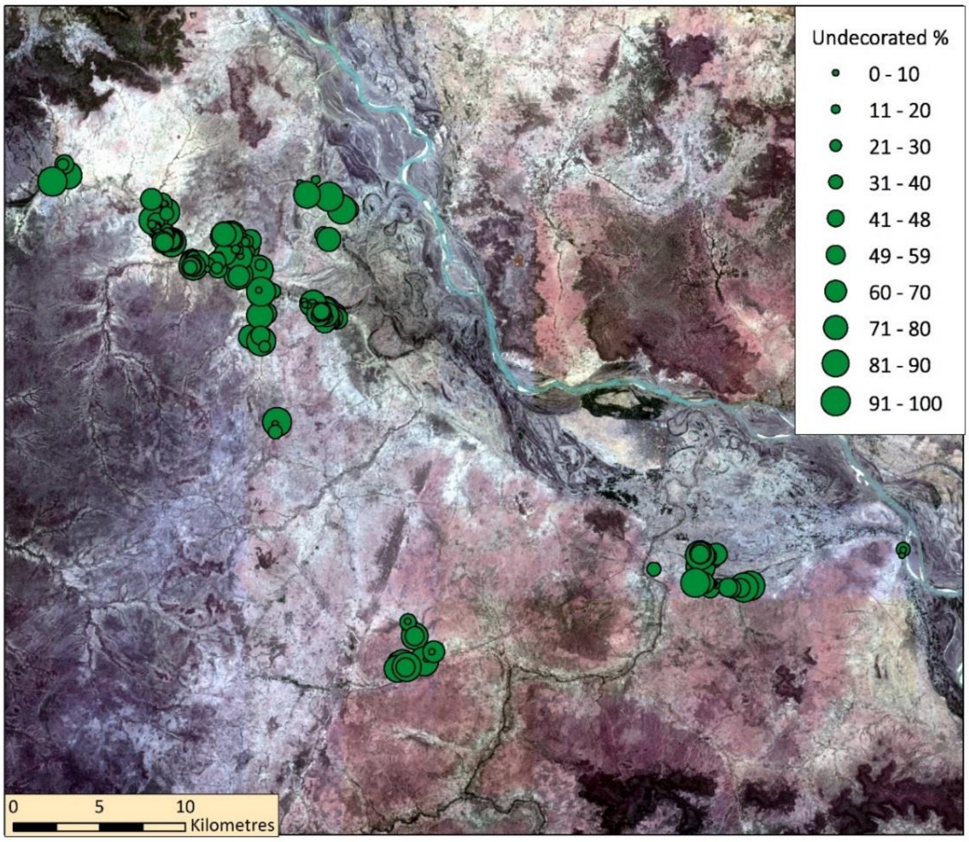

Figure 5.26 *Landsat 8 image of the study region showing proportional symbols to illustrate percentage of undecorated sherds per collection unit.*

Folded Strip Roulette (FSR) was the most common decoration found on ceramic sherds collected within the collection unit on the field survey. Figure 5.27 shows the spatial distribution of FSR throughout the landscape. Unlike the spatial distribution of undecorated ceramic sherds, there are clear differences in the distribution between east and west of the study area. The west, which encompasses the Alibori and the Birni Lafia survey zones, appears to have a high concentration of FSR sherds in comparison to the east, which incorporates the Sota survey area. However, the Sota has a high percentage of decorated sherds, similar quantities to that found in the Alibori (61% Sota, 63% Alibori) but, as illustrated, these decorated sherds do not consist only of FSR decorated pieces. As outlined briefly in the previous chapter, eroded sherds make up a large quantity (38%) and the other category has 7%, equating to 45% of the assemblage found here. Of the 7% that were identifiable and recorded in the 'other' category, many were burnished (15 out of 25 sherds, thus

60% of this category. This density of burnished ceramics is absent from the Alibori assemblage.

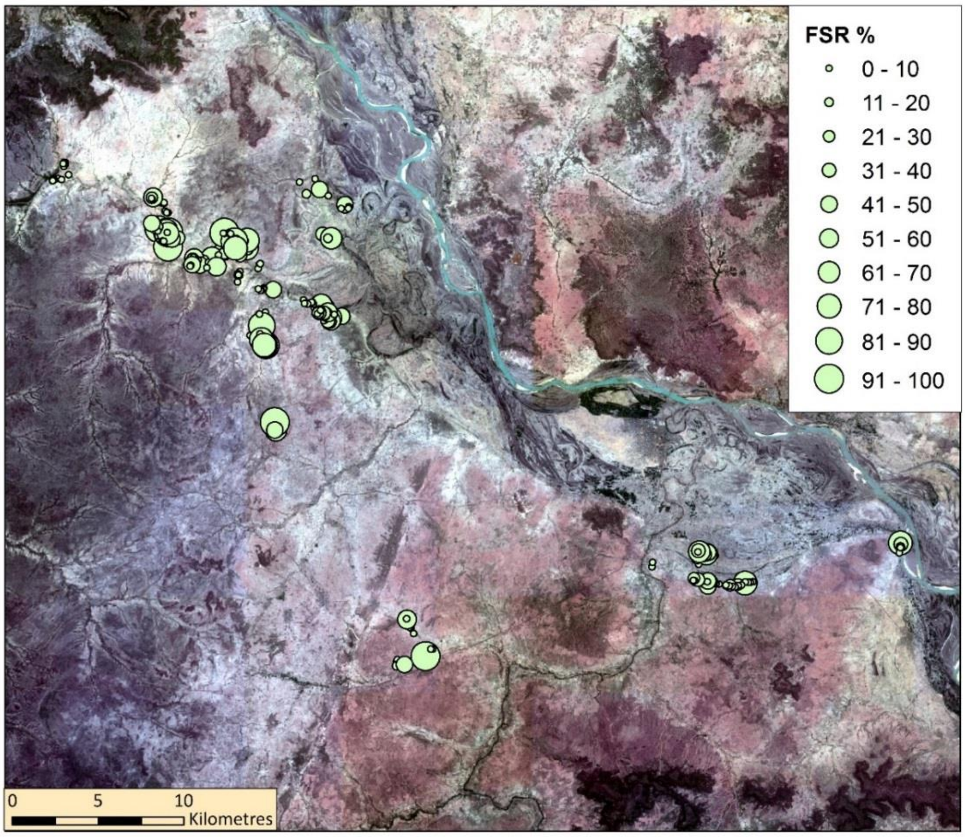

Figure 5.27 *Folded Strip Roulette distribution and quantities illustrated with proportional symbols across the landscape.*

5.5.2. Desampling

This section discusses the density of small fragments (smaller than a 25 CFA coin) and shows their spatial distribution. Of all the sherds collected, 86% were desampled. Degree of fragmentation can be an indicator of erosion in the region. This was briefly discussed in the previous chapter, but will be outlined in further detail in regard to different survey areas. Firstly, in the west of the study area, Birni Lafia has on average 82 sherds per site and, of these on average 47 were desampled and discarded (58%); the Alibori has 179 sherds per site on average with 154 sherds on average per collection unit discarded (86%). This can be seen spatially in Figure

5.28, where the Birni Lafia region slightly to the north of the Alibori has relatively low levels of desampled density. The other two survey areas in the east appeared quite similar on the map to those just discussed in the west. The Kouara Tegui area shown as the most southerly cluster of points has on average 39 sherds per site, and of these, 30 sherds were discarded (77%). The Sota area has 113 sherds per collection unit on average, with 107 sherds desampled (95%). The high levels of fragmentation can be seen on the map with the red circles where these collections had 90-100% of its sherds desampled. This will be considered further in the discussion chapter (Chapter Six), but a future consideration may be that the desampling method needs to be adjusted to allow more pottery sherds from sites to be considered. But as pointed out in the methodology section (Chapter Three) all of the sherds, even desampled, were photographed, so there is the opportunity to further analyse these in the future. Nevertheless, over 7,000 pottery sherds were not desampled and analysed in detail.

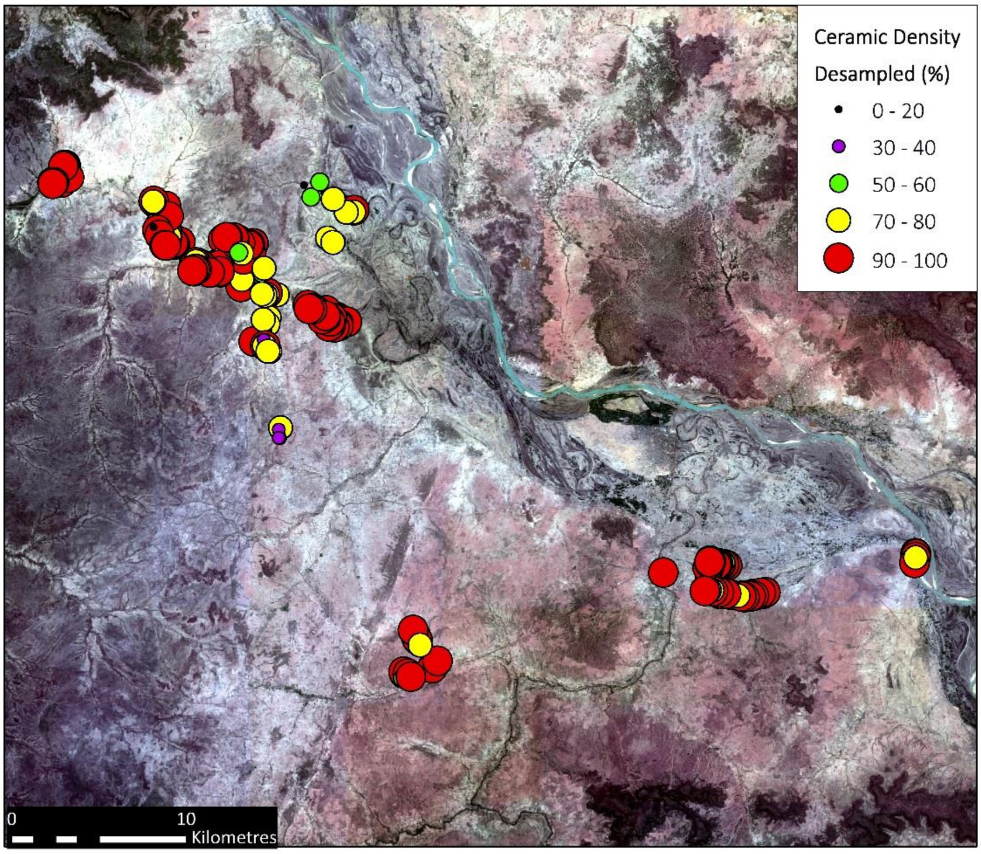

Figure 5.28 *Landsat 8 image with proportional symbols indicating the density in percentage of desampled sherds from every collection unit.*

5.5.3. Pottery pavements

Although no substantial evidence for architectural remains in terms of standing structures was discovered during the survey, there are ample examples of pottery pavements seen in the landscape. Pottery pavements are defined as floors of potsherds, stone, pebbles, cobbles or other material purposely laid over mud (Nzewunwa, 1989), they are widespread in West Africa and an example of one found during survey in the Dendi region can be seen in Figure 5.29. In total, 21 pavements were discovered during field walking across the region, this includes all surveys over the four years of work in the area. As discussed in Chapter One in relation to research in West Africa, the presence of pottery pavements has been shown in other research areas as an indicator of complex urban societies. Figure 5.30 shows the distribution of pottery pavements throughout. Expectedly the Alibori displays most evidence for the occurrence of pottery pavements, mainly due to the erosion close to the river in this area.

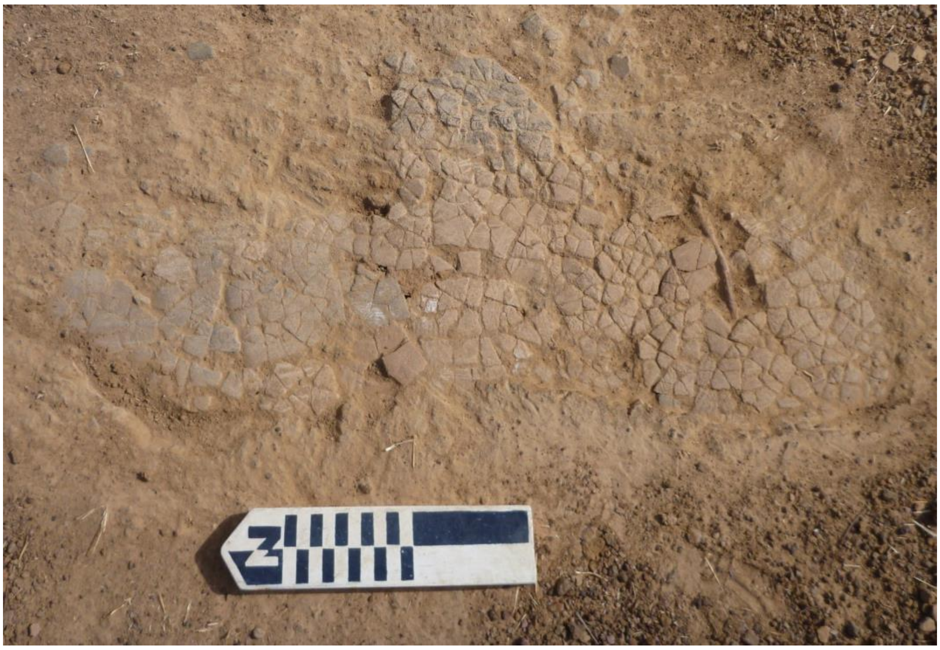

Figure 5.29 *Pottery pavement discovered in the Alibori survey area during field walking.*

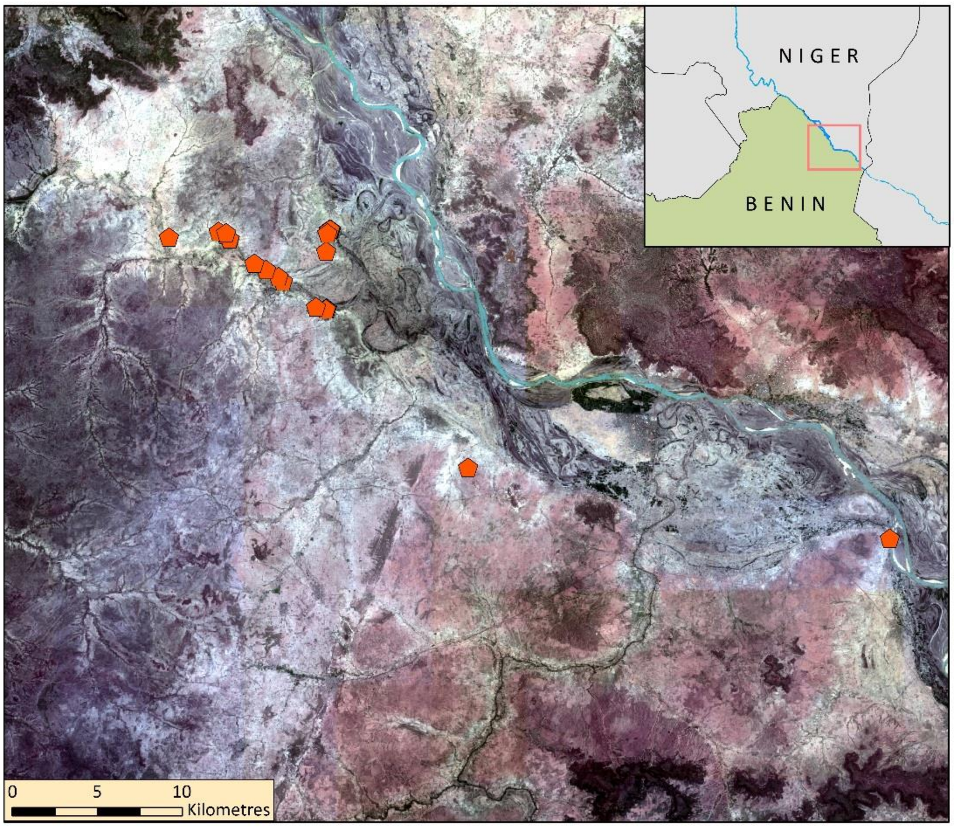

Figure 5.30 *All pottery sherd pavement locations in the region.*

5.5.4. Stone tool distribution

During surveys across all field seasons between 2011 and 2014, there has been frequent mention of the presence of stone tool lithics discovered on the surface. As this thesis is concerned with the late Iron Age archaeology associated with the settlement mounds (as discussed in Chapter One), there has been little consideration of the stone tool evidence. Nevertheless, the lithic data were collected and the artefacts counted, therefore worth a mention for their distribution. Figure 5.31 shows the locations and density of stone tools found within a collection unit. The clear pattern in this distribution shows most lithic sites occur around the Alibori River. This also coincides with the test pit excavation carried out by the *Crossroads* project on a site close to the Alibori which yielded a C14 date of Cal BC 755 to 680 (Beta-378258: Cal BP 2705 to 2630, error BP 2440 +/- 30).

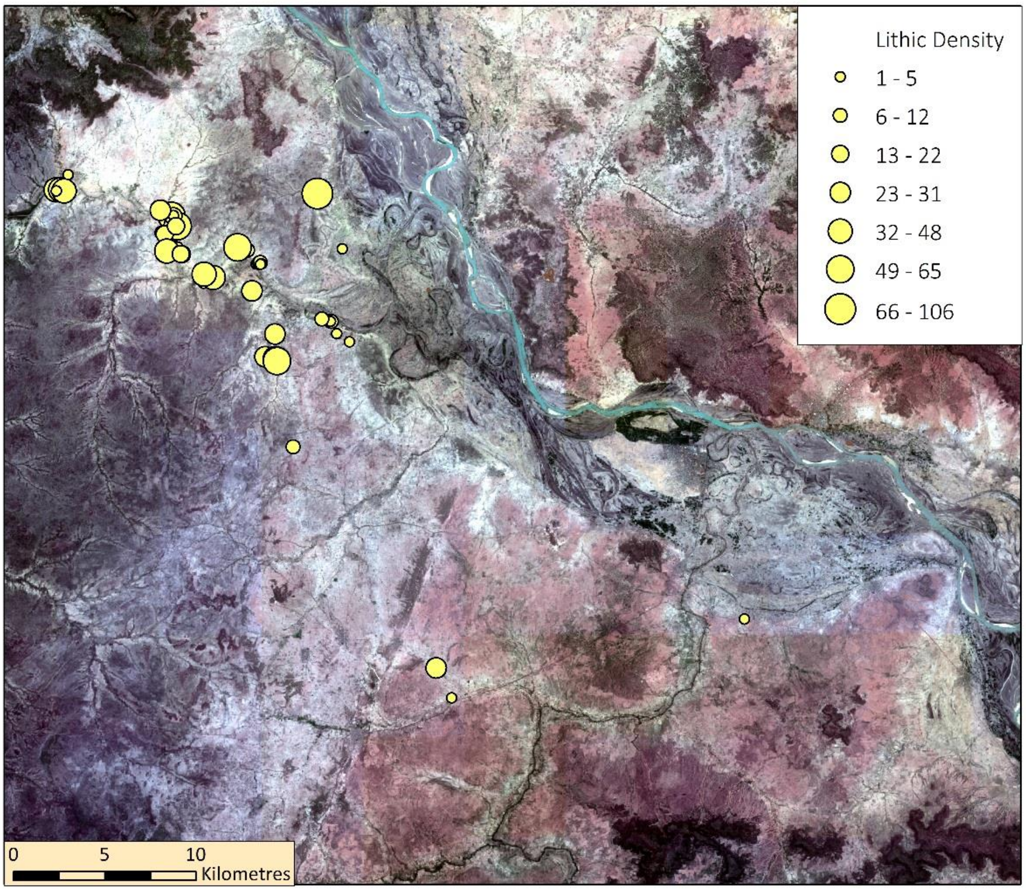

Figure 5.31 *Landsat 8 image showing the study area in relation to density of lithic remains discovered within collection units during survey for this research.*

5.6. GIS and Spatial Analysis

The final part of this chapter will consider the use of GIS in detecting patterns and trends in the landscape. Studies that use GIS were discussed in Chapter Two, and are mainly used to expand and substantiate theories and information distribution beyond the static map. There is a clear case for the inclusion of spatial analysis procedures when considering settlement distribution in the landscape and how it was undertaken within the Dendi study region is considered in the following sections. The key processes that will be undertaken in this section will be: proximity and buffer analysis, point pattern analysis, linear regression and spatial autocorrelation.

5.6.1. Point Pattern/ Cluster Analysis

Discussed in the second chapter of this thesis is the concept and method of analysing patterns geographically by using spatial analysis functions such as cluster analysis. Cluster analysis measures what degree events, in this case archaeological sites, are spatially clustered or dispersed. This can substantiate patterns that can be seen visually in the landscape, giving us insight into settlement organisation. Cluster detection is a type of point pattern analysis, where statistics are used to ascertain the degree to which points on a map demonstrate a pattern. The *K* Function (also known as *Ripley's K* after Ripley (1976)) will be used to assess the degree in which sites cluster in the landscape. It is determined by calculating the average number of events inside a polygon, then by dividing the points by the area of the polygon to obtain the average density.

Site clustering features heavily in the work of McIntosh and Keech-McIntosh at Jenné-Jeno (McIntosh, 1995; 1999) and features in other areas of the IND (e.g. Iron Age sites at Méma (Togola, 2008)), which was discussed in the introduction of this thesis (Chapter One). Because of the similarities between the sites in the IND and the Niger River, clustering is an important concept to consider in this investigation. During work at Jenné-Jeno in 1977, 404 sites were discovered over a 110 km^2 area, using aerial photography and field survey, and of these 65 (16%) were clustered within 4km of Djenné (McIntosh, 1999). This work was undertaken almost 40 years ago and worked well at the time to establish spatial patterns and became an influential piece of research for the region. There is clear evidence for site clustering in the Niger River Valley demonstrated in this chapter and Chapter Four. However, this research introduces a statistical element to further confirm and validate the findings of site clustering.

To test the degree to which sites cluster, Ripley's K function is applied to the data within the northern Benin study area. As discussed in Chapter Two, this analysis places a polygon over a defined area (in this case this will be our study area) and then calculates the distances between each point, or in this case archaeological site, then determines whether the points are spatially random/dispersed or clusters. The first analysis of clustering using this algorithm considers all of the sites described as mounds (Figure 5.32) that were discovered during all of the field seasons by the *Crossroads* project, and the sites discovered in this research. This includes the Birni Lafia, Alibori, Kouara Tegui and the Sota survey zones, but also sites found in the northwest of the river valley at Pekinga, right through to the southeast of the river valley at Djaboutchia. The degree of clustering was calculated within the smallest polygon that encompasses all of the mounds points and survey areas investigated. Figure 5.32 shows the results of this analysis.

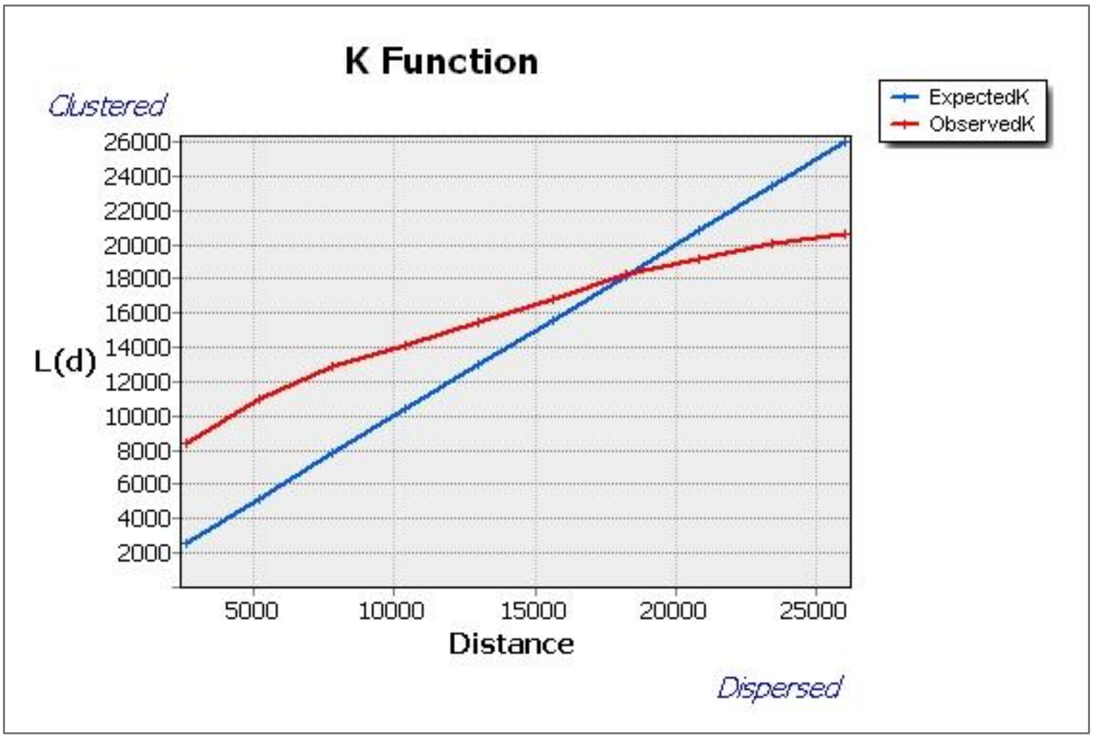

Figure 5.32 Graph to show the degree to which clustering of mound sites occurs across the study region using Ripley's K-function, multi distance spatial cluster analysis.

The graph demonstrates a higher than expected degree of clustering of the mound sites within around 18,000m (18km) and after that distance, the pattern is more dispersed. The stretch of the river analysed spans around 95km, therefore witnessing clustering up to 18km is perhaps expected, as this is quite a vast distance. The graph does show however, that within an 18km space there is a higher than expected degree of clustering in the landscape. To understand clustering on a smaller scale, within the different regions identified during survey the next analysis will consider these.

Ripley's K cluster analysis was conducted over the Alibori study area, but also encompassing the sites around the Birni Lafia region as they are in close vicinity (around 5km). The results of this can be found in Figure 5.33. Evidence for local-level clustering of sites within this area is extremely apparent, more so than in the region as whole (Figure 5.32). Although this is to be expected when analysing the distribution maps for clustering in this area, the graph indicates that after 2,700 (2.7km) sites become dispersed. This additional information gained from the analysis demonstrates how closely the sites cluster together. Sites that are more than 2.7km away are isolated, which explains the secluded sites encountered when walking transects away from the river. The arrangement of the clusters of sites in the landscape around the Alibori River will be discussed in further detail in Chapter Six.

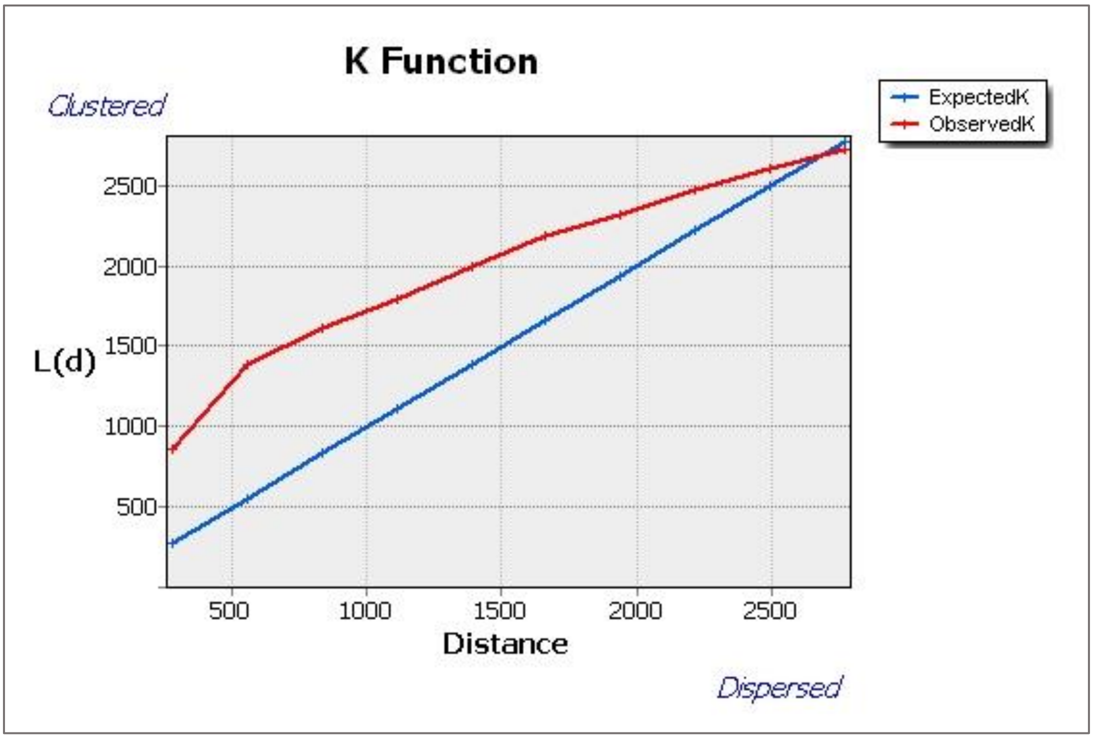

Figure 5.33. *Graph to show the degree to which mounds cluster in the Alibori/Birni Lafia study region. Graph shows sites are heavily clustered up to 2,500m (2.5km).*

Similarly, pattern analysis was also undertaken in the east of the study region, at the sites found close to the Sota River. The results of this can be seen in Figure 5.34. The graph shows that there is a clear clustered pattern of archaeological sites in this area, up to around 2.5km, after that the sites become dispersed. We are seeing this pattern because the twin mounded sites referred to in section 5.3.4 of this chapter are clustered together, then the site of Djaboutchia is more isolated, on the banks of the Niger River, which is why we see dispersion on the graph.

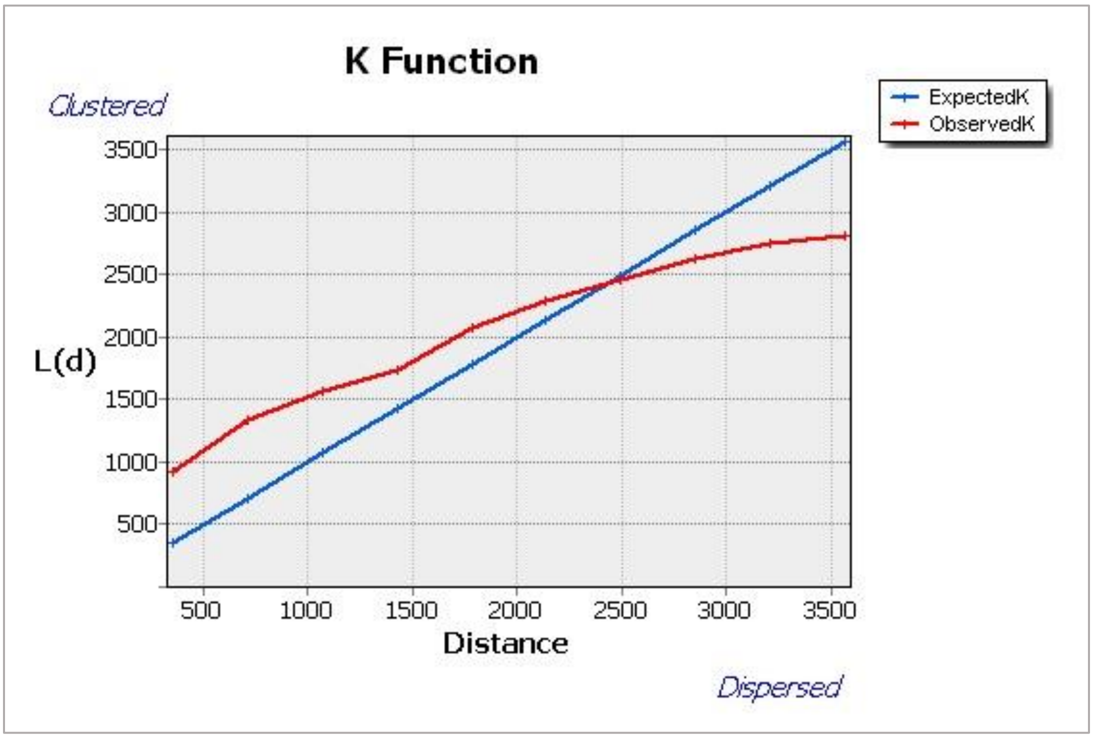

Figure 5.34 *Graph to show the degree to which mounds cluster in the Sota study region. Graph shows sites are heavily clustered up to 2,400m (2.4km).*

Overall, applying *Ripley's K-function* statistical analysis to the locations of the archaeological sites in the northern Benin study area has proved that there is a high degree of spatial clustering. Clusters occur up to 2.5km from most of the sites in the study area, apart from the few outliers that were recorded. Now that clustering has been demonstrated, the next section will consider the vicinity in which the archaeological sites occur in the landscape.

5.6.2. Proximity and buffer analysis

In Chapter Two, the concepts of proximity and buffer analysis were discussed, to consider the relationship a point has within its catchment or vicinity. This process measures a buffer (usually a circle) around all chosen points (in this case it will be the archaeological sites) and visually illustrates the features that are within the measured buffer zone.

A 500m buffer/catchment was chosen as this is a reasonable walking distance that takes around five to seven minutes. Walking and the terrain was not considered in this scenario as we know that the area is relatively flat, so there would have been no obstacles. The buffer was placed over the site points, this can be seen for the Alibori and Birni Lafia region in Figure 5.35 and for the Sota and Kouara Tegui region in Figure 5.36. Both of these outputs from the analysis further support the presence of the interconnectivity of the sites, but also shows that they are close to open water areas, all within 500m and close to healthy vegetation, because of the access to water.

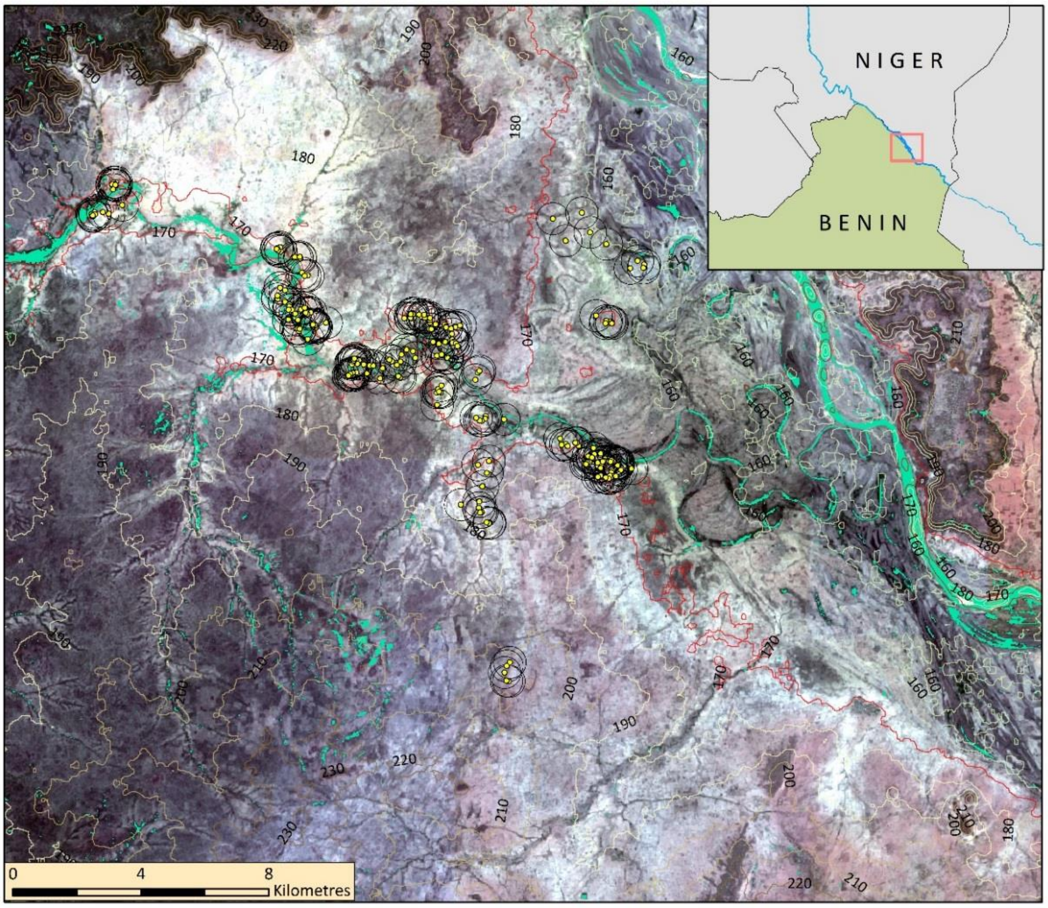

Figure 5.35 *The Alibori and Birni Lafia survey regions, turquoise illustrates surface water, contours show elevation. The sites surveyed are shown in yellow with a 500m circular buffer zone to demonstrate the close proximity to water. Landsat 8 image.*

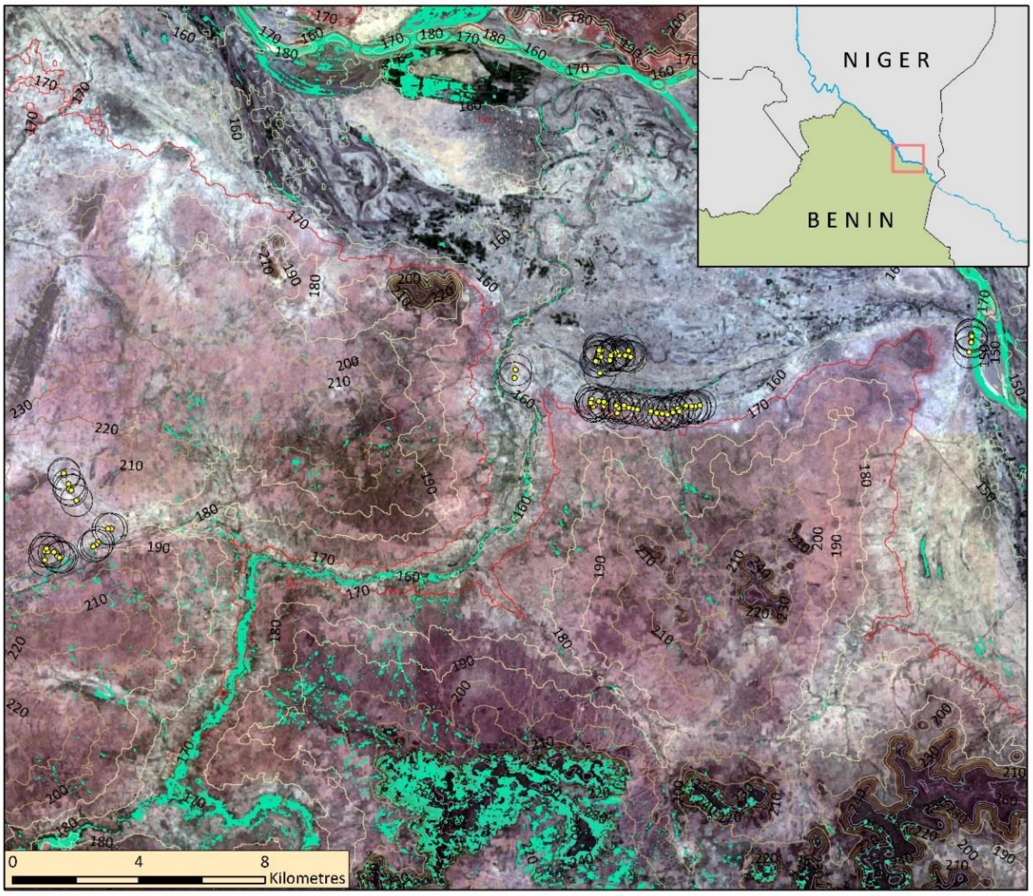

Figure 5.36 *The Kouara Tegui and Sota survey regions, turquoise illustrates surface water, contours show elevation. The sites surveyed are shown in yellow with a 500m circular buffer zone to demonstrate the close proximity to water. Landsat 8 image.*

5.6.3. Linear regression and spatial autocorrelation

It has been demonstrated through the various spatial analyses that there is a strong case of spatial autocorrelation between the location of sites and their association in hinterland, particularly with elevation and vicinity to water. As the vicinity to open surface water was considered in the previous section, spatial autocorrelation using linear regression will be considered for the elevation of sites. All of the sites in the survey region were tested to see if they were clustered around a particular elevation. The results can be seen in Figures 5.37 and 5.38.

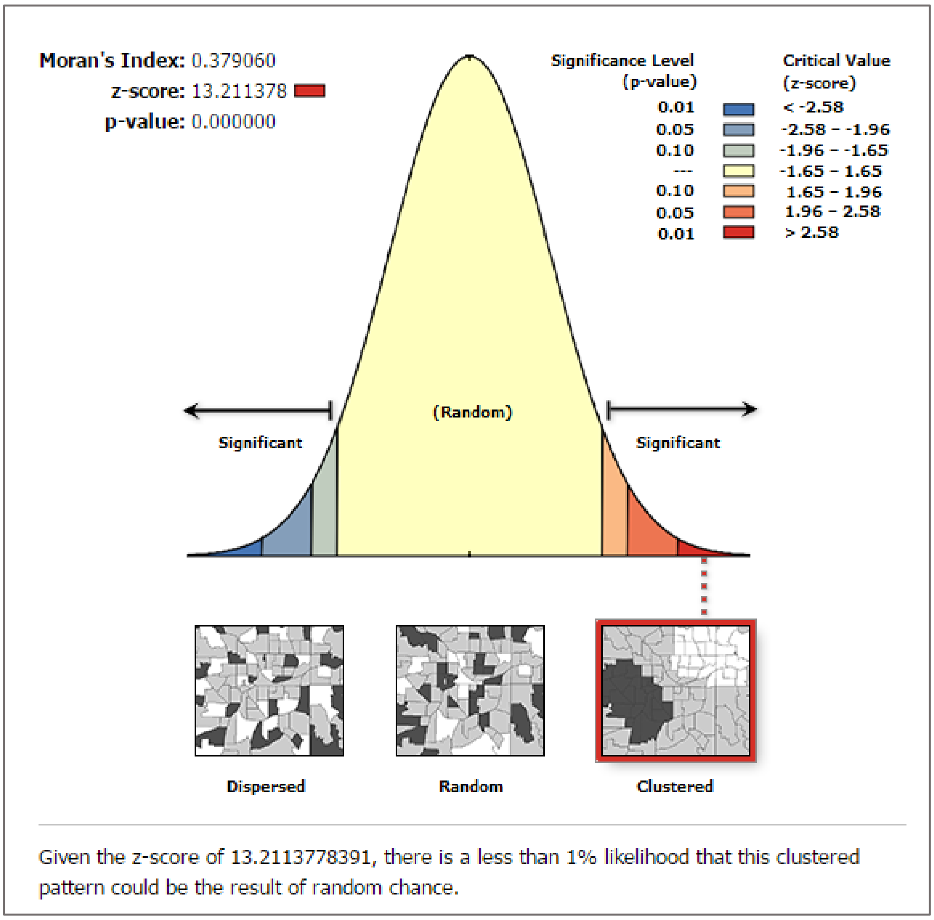

Figure 5.37 *Graph to show the degree in which sites are correlated with elevation. The graph suggests a high degree of clustering. Graph generated in ArcMap 10.2.2.*

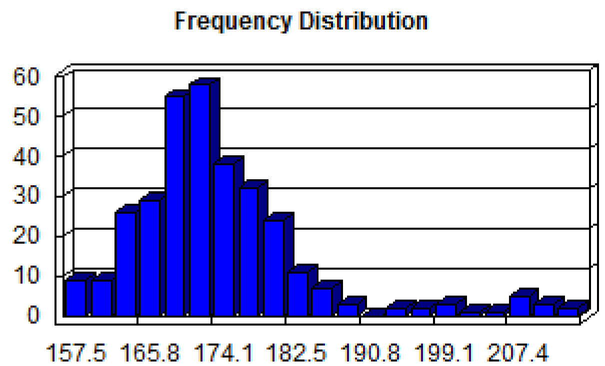

Figure 5.38 *Histogram to show elevation*

It is clear from both Figures (5.37 and 5.38) that sites do cluster at a certain elevation and the peak of this is around 170m. This demonstrates a high degree of spatial homogeneity between the sites, showing again their interconnectivity.

5.7. Site size histogram

Finally, the size of site in the region will be considered. In Chapter One, size of site was measured at all of the IND examples. At Jénne-Jeno, this site size analysis considered whether there was an urban centre that was surrounded by smaller, satellite sites (McIntosh, 1995). In order to consider site size across the study region, a site size histogram was generated after the work of Harrower and D'Andrea (2014), which used geospatial analysis to consider Aksumite settlement patterns in Ethiopia. The results can be seen in Figure 5.39.

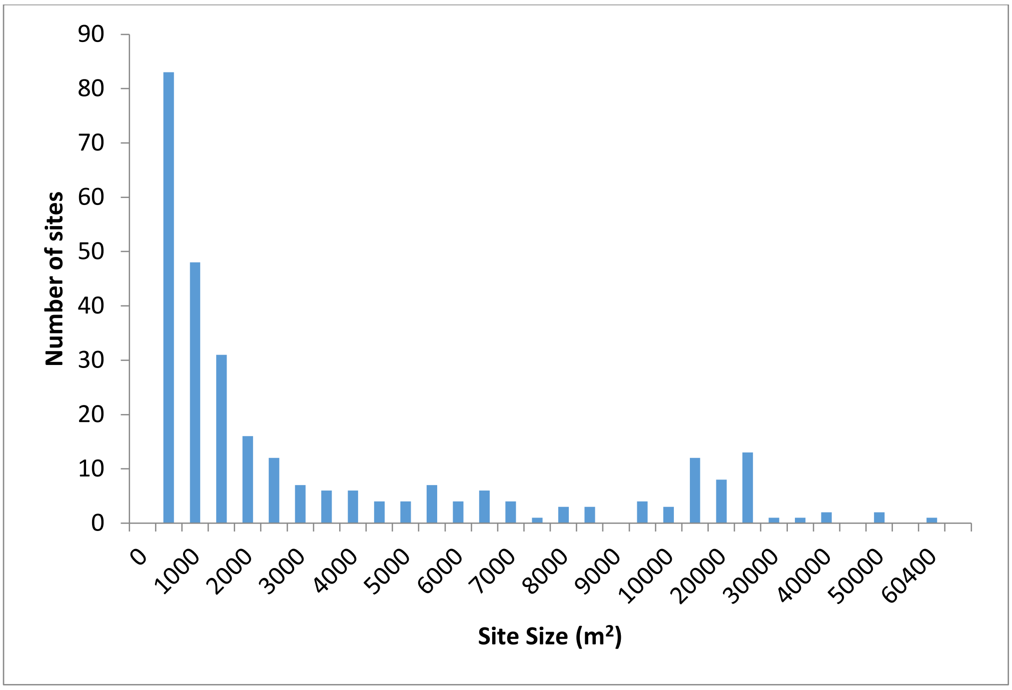

Figure 5.39 *A histogram to show site size of the 320 sites surveyed in 2014.*

Analysing the histogram of site size, it is clear there is no distinct category of the size of sites. The distribution is relatively homogenous after the small sites (less than 2,000m^2), apart from a small increase around 15,000 to 25,000m^2, and this suggests there is no site size hierarchy across the region. This shows similarities with the findings of geospatial analysis of Aksumite settlement patterns in Ethiopia (Harrower and D'Andrea, 2014). The patterns in Ethiopia showed that there was no single exceptionally large settlement dominating others, and no evidence of site size hierarchy. This situation appears similar within the sites of the Niger River Valley.

Site Size (m^2)	Frequency	Percentage
500	83	28
1000	48	16
1500	31	11
2000	16	5
2500	12	4
3000	7	2
3500	6	2
4000	6	2
4500	4	1
5000	4	1
5500	7	2
6000	4	1
6500	6	2
7000	4	1
7500	1	0.3
8000	3	1
8500	3	1
9000	0	0
9500	4	1
10000	3	1
15000	12	4
20000	8	3
25000	13	4
30000	1	0.3
35000	1	0.3
40000	2	1
45000	0	0
50000	2	1
55000	0	0
60400	1	0.3
260000	1	0.3

Table 5.4 *Number and percentage of sites by size measured in metres squared. The grey row at the bottom of the table shows the site of Birnin Lafiya for comparison.*

The table shows the number and percentage of sites by size that was recorded in the landscape. As can be seen, the majority of the sites (over half) are less than 2,000m^2 in size. These sites are considerably small and consist mainly of the eroded sites that were discovered in the Alibori region. It is more than likely that these smaller areas with archaeological activity formed much larger sites in the past, and the clusters of small sites that can be seen in the Alibori region (Chapter 4) once formed much larger settlement compounds. Because evaluation of site size was made relatively quickly on the field, further analysis of site size is needed focusing on test pits focusing on the periphery of sites. The site of Birnin Lafiya, which has been extensively surveyed, is over four times the size of the largest site discovered during the survey, making it extremely prominent. It is unusual then that it is found 5km away from the clusters of sites around the Alibori.

5.8. Conclusions

Remote sensing using satellite imagery reveals the heavy influence of fluvial systems in the landscape, which we can perhaps infer a wetter landscape of the past. This is perhaps why settlements occur on mounds and elevations in the landscape above the water areas; however, further geomorphological work on the field is needed. It is very evident that there is an increased density of sites around the Alibori River area in comparison to any other area due to the post-depositional processes occurring in the area. The sedimentary bedrock in this area is more susceptible to erosion and climatic fluctuations, which has meant that archaeological sites have been revealed.

Chapter Six: Discussion

6.1. Overview

The research outlined in this thesis aims to advance our understanding of ancient landscape and settlement in the Niger River Valley in the Republic of Benin, focusing on the Dendi region, which before this research was undertaken, was an unknown. Presented in this thesis are a range of methodologies that were used to identify sites and analyse them with their landscape to shoe the archaeologically rich Niger River Valley. Not only have hundreds of sites on the ground been documented through field survey, but this research has also shown the potential of desk-based methods in analysing the archaeological surroundings. This doctoral research has sought to use an interdisciplinary approach to the landscape, by integrating archaeological survey, remote sensing science and GIS, which makes this investigation one of the first of its kind in West African archaeological research.

This chapter will consider the research questions that were set in Chapter One, and examine how they have been tackled through the methodology, data collection and resulting evidence presented in this thesis. The questions were:

- How can we systematically and accurately record the distribution of archaeological sites and surface artefacts in the landscape and how will this benefit cultural heritage management of the area?
- To what degree does the environment influence settlement and material culture patterns?
- To what extent is this an urban landscape, such as those noted in other areas of West Africa, including the Inland Niger Delta (IND)?
- How useful are desk-based methods, specifically GIS and satellite remote sensing, in investigating the archaeology of the region?

The first question considered the best way to accurately record overall distribution of sites and material culture within the landscape, which could be adopted by others easily in the region. This objective was embarked upon by generating a comprehensive field survey methodology to identify sites by field walking in transects and filling out survey sheets, whilst systematically recording material culture locations, type and densities. The outcome of this work was the production of accurate 2-dimensional and 3-dimensional maps showing the locations of sites, size of the site and the type of site distributed in the landscape. The maps were created with an accompanying gazetteer, which details exact geographic details and associated information collected, and is important for cultural heritage management in the area. Furthermore, material culture types and densities were also charted and with the information collected, distribution maps were produced which led to patterns being visually identified. These procedures lead to some initial insights into the people of this landscape.

The second question examines the role of the environment for settlement preference in the landscape, particularly considering human-environment interactions. This followed on from the first question, where distributions of sites were accurately mapped, which highlighted some initial patterns in distribution. The natural environment of the region has been considered through the use of satellite remote sensing images (Chapter Five). These images, which have a full coverage of the landscape, helped us to understand the topographic and geomorphic features of the area in relation to mapped sites. In particular fluvial systems, including perennial and ephemeral river channels, were a focus for analysis. Vicinity to surface water and vegetation are also considered within this question, arguing the case for preference to these features in the landscape. Furthermore, elevation was mapped, and it was evident from the distribution of archaeological sites that they were located around the same elevation. GIS methods such as the use of buffer spatial analysis was integrated to corroborate our findings.

The third question relies on current research and theory of the wider West African archaeological landscape, by considering the early rise of urbanism. Although there is no agreed definition of urban, as discussed in Chapter One, work in the IND revealed some pre-requisites for a potentially urban culture and society. Evidence for this has been considered in this thesis by investigating settlement patterns, particularly site clustering and size of site. Furthermore, distribution of artefacts in the landscape has offered insights into how people were interacting with each other, particularly the distribution of iron-working remains in relation to settlement and decoration of ceramic vessels found throughout the region. All of which will be discussed in this chapter. This section will so discuss the chronology of sites in the Niger River Valley, which are broadly contemporaneous with the sites found in the IND.

Finally, this research sought to examine the use of non-intrusive, desk-based methods in exploring the archaeological landscape. Outlined within this thesis were approaches that used high and medium resolution satellite imagery. Like other studies that use remote sensing methods, high resolution imagery was tested for its site identification capabilities. Medium resolution imagery was applied to investigate the landscape and environment, particularly elevation and change in water and vegetation over the past 20 years. Furthermore, use of GIS spatial analysis tools was considered for their abilities to expand on knowledge of site distribution in the wider landscape and substantiate patterns found in the region.

Overall, this chapter will draw upon the information collated throughout this thesis to construct hypotheses and theories in order to give a complete overview of the Iron Age historic landscape of this area. The following sections will reflect on the research questions outlined and go into further detail as to how this research sought to address the aims and objectives of this doctoral work. The chapter will discuss the advantages and disadvantages of using the methodology outlined within this thesis. The results of the research that stemmed from these methods will also be discussed.

6.2. Recording settlement and material culture distribution

How can we systematically and accurately record the distribution of archaeological sites and surface artefacts in the landscape and how will this benefit cultural heritage management of the area?' was the first research question asked in Chapter One. A systematic field survey was devised to endeavour to answer this question, its goal was to build an overview of the nature and distribution of sites and material culture in the study region, which prior to this survey, had never received a systematic archaeological investigation. The general survey methodology will be discussed in this section and how it was successful in delivering the aims of the thesis. A major outcome of this survey was the compilation of a site and material culture gazetteer, and this will be discussed in relation to the importance of protection of sites and cultural heritage management. Production of two and three dimensional maps to illustrate the distribution of sites and material densities will be discussed. How these maps facilitated in identifying initial spatial patterns that were discovered will be examined, which in turn helps us to understand the dynamics of the people in this landscape.

6.2.1. Field walking survey

The field walking survey devised and undertaken within this research was very successful as it established the geographic locations of 320 archaeological sites and recorded over 50,000 surface artefacts comprising mainly of ceramic sherds, but also remains of slag and furnace; stone tools and lithics; and beads. The data obtained was used to create various accurate archaeological maps of the region illustrating location, type and density of settlement sites and material culture. This information was also used to compile a comprehensive gazetteer found in the Appendix of this thesis.

Field walking surveys are a common method used to identify sites in the landscape and this has been carried out in various contexts across the West African region (Arazi, 1999; Loukou, 2013, Schmidt, 2010 to a name a few). The importance of conducting a survey which illustrates the spatial distribution of human activity and thus demonstrates how ancient people were interacting with its hinterland are obvious (Bower, 1986; Orton, 2007). Chapter Two of this thesis considered research where field walking survey was undertaken in contexts outside of Africa, and the resulting information integrated within a GIS. It was clear from the literature that methods of field walking, for example artefact recovery, production of survey recording sheets and spacing of field walkers (Banning, 2002; Banning et al., 2006, 2011; Haselgrove, 2007; White and King, 2007), is all dependent on the situation of the study area and the aims of the individual project, therefore the method devised for this research had to be produced accordingly to suit.

The field walking survey carried out for this research was outlined in Chapter Three. The survey aimed to be systematic, but simple enough that all members of the survey team (including the Benin students and local people employed who were not formally trained in archaeology) could understand it, so it remained consistent. The strategy devised and implemented was extremely successful, particularly in terms of site identification and the collection and analysis of material culture in the field. Field walking was carried out in linear, parallel transects, spaced 20 metres apart. As discussed in Chapter Two, there are various methods for field walking which sometimes rely heavily on statistical approaches, i.e. Banning *et al*. (2011), who argues spacing between walkers should be dependent on artefact density per minute. This approach would involve experiential procedures to determine how many artefacts were accounted for per minute of survey, using different spacing widths. Such an experimental approach would be useful in other contexts where time is not short and archaeological material density is well known. Because this region was a complete unknown before the research was undertaken, the survey had to remain dynamic enough to be adjusted where necessary, but also be systematic, therefore such experimental approaches to field survey were not used. Banning (2002) also states that parallel transects are a very common form of arrangement used to cover a survey area, however, they may be the most difficult depending on the terrain and other mitigating circumstances, such as access to a vehicle. This was certainly the case for field walking in the Niger River Valley, where access and terrain were sometimes issues. Because of all of these factors, the survey produced tried not to be over complex, so that results could always be obtained. Twenty metres spacing between walkers worked well in all areas and was slightly adjusted dependent on terrain. In some flat areas with high visibility, wider spacing was implemented. Overall, the field walking in transects method that was conducted was very successful, and this is demonstrated through the good quality and volume of data collected.

Some field survey issues should be addressed in the discussion of this method and how it affects recording archaeological distribution in the landscape, which is part of the first research question posed at the beginning of this thesis. The first issue, and is common in any field walking situation, is the differences in information collected by the individual surveyor. This was discussed in detail by Banning *et al.* (2011) who acknowledges that there are limited examples of research that explicitly explain their field walking method, particularly the effectiveness or reliability of detecting sites and surface artefacts. It is generally acknowledged that each field walker will have different archaeological detection and interpretation abilities, thus this will have an impact on the results. These inconsistencies that occur between surveyors is not generally documented or published when discussing archaeological surveys. When this research was conducted, there were some discrepancies between the different surveyors and these will be discussed. There were variances in the recorded details outlined on the survey record sheet in relation to each site (a copy of the survey sheet can be found in the Appendix). For example, some record sheets that were completed only had one or two words written within the note section which asked the surveyor to describe the morphology of the area and site, whereas others may have written an entire paragraph. The way the survey was devised however meant that this lack of information had limited impact on the results. This is due to several reasons, firstly because a good categorisation of the site could be made from the photograph that was implemented within the field survey strategy. Secondly, the exact details of the site were recorded by GPS so the site could be situated in the landscape via Google Earth and satellite imagery. Lastly, material culture from all of the sites surveyed was collected; adding to the overall site information.

Another issue that is worth highlighting in this discussion is the effectiveness or reliability of detecting surface artefacts. Haselgrove (2007) recognises that in order to have confidence in the material culture collected, systematic collections have to be made. The systematic procedure for collecting artefacts within this research was outlined in Chapter Three, whereby a collection was made at the centre of every site encountered by scoring a $10m^2$ circle in the ground and collecting the artefacts within it. Like the written record, material culture collection also varied between survey teams, due to the fact not all of the surveyors identified every single artefact within the collection unit. Again this was partially solved by the use of photographs and this in most cases was rare and did not affect the density of material culture patterns. As Orton (2000) states, many factors contribute to the formation of surface scatters and the recovery of the material. Furthermore, there are many variables that affect the recovery of potsherds including the soil type and vegetation cover, the colour of the sherds, as brighter or more distinctively coloured sherds are more like to be recovered than the sherds that are the same colour as the soil. Also, different individuals may be better at collection than others resulting in a greater quantity of sherds. Figure 6.1 shows a typical situation during the field survey of team members collecting pottery within a collection unit.

Figure 6.1 *Students and locals collecting surface artefacts from a collection unit at the site of Djaboutchia.*

It is not only anthropogenic error that can affect the results of the field survey. A wealth of information regarding material culture in the Dendi region was collected during the field walking survey. It revealed how different types of artefacts and ceramic decorations and styles were spatially distributed, but not all surface remains would have been identified or collected for analysis due to post-depositional processes. As commented in Chapter Two by Mills (2007), weathering will affect the exposure and distribution of artefacts, and this is certainly the case within this study. The Alibori survey area exhibited a high density of ceramic sherds in comparison to the Sota area because of the amount of erosion that has occurred, forming Badlands, and exposing archaeological remains. The Sota on the other hand, has not suffered the same degree of erosion and as a result has fewer pottery sherds per site. The erosion occurring on the archaeology at the Alibori, however, should be used to our advantage. The otherwise empty archaeological record of the area now has a rich database of information particularly on the ceramic assemblage, and due to erosion, these pottery scatters probably come from several occupations of the site. Because the bias in the survey recording between the different survey areas has been recognised, this will not influence the way the information is interpreted. At face value if only considering the total number of collected artefacts, it could be assumed that the Alibori River survey area was more densely populated in the past, because of the sheer density of ceramic sherds recovered. However, the reality is that Sota area may also exhibit high densities of material culture and even sites, but as the area has not suffered the same degree of erosion, the remains may be concealed beneath ground surface. The only way to consider population estimate through material culture density (this is discussed by Chamberlain, 2009) would be through further investigative work, including excavation, comparing the two regions. Overall however, the recovery of surface artefacts on the field during survey was a success, with over 50,000 artefacts recovered (see appendix for further details).

Finally, this section of the discussion regarding field survey will consider the ways in which the surface assemblage was recorded in the field. The recoding strategy was simple, yet very affective. The site and collection unit shared its own unique number, which was basically the date the collection was made. This number was written on the record sheet and on a label that was placed in the finds bag, this same label was then used for the photographs of the assemblage which was taken at the same time. Recording the artefacts like this lead to no mistakes, so each of the

50,000 artefacts accounted for relate to a geographical coordinate, all of which was collected on the field survey.

When considering the primary analysis of the material culture conducted in the field, this research used a coarse-grain approach to recording the type and decoration of the ceramic fragments recovered. The recording system noted whether the sherd came from the body or the rim of the ceramic vessel and recorded a broad type of decoration, often using one or two words, such as 'undecorated' or 'incised'. Overall, this method was satisfactory in its findings. However, further analysis on the sherds could reveal greater detail of ceramic diversity, which in turn may illustrate different spatial patterns. Moreover, this methodology used the desampling strategy employed by the *Crossroads* project, and was generally only used on excavated material. As previously discussed in Chapter Five, there were many sites with a high degree of desampling. The results showed that a high percentage of sites had almost 90-100% of its ceramic sherds desampled after collection. A future consideration may be to use different desampling method for survey material. Regardless of this, the methodology of this research ensured that every sherd was photographed from every collection unit, therefore it is not impossible to analyse them for their decoration motif from the image.

Overall, the survey methodology implemented was very successful in systematically collecting archaeological data of the region. The *Crossroads* project had undertaken surveys in the years previous and had not gained as much data as they had used a less systematic approach. The systematic survey has given a detailed outlook of the material culture types and densities that are seen in different parts of the landscape. The previous unsystematic surveys made very limited pottery collections, only collecting interested pottery sherds. Notes were taken on the type of material culture present, but this was not undertaken at every site. This made the two types of survey very different in the amount of information revealed. Furthermore, site size was measured within the systematic survey but it was just estimated within the *Crossroads* project survey. The outcome is that the systematic survey has given us many variables of data to investigate the historic landscape; for example, site size, material culture density, type of site and so on. Whereas the unsystematic survey left fewer variables to work with and included the geographic location of the site and a description in note form that was inconsistent in details between different surveyors.

In terms of looking at surveys outside of a West African context it is useful to bear in mind that stringent surveying methodologies that are undertaken elsewhere are not possible within this region. Measured transect spacing and sampling of surface remains were carried out in the most favourable way to the conditions. Previously, surveys in West Africa have not been entirely systematic in their approach, and little awareness of the recording strategy is considered. Consequently, this research is offering an approach that could be used in other areas of West Africa relatively easily. Furthermore, whilst undertaking the survey, students and local people were able to engage with the archaeology and learn new expertise, which can be carried on to ensure that many more sites can be recorded.

6.2.2. Gazetteer

The importance of creating gazetteers for research in Africa has been shown in several examples including, 'The Archaeology of Fezzan - Volume 2', Mattingly, D. eds. (2007) and work in the Chad-Cameroon area by Lavachery *et al*. (2010). There is also a more important agenda for national legislation to protect sites of heritage. This has been highlighted by McIntosh (1993:500) who states that the nature and distribution of sites are largely unknown in many African countries, and in West Africa alone, there are many countries where the total number of known sites from all periods does not exceed 50. Furthermore, site destruction is rapidly increasing particularly due to urban development and looting of archaeological sites (McIntosh, 1993). Although writing over 20 years ago, the situation has not improved vastly and large areas of West Africa have had little or no archaeological prospection.

For the Republic of Benin, the research undertaken in this doctoral project has led to progress of the vision of a countrywide site inventory of all known archaeological sites. The need for this has been highlighted by N'Dah (2017) in the forthcoming *Crossroads* monograph. He discusses the problem of lack of archaeological work in the region, which eventually led to the creation of *Laboratoire d'Art, d'Archéologie et d'Expertises Patrimoniales* (LAAEP). The objectives of LAAEP, which was created in 2012, were: 'to continue the discovery, identification and precise localisation of archaeological sites on the territory of Benin, assess their archaeological potential through direct observation of surface remains, and study certain sites relating to the various periods of human occupation, by conducting excavation and artefact studies.' The identification and precise localisation of over 300 archaeological sites and material culture were obtained in this doctoral work, accordingly aiding one of the objectives of LAAEP.

Ensuring an accurate record of archaeological sites is imperative for Cultural Heritage Management programmes, particularly because having archaeological information readily available is important for site monitoring and reducing the destruction of sites in the region. Site destruction was mentioned in Chapter Four, and in the Sota study area was very prevalent. As the survey was conducted we either encountered destroyed sites, or sites in the process of being destroyed, to make way for the creation of a new road. Not only is this destruction detrimental for the archaeology, but it alters our understanding of the spatial layout of distribution of the sites. As was discussed in Chapter Five, sites in the Sota survey area appeared to be 'twinned', however the construction would have removed sites. Figure 6.2 shows a detailed Google Earth view of the area of destruction and the new road in relation to that archaeology found.

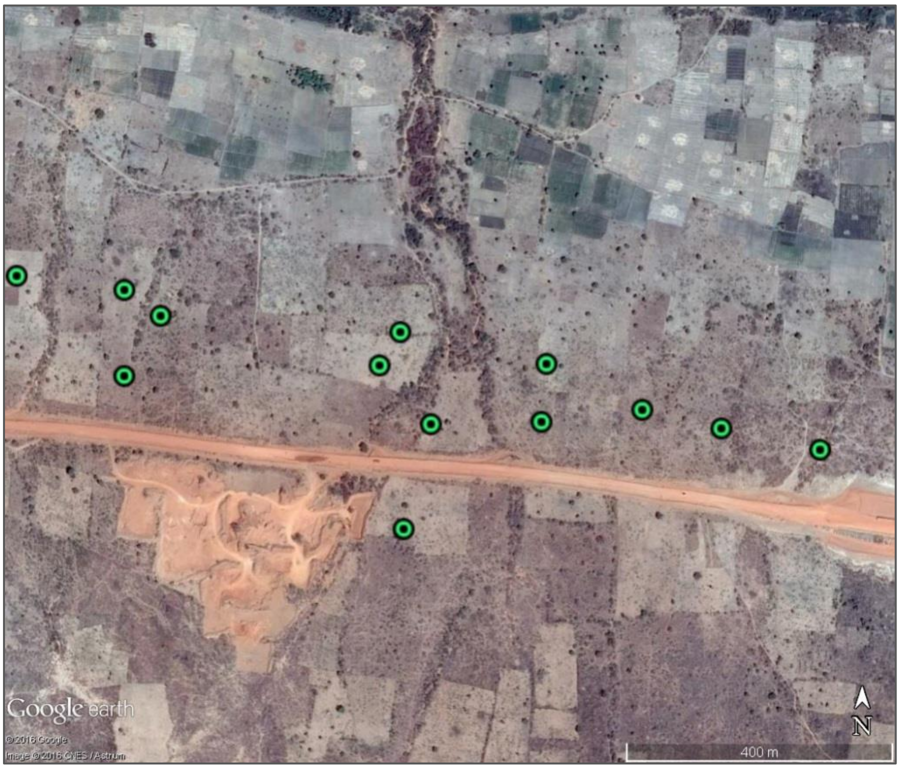

Figure 6.2 *Google Earth image of a section of the Sota survey zone where the construction of a road and the quarrying for material has destroyed sites. Green points illustrate archaeological sites discovered and the most southern site pictured in this image was destroyed after it was recorded by this survey.*

The southernmost site on the Google Earth image (Figure 6.2) was quarried away shortly after conducting this survey. In Chapter Four, site 120 was discussed as some interesting ceramic material was obtained from this destroyed site. The ceramics uncovered from the destroyed section consisted of one geometric design/twisted cord decorated sherd and a complete rim with narrow neck with additional small piercings at the edge. An image of the destroyed site is illustrated in Figure 6.3. This further demonstrates not only the requirement to accurately record the location and distribution of archaeology in the region, but also collect material culture evidence as this may be lost after a site has been destroyed.

Figure 6.3 *Photograph showing Abbass Diallo, student and surveyor, standing on the edge of a large settlement mound that was being destroyed by heavy machinery for the construction of a road.*

To consider the benefit to cultural heritage management, the creation of a gazetteer that is available for researchers and government alike is imperative for achieving this aim. Creating this geographic database of information in an easy to understand tabular format for the region, not only comprised of sites discovered through this research, but also containing the discoveries of the *Crossroads* project, has made an accessible avenue for anyone wanting to gain understanding into the distribution of sites in the landscape. Moreover, ample maps have been produced in order to visualise the data (this will be discussed in the next section). Finally, and perhaps most importantly, using the coordinates provided in the gazetteer found in the appendix means anyone can pinpoint the site for years to come, ensuring their protection. This will be discussed further in the future considerations section of Chapter Seven.

6.2.3. Site distribution and mapping

The last factor to reflect on when considering distribution of settlement and material culture in the landscape is the production of maps. Presented in this thesis was an array of static maps, illustrating various archaeological occurrences. These were produced to enhance a view or argument given in the thesis. These initial maps provided a vital first interpretation of the distribution of sites in the landscape and lead to the development of delimited survey zones chosen for the fieldwork carried out within this doctoral research. As discussed in Chapter One, distribution maps have been widely used in West African archaeological research particularly when considering site clustering (McIntosh, 1995; Togola, 2008) and an initial visual identification of clusters can be seen from a standard distribution map.

For the purpose of the research presented in this thesis, after the field survey was conducted, the data was cleaned to remove any inaccuracies, and precise maps of the region with the archaeological occurrences within the landscape were produced. During field survey the geographic coordinates of each site were obtained through the use of a handheld GPS device, these were then verified on Google Earth to ensure ultimate accuracy of position. Base maps of the landscape were created using free, medium resolution satellite imagery; this process was discussed in Chapter Five. These maps were dynamic as they were produced using multispectral satellite imagery and elevation data so they could be visualised in a multitude of ways and this has been demonstrated throughout this thesis. For example, to highlight vegetation, the near infrared band was used. Contour maps were also produced from the ASTER GDEM data obtained of the study area.

The advantage of creating a series of archaeological maps is that they revealed some immediate spatial patterns, which were later validated with the use of GIS. The cartographic representation of the sites distributed in the landscape gave an initial understanding of the dynamics of the people in this hinterland. Moreover, because of the wide variety of information that was collected during the field survey, several options were available for visualisation of the data; for example, distribution of settlement mound sites, Folded Strip Roulette ceramic sherds, and total area of a site, to name a few. The spatial patterns observed and how they relate to the environment will be discussed in the following sections.

A site typology was formulated when considering the distribution and mapping of the archaeology. Some broad categories were developed and described in Chapter Four. These categories were split into three: mounds, flat/eroded and cultivated sites. Defining a site in an under-researched region is problematic, which is the reason why the types were left broad and defined the morphology of the site, rather than their function.

6.2.4. Summary

Using a combination of field survey and comprehensive mapping, this research has demonstrated a method to illustrate the general distribution of settlement and material culture within the wider hinterland, which has revealed some promising patterns to help us understand the people that were once in it. The fieldwork methodology on the whole was successful in that it systematically pin-pointed the distribution of settlements and artefacts within the wider region. By considering these initial patterns encountered on the map, the next research question regarding the environment can be answered. But initially what we understand of the people here is that they live in clustered communities. The degree of clustering will later be discussed in relation to spatial analysis methods.

In Chapter One it was argued by Randsborg and Merkyte (2010) that Africa is archaeologically rich, a 'treasure', which can be used to explore different methods to gain a greater understanding of the organisation and development of ancient society. In fulfilling the aims of the first research question, the method of field survey and mapping undertaken within this doctoral research has demonstrated a simple and effective way of understanding the spatial dynamics of this ancient society and the potential of future work in the Niger River Valley. Furthermore, it has been claimed by LaViolette and Fleisher (2005) that in order to fully reveal whether settlements are influenced by their hinterlands, the view which has been used extensively by projects in the IND (e.g., Jenné-Jeno and Timbuktu), major and expensive work is needed consisting of survey, test pits and large scale excavation. However, the field survey and mapping demonstrated a relatively inexpensive process of identifying hundreds of sites, associated material culture and mapping their distribution in the landscape to gain understanding about the relationship these people had with their environment. Also, it showed the potential for developing a comprehensive gazetteer, valuable for Cultural Resource Management.

6.3. The role of the environment for settlement preference

The fundamentals of collecting, recording and producing maps of the landscape have been discussed. This section will discuss the evidence for human-environment interactions in the landscape, and consider if the environment had a role to play in settlement placement in the past.

The theme of environmental determinism is a hotly contested issue in archaeology. One school of thought believes that climate and environmental change were drivers of societal change in the past, particularly evident in Saharan archaeological examples (e.g. Kuper and Kröpelin 2006), whereas others challenge this view (e.g. Wengrow *et al*., 2014). The data required for such studies is often substantial, ranging from paleoclimate data to geomorphological analysis. This type of data and analysis is generally lacking from West African archaeological contexts and this was highlighted in the case of Timbuktu (Post Park, 2010). Regardless of this, the research outlined in this thesis sought to evaluate how environmentally deterministic the people of the Niger River Valley were and consider how the environment shaped settlement preference in the region. It sought to answer this question by using survey, GIS and remote sensing methods. It has been demonstrated in previous research highlighted in Chapter Two (Bevan and Connolly, 2013; Newhard *et al*., 2013) that these methods can advance and enhance our understanding of human-environment interactions of the past.

Firstly, it should be acknowledged that the approach taken within this research to investigate human-environment interactions of the past, by only considering field survey, remote sensing and GIS data is coarse grain. Nevertheless, producing this type of information is a useful preliminary step needed before further research can be undertaken and is beneficial for pinpointing the areas where a more refined methodology is needed, for example, coring, sedimentary profiles of fluvial systems, and phytoliths examination, to name but a few modes of exploration. This will be considered in further detail in the conclusion of this thesis (Chapter Seven).

Several approaches and methods were carried out to investigate this research question using the data and methods available. This included the mapping of topographic and geomorphic features from satellite imagery in order to establish the natural topography and general geomorphology of the landscape, to establish the natural setting of the archaeological sites. Secondly, spatial analysis techniques used in GIS were undertaken to establish patterns between the site and the landscape, which can indicate the degree of environmental determinism that may have been occurring in the region. This process measures how far archaeological sites cluster toward certain topographic features, indicating that they were given preference for settlement in the past.

The role of the environment within the IND sites was referred to several times to argue for the abandonment of settlements after 1400 AD, particularly the role of water. This was referred to at the site of Dia, where site selection strategies were based on factors such as being close to good fishing grounds and arable lands, with an unmistakable clustering distributed along the water ways (Schmidt, 2010). Haskell *et al*., (1988) pinpointed the environmental deterministic nature of settlement at Dia, where he states that site clusters deteriorated and became abandoned after the disappearance of the marigots, small lake areas where people could obtain water, highlighting the importance of the environment for the survival of large populations of people. However, as shown in a North African example, this can be a two-way debate. In their Garamantian example, Mattingly and Sterry (2013) highlight that urbanism is supported by the landscape, but this natural environment is also reliant on the population. It is commented that the security of the Garamantian desert towns could be just as profoundly affected by political and economic shifts, as by environmental changes (Mattingly and Sterry, 2013). The following sections will consider evidence for environmental determinism within the Niger River Valley.

6.3.1. The role of fluvial systems

The Niger River and its tributaries, the Alibori and the Sota rivers, are key topographic features that make up the Dendi landscape and are imperative for the discussion of site and settlement patterns in the area. The survey considered several areas where there were currently active fluvial systems or where there were ephemeral, non-perennial river channels, identified through satellite imagery. As discussed in Chapter One, the Niger River is very active and has changed its course gradually over time and these tributaries and channels have formed. Consequently, the Dendi landscape, as a whole, exhibits extensive fluvial activity, making it an attractive area for settlement. The Niger River and its tributaries are said to be 'life-givers', as water is used for rice cultivation and fishing (Harrison Church, 1961).

In the Alibori region, there is a clear relationship between the sites and the river as they cluster very close to the edge, no more than a few metres from the water. The Alibori River is a perennial river that has water flow all year round and this may account for the abundance of sites within its vicinity. When transects were made away from the river, in one case, one transect measured 2km, there were no sites evident. This evidence clearly demonstrates that the people of this area wanted to settle close to the river. The same pattern is evident in the Sota area, where sites line an ephemeral river channel, which was potentially a much larger river in the past and the remnants can be see of this in satellite imagery (this is shown in Chapter Four). The fluvial systems of the region must have had a large impact on settlement in the past. Furthermore, in her work on the Crossroads project Veerle Linseele (pers. comm.) indicates from the faunal remains found during excavation, that the river played a large part in daily life. There as substantial evidence of animal and fish remains which typically inhabit riverine contexts.

The river may show evidence of being a life giver, but there is also a possibility it could have led to the abandonment of sites. The total number of sites discovered in all surveys was over 800. This is an outstanding number for the size for the area, around 50km^2 if considering the *Crossroads* data, particularly as this area in the recent past was sparsely settled. There are two reasons why life by the river is not sustainable and that is flooding and erosion. Behanzin (2014) writes in his Master's thesis 'Flood Disaster and Human Security in Bénin Niger River Valley' (one of the few geomorphological research studies in the area), that currently river tributaries of the Niger River frequently flood and destroy crops, making it an unsustainable economy. However, people are attracted to this area as fertility of the land next to a river is affected by the constant saturation and drying annually, but as the active river moves and channels form fertile soil is deposited within the sediment, making this land more favourable for agricultural crops (Behanzin, 2014). This is why there is an increase in cultivation in the area (see Chapter Five). However, it is well documented archaeologically that soil erosion has been associated with the rise and fall of early civilisations, for example in the Maya Lowlands (Beach et al., 2006), where sustained cultivation over a long period of time can cause substantial erosion. Over utilisation of the areas close to the rivers in the region may have eventually lead to the demise of settlement.

Regardless of accessibility to water, there is evidence in the present day landscape of the Niger River Valley which shows people adapt to their environment. There has been a decrease in precipitation due to climate change (N'Dah and Laïbi, 2017); however, this research has showed an increase in vegetation across the region, due to irrigation. Further environmental evidence is needed to substantiate the theories outlined in this section; nevertheless the relationship with the river is a fundamental one.

6.3.2. Elevation and site preference

Elevation of the region was calculated and mapped by using ASTER GDEM elevation satellite imagery. A general elevation map and a contour map were produced and sites were located within it to consider where the sites were situated in the landscape. From a visual analysis of the elevation map, sites appear to clusters toward particular elevations in the landscape. This was further corroborated with the use of spatial autocorrelation (Chapter Five) showing settlement clusters around an elevation of 170m. Almost half of the sites that were recorded lie on an elevation between 170-180m above sea level. The most obvious reason that this seems apparent is because this is the same elevation of the land closest to the river, and as discussed in the previous section, this is where people preferred to settle. In other study regions, there is evidence to suggest settlement clustering at certain elevations in the landscape; this is usually for a variety of reasons such as, defence and favourable arable land. This is evidenced within Zimbabwe hill settlements (Baxter and Kudakwashe, 2008). In the Niger River Valley, there is higher ground within the study region, however few sites are found within these elevations, only 6% of sites over 190m. Therefore, this evidence further indicates that the river was a vital topographic feature for past settlers.

6.3.3. Palaeoeconomy of sites

Location of the settlements in the landscape has an impact on the palaeoeconomic functions of the site, which is also illustrated through the archaeobotanical and faunal data collected within the *Crossroads* project. Ancient habitants of the settlement sites more than likely survived within an agricultural economy. As has been mentioned, the river played a vital role in daily life and initial analysis of the faunal remains suggest that aquatic fauna dominates the assemblage collected from excavated samples (Veerle Linseele, pers. comm.). A range of domesticated and non-domesticated mammals were also present in the assemblage, mainly consisting of ovicaprids (sheep and goat) and some cattle and large bovid. There is also indication of wild animals including caracal/serval and hare.

The archaeobotanical remains consist mainly of cereals. These include rain fed savannah and flood plain cultivation, comprising of pearl millet, sorghum and rice (Champion and Fuller, forthcoming, 2017). One important finding is that there is a decrease in proportion of rice found in the assemblage after AD 900. Champion and Fuller (forthcoming, 2017) comment the extent to which this affects social changes in the settlement dynamic or is a response to climate change needs further investigation.

Generally it appears that people in this landscape were making the most of their natural resources through fishing and using the close by plateaux for pasture, which is perhaps why settlement are dominant in the low lying areas close to the river. People also appear to be making use of both domesticated and wild animals where possible. Further advances in this theory will be established in later publications of the Crossroads project and through further investigative work on the field.

6.3.4. Summary

The overall trend in the Niger River Valley demonstrates that people preferred to be located next to the river. There is evidence elsewhere in West African archaeological research (shown in Chapter One) that settlements declined because of environmental change, and this may be the case here. However, such theories are generally hypothetical until more palaeoenvironmental data becomes available. Also, there is no agreement in the IND examples whether climate change or economical change led to the abandonment of settlements. This is evident from the discussion at Dia. For example, S.K. McIntosh (1995) does not place major emphasis on the environmental factors that may have influenced the abandonment of settlements at Dia, but focuses on economic and trade reasons, disagreeing with previous findings in the work of Haskell *et al.* (1988) that blamed the drying up of water areas. Roland Fletcher, when discussing Angkor Wat, comments that low density settlement is vulnerable to environmental instabilities (pers. Comm), as they are not large enough to sustain the change. This is a likely scenario in the Niger River Valley, however, further work is needed to validate these findings.

6.4. The rise of early urbanism

This section explores the theory of an early urban culture that developed in West Africa between 500 and 1400 AD, and considers whether a similar urban centre developed in the Niger River Valley around the same time. West African complex urban societies were exemplified in Chapter One through a range of examples and some case studies; particularly the work at Jenné-Jeno, which S.K McIntosh and R. McIntosh have long argued was an urban centre. There are specific rules that McIntosh and McIntosh (1993) argue should be examined when considering urbanism. These are site size distributions and the heterogeneity of artefacts and features at individual sites, all analysed in order to explore inter-site diversity (McIntosh and McIntosh, 1993). The assumption made from theories is that a settlement is urban if it is more varied than their village counterparts in terms of wealth, social and ethnic background, and personal eccentricities (McIntosh and McIntosh, 1993). Furthermore, site clustering of contemporary sites, which occurred at 77% of sites found at Jénne-Jeno, whereby between two and 15 mounds sites are 'within shouting distance', exemplifies an urban landscape (McIntosh and McIntosh, 1993). This section will examine what degree do the results obtained in this doctoral research echo these rules? One important consideration is, unlike the research in the IND, the sites under investigation in this research thesis were not excavated, therefore any theories on the Niger River Valley exhibiting an urban landscape can only be developed from spatial patterning, size of site, and material culture found on the surface. As will be stated in the conclusion (Chapter Seven), more work is required to gain a thorough understanding of the dynamics of this society, beyond settlement and material culture distribution. However, as this section will show, the results of the survey show a leap forward in understanding the societal undercurrents of this landscape.

This section will first consider the arrangement of settlement sites, particularly considering site clustering and size of site. Then, the spatial distribution of material culture types and ceramic decorations associated with the sites will be discussed to deliberate any evidence of social heterogeneity. A broad chronology will be discussed in relation to exploring whether these sites are contemporaneous.

Finally, a counter argument to the heavily theorised research on West African urbanisation will be briefly discussed.

6.4.1. Spatial organisation of settlements

It is starkly obvious from the distribution map that the sites in the Niger River Valley are clustered together. Like Jénne-Jeno, there is evidence for site clustering, particularly in the Alibori area, which is indicative of the traits of early urbanisation. Furthermore, there appears to be the presence of epicentres within the Alibori study region. These epicentres have been highlighted in Figure 6.4. It is important to realise though that the site size data was based on distribution of material culture on the surface, and some site extents may vary considerable in size after excavation. Nevertheless, there is a clear pattern in the settlement distribution, and this is further reinforced after buffer analysis (Chapter Five) which demonstrated that most sites were within 500m of each other, in fact generally much closer, with clusters of sites c. 50m distance. Cluster analysis using Ripley's K function also revealed a high degree of clustering that was not a random set of events.

Birnin Layfia ancient site was chosen for excavation because it was extremely large in size and had apparent deep stratification with potential evidence for well-preserved architecture in association with pottery pavements that could be seen on the surface. This site, however, lies around 5km from the site clusters at the Alibori and there are no sites in between. Furthermore, if Birnin Lafya were the urban centre due to its size (like the situation at Jénne-Jeno), then there should be a difference in material culture here, if adhering to the rules given by S.K. McIntosh and R. McIntosh. This is a future line of enquiry at this stage. However, the material culture remains found at Birnin Lafiya appear very similar to that found in the Alibori, with a selection of undecorated, Folded Strip Roulette and perforated sherds.

There was only one similar site to Birnin Lafiya encountered during survey, notable for its large size. This site was briefly mentioned in Chapter Four as site 53, which is nestled in the meander of the Alibori. This site is the centre of the most westerly cluster seen in Figure 6.4. There is the potential then for three urban centres in this region (if we include Birni Lafiya), broadly following the spatial rules of urbanism given by S.K. McIntosh and R. McIntosh.

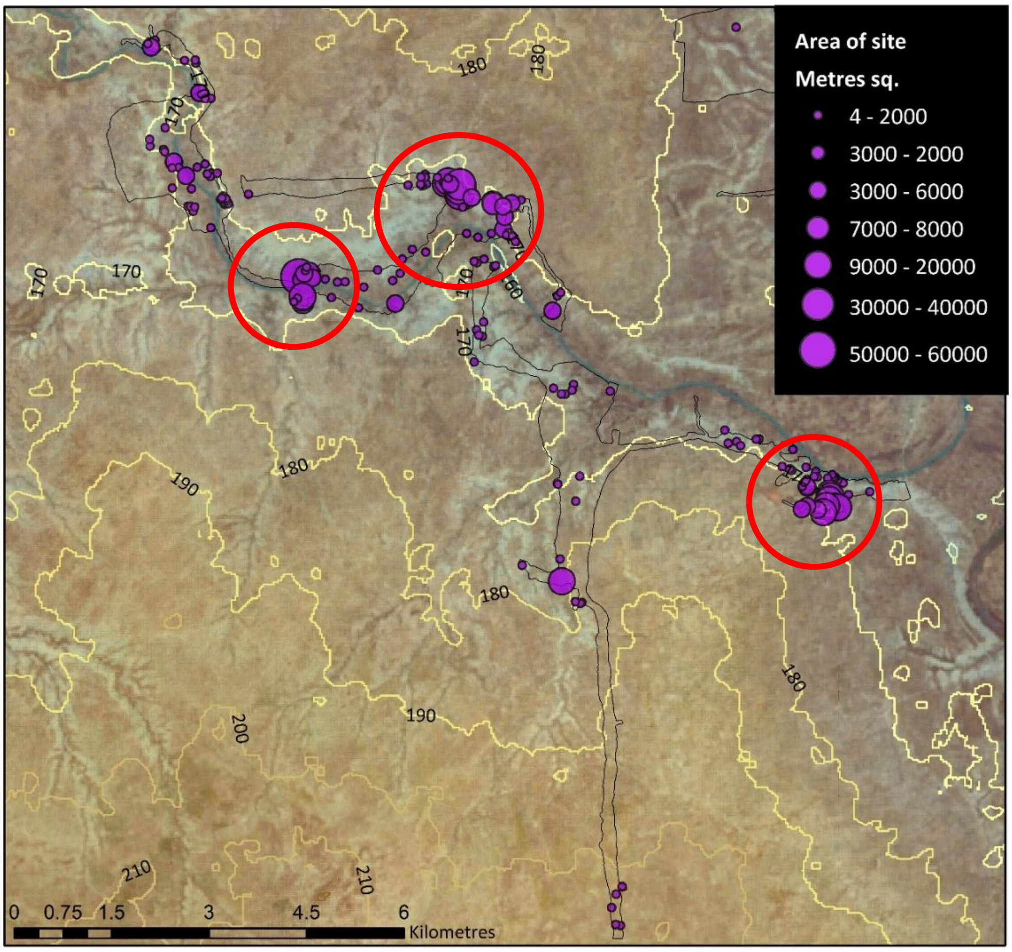

Figure 6.4 *Landsat image with contours showing the area in m² of sites in the Alibori survey area. The red circles illustrate potential urban epicentres.*

The spatial organisation in the Sota region told a slightly different story and this was discussed in Chapter Five, where we see evidence of 'twinned' settlements. Spatial analysis using GIS demonstrated that these sites are clustered and are spaced very close together, which could be argued 'within shouting distance' adhering to the rules given by S.K. McIntosh and R. McIntosh. This variation in spatial organisation may demonstrate a difference in the organisation of society here. However, as has been stated previously, archaeological visibility is not as prominent compared to the Alibori area, therefore we may not be experiencing the full prominence of the sites.

Nevertheless, this spatial organisation of settlements between east and west is not similar, perhaps illustrating two societies functioning in this landscape.

6.4.2. Material culture distribution

Like the distribution of settlement, there were evident differences in the material culture decorations between each survey region. For example perforated sherds, in association with domestic or industrial food preparation (see MacLean and Insoll, 1999) were only found in the Alibori study area. This suggests that this area was either performing different social functions, or we are restricted by the archaeological visibility in the Sota region. Additionally, there was a lower density of Folded Strip Roulette sherds present in the Sota study area. But when considering undecorated versus decorated sherds, both the Alibori region and the Sota region saw similar percentages. This was because the Sota had a significant number of burnished sherds in the assemblage, which was not identified in the Alibori survey. Again, this evidence perhaps illustrates that there were two different social groups evolving in this landscape that were located only 20km apart.

The placement of iron working, or sites with slag material had an interesting distribution. Iron working remains appear quite frequent in the landscape, concentrated around settlement sites (Figure 6.5). There are clusters of iron working evidence distributed close to the epicentres of clusters discussed in the previous section, this is particularly evident in the Alibori area. This distribution perhaps indicates that these craft specialists worked on a local, settlement level basis. Something similar was alluded to in the Kompa area by Rubion-Brunner *et al.,* (2015).

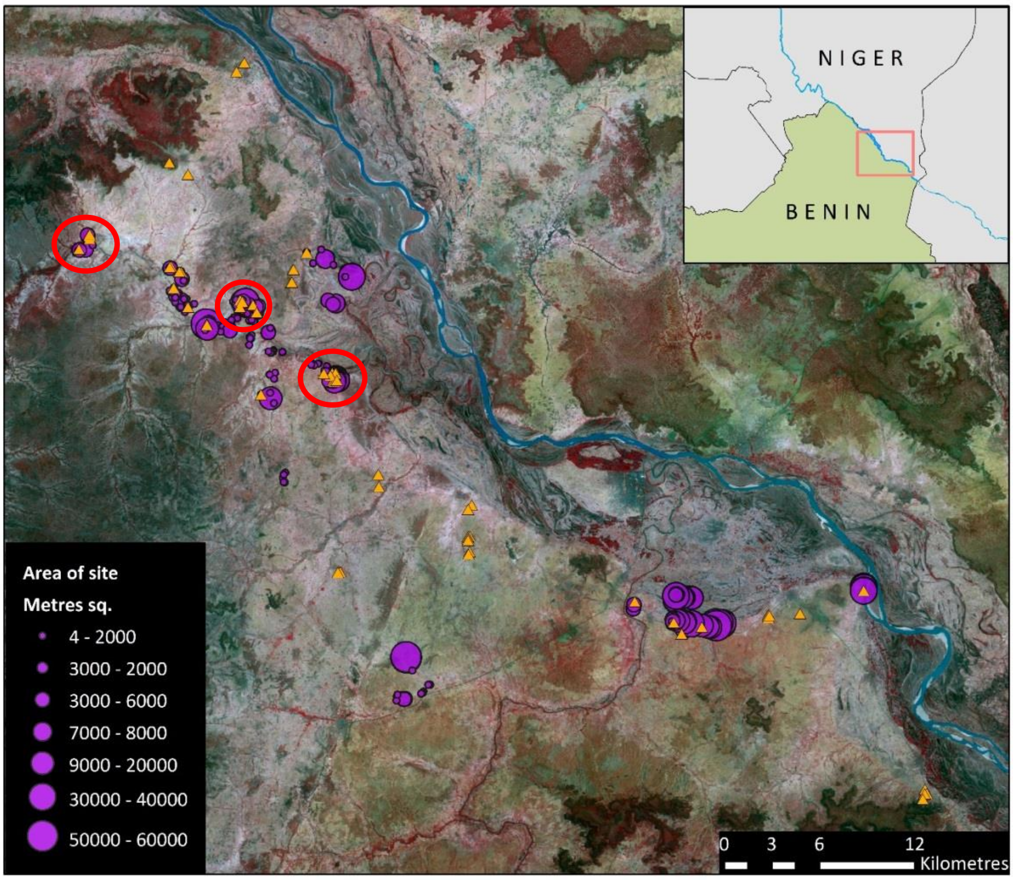

Figure 6.5 *Iron working remains in relation to size of site. Clusters of iron working remains have been circled.*

There appeared to be little diversity of material culture distribution within the individual survey zone, where it appears decoration and density is relatively homogenous throughout. This finding is similar to Schmidt's (2010) work at Dia. Within Dia, the complex of settlements evidenced a homogeneity of material culture, which suggested that there were close contacts between the urban centres and the surrounding hinterland. There is a similar situation within the Niger River Valley, where there is evidence for homogeneity in material culture within the different surveyed.

6.4.3. Chronological consideration

The last component to consider for this investigation of urbanism is chronology. Accurate dating of ancient remains within a new archaeological project, where no research has taken place prior takes a considerable amount of time. Although no dating evidence was collected as part of this research, the *Crossroads* project in its five year duration obtained over 100 carbon dates (see appendix) which correlate directly to the results obtained in the research for this doctoral research. This research sought to investigate the Iron Age sites located in the region, contemporary to those sites that are found in the IND. As already discussed in Chapter One, a majority of the dates obtained by the *Crossroads* project are around AD 500 – AD 1400. From the excavated data that has been recorded by the *Crossroads* project there is an indication that the large settlement mounds in the landscape had the longest occupation, either continuous or periodically, between AD 500 – AD 1400. The smaller sites, also dating to the medieval period indicated by the homogeneity of ceramic remains, probably had shorter occupations. At this stage of the research a refined chronology of these sites cannot be established, and this research can only work with a five-fold chronology. The pottery data is not sufficient enough to develop the chronology bracket already established for the sites. The artefacts that were seen on the surface are consistent with a 'medieval' occupation, and for the time being none of the hypotheses advancing in this PhD project relies on fine-grained, decadal, chronology at this stage.

As alluded to in the previous section, there were some distinct differences in the material culture uncovered between the Sota and the Alibori study areas. The dates obtained show that the abandoned mound sites (such as those investigated in the survey) all exhibit similar dates, emphasising that these settlements were contemporary with one another. As discussed in Chapter One, some sites originated earlier than others, but on the whole, abandonment around AD 1400 occured, contemporary with the IND sites. This could reinforce the idea that climate and the environment in the West African region as a whole, was a factor for site abandonment. McIntosh (1999) comments that most of the tell sites around Jenné-Jeno were over 2m high, which suggests occupation spanned several centuries.

Therefore we may assume that the large settlement mounds encountered in the Niger River Valley, experienced similar length occupation.

During the survey we found no datable objects, such as tobacco pipes, which are sometimes encountered during survey in the Niger River Valley. However, painted vessels were found, which Gosselain (2016) highlights as a relatively modern occurrence.

In the Alibori region we are potentially seeing occupation from the Stone Age through to the late Iron Age, particularly due to the presence of many lithic sites close to the river. This pattern is not shown in the Sota region. However, lack of erosion may mean that earlier sites are uncovered.

6.4.4. The urban debate

Overall, this section sought to relate urban sites of the IND, with those found in the Niger River Valley; however the theoretical debate around the urban culture argued by S.K. McIntosh and R. McIntosh is not as entirely clear as portrayed.

In his discussion regarding urbanism in African complex societies Connah (2008), states that in order to fully understand social complexity in African ancient settlements there is a need to improve the methodology. He notes that a greater use if aerial photography and satellite imagery should be used to locate sites. Moreover, regional surveys and systematic surface collections are required in order to establish settlement hierarchies (Connah, 2008). An accurate site distribution has been achieved successfully within this research, giving us greater understanding of this landscape. However, further excavation is needed now to substantiate any theories regarding the social organisation of the landscape and hierarchies, distribution of settlement and surface collections cannot do this alone as it usually only takes into consideration ceramic evidence.

Fletcher (1998) states that the use of the word urban is ‘ambiguous and unresolvable’ because there is a great diversity in the types of urbanism that occur, and a universalistic model does not fit all. He points out that communities are all unique and do not necessarily fit already established theoretical frameworks (Fletcher, 1998). In this section, some very broad similarities to the IND examples in terms of settlement distribution have been illustrated, and mainly only in the Alibori area. The Niger River Valley lies over 300km east to the IND and the same theoretical models used for society here do not necessarily fit the Niger River Valley. Further investigation of the material culture obtained through this project, and future excavations is needed to fully understand the social complexity here.

6.5. Assessment of desk-based techniques in investigating the Niger River Valley

This final research considered within this discussion investigates the usefulness of using desk-based methods, specifically the use of satellite remote sensing and GIS for the study of the archaeological landscape in the Dendi region. It was demonstrated in Chapter Two that the use of remote sensing and GIS in archaeology is commonly used to help test hypothesis, particularly regarding landscape-human interaction and site patterns. Accordingly, the research demonstrated a range of methods using high and medium resolution satellite imagery, and GIS spatial analysis methods in order to validate patterns that could be seen in the landscape. This chapter reflects on the usefulness of these methods, which are rarely used in West African archaeological research. In the introduction of this thesis, the comments of Kense (1990) were highlighted. They stated that themes and methods in archaeological investigations of the West Africa region are relatively homogenous, with standard survey and excavation techniques. This research sought to address this issue by introducing a new way of surveying that integrates the use of GIS and remote sensing, something that is used considerably across the globe in archaeological contexts. Katsamudanga (2010) identifies the lack of GIS methods in sub-Saharan African archaeology. Furthermore, in a recent questionnaire given to all members of the Society of Africanist Archaeologists (SAfA) asking whether they used GIS methods in their research, there were only 20 positive responses, showing the stark lack of use in sub-Saharan Africa.

This section will first consider how useful high resolution satellite imagery was in identifying archaeological sites away from the field, then medium resolution satellite imagery will be discussed for its expediency in setting out the landscape and environment, and finally the use of spatial analysis techniques used in GIS will be discussed in relation to their effectiveness in investigating the settlement patterns in this landscape.

6.5.1. High resolution imagery

Traditionally air photographs and high resolution satellite imagery are used for the identification of archaeological sites prior to visiting the study area. Even in the case of Jénne-Jeno, air photographs were used to locate some settlement mound structures. Archaeologists are generally familiar with the concepts and advantages of aerial archaeology, but studies have been mainly limited to contexts outside of West Africa. One of the reasons for this is that archaeological sites are not obvious from high resolution images; this is apparent from studying images of the area in applications such as Google Earth. However, as this research has demonstrated there are other ways in which archaeological sites can be visualised and that is by manipulating the multispectral bands of the satellite imagery by applying different algorithms. Discussed in this thesis in relation to high resolution satellite imagery, were the methods of panchromatic sharpening and NDVI. Both of these methods had proved successful in highlighting archaeological sites within other contexts, for example, sites in southern Italy in vegetated and non-vegetated areas (Masini and Lasaponara, 2007). The same algorithms were applied in the area of Birni Lafia, where a 25km^2 image had been acquired from the Quickbird2 satellite sensor. Birni Lafia was chosen because the main excavation site of the *Crossroads* project was located here and accurate differential DGPS mapping, which has been illustrated in Chapter Five, was obtained for this site. The ancient site of Birnin Lafiya was successfully identified in this image after applying the process of panchromatic sharpening. The result showed a distinct colour difference in the archaeological area compared to the non-archaeological area, highlighting the successful use of this method.

Beck and Phillip (2013) in their study of Homs, Syria, highlighted the possibility of identifying archaeological remains through spectral signatures of an image (as this research has demonstrated) and producing a catalogue of these signatures, so more sites can be identified without contact with the ground. However, there are drawbacks to this that must be noted, the cost of obtaining the imagery is expensive and the computation time and expertise required would be great. Nevertheless, if archaeological sites in this region or similar regions across the Niger River cannot be visited, investment in this type of work would be advantageous. But one should consider that at some stage the sites would need ground trothing, and material culture associated with the site collected for dating and verification.

6.5.2. Medium resolution

Remote sensing in African archaeological contexts is limited to a few case studies, yet offers a relatively inexpensive way to analyse the landscape setting of archaeology in great detail, for large study areas. Free medium resolution satellite imagery such as Landsat and ASTER Global DEM has been used to map the geomorphological features of the landscape, which has complemented the landscape archaeological research of this region.

The medium resolution imagery has been advantageous in several ways throughout this thesis. Firstly, it was invaluable in creating a base map for the sites that were discovered. Secondly, the multispectral data went beyond the static distribution map and demonstrated that there was an increase in vegetation and surface water in the last 20 years. Furthermore, elevation and a contour map of the region were created with ease, placing the sites within the landscape.

In terms of protection of the cultural heritage in the region, the medium resolution imagery has revealed the threat of erosion to archaeological sites, due to the increase of surface water and vegetation, which has an impact on the ground. It has also exposed the rapid rate in which this destruction is occurring, particularly at the site of Djaboutchia.

Finally, it should be noted that the medium resolution imagery facilitated in investigating some of the key research questions that were outlined in the beginning of this thesis, particularly in regards to settlement distribution and site preference in the region. By understanding the topography and geomorphology through the satellite imagery and analysing the placement of archaeological sites, some key patterns emerging, showing placement close to ephemeral and perennial channels, some of which would not have been identified without the use of satellite imagery.

6.5.3. Spatial analysis tools

Digital archaeological methods have been shown to be influential in many aspects of archaeology, this was discussed in some detail in Chapter Two (see Opitz and Limp 2015). There is still much suspicious about this technology, particularly how it might fit within theoretical frameworks (see Llobera, 2015). But what must be remembered from these tools is that they can extend our understanding of the archaeological record. What have been demonstrated by the use of remote sensing and GIS in this work are the capabilities of the tool in analysing the landscape, which has provided new evidence in the region. This has been shown in pattern analysis of the archaeological points and was invaluable in validating observations of site clustering (which has been highlighted as an indicator of urbanism).

The use of Ripley's K-function showed not only distinct clustering of sites throughout the entire study region, but heavily clustered sites within each of the survey zones. The use of buffers showed that over 98% of the sites occurred close (less than 500m) to open surface water and healthy vegetation. Spatial autocorrelation was considered to analyse the distribution of settlements in regard to their elevation and this showed that most sites occurred around 170m above sea level.

Overall, the GIS toolbox in analysing spatial patterns have proven to be invaluable in this research and as it is relatively quick, inexpensive and simple to use, it should be considered more widely within sub-Saharan archaeological contexts.

6.6. Summary of discussion

The research questions addressed in this chapter should not be considered separately and were formulated to challenge the wider objective, and this was to examine the wider debates and themes that have materialised in West African and landscape archaeology, relevant to our study region. The comprehensive array of data which resulted from conducting this research has been shown to be invaluable in the discussion of this historic landscape, and each method complimented the other in conquering the aims and objectives. The next chapter will end the thesis with some concluding remarks.

Chapter Seven: Conclusion

7.1. Summary of work

The archaeological history of the Niger River Valley, Benin, prior to this research and that of the *Crossroads* project was a *terra-incognita*. This doctoral research mapped over 800 sites in the landscape, collected over 50,000 artefacts and recorded the details of the findings using comprehensive maps and gazetteers, which have been presented in this thesis. Furthermore, this work went beyond usage of the static distribution map, often seen in landscape archaeology research. Instead, it tested methodologies taken from satellite remote sensing and GIS, which are used in global archaeological contexts but are novel for West African archaeology. By doing so it substantiate and built on archaeological patterns seen in the region, forming new knowledge.

An underlying objective throughout this doctoral study was to bring landscape archaeology methods used outside of Africa into West African research; particularly systematic field survey integrated with GIS methods. Typically, studies in West African archaeology generally focus on material culture and excavation. The dearth of information considering the landscape can be seen in any internet search by typing 'landscape archaeology and Africa' into any search engine, there is a distinct lack of scholarly research available. Despite the extensive research that has been undertaken in sub-Saharan African archaeology, it is still largely unknown to Western audiences. This void in research is even greater when considering GIS and remote sensing methods, which are few and far between in the African continent.

Overall, this research has demonstrated the success of an integrated approach combining information compiled from a comprehensive systematic field survey with GIS and remote sensing data, and applying the findings to wider theoretical debates in West African archaeological research; urbanism and environmental determinism.

7.2. Cultural heritage management

Cultural heritage management is important for archaeologists, heritage experts and local inhabitants of Benin, which led to the creation of LAAEP. The third article in the document outlining LAAEP's aims and objectives states the need for promoting research on cultural and heritage resources in Benin. In order to accomplish this, LAAEP wish to aid development and training in theoretical and practical research, in the fields of art history, archaeology and related disciplines. Furthermore, there is a need for the production of educational material, provision of services in the field, all of which aims to contribute to the protection, management and promotion of heritage, be it in Benin or outside. The data generated in this thesis has helped in the effort to support local authorities and researchers in region, who require an accurate record of the archaeological sites. This is also why students and local people were engaged in this research by carrying out the fieldwork, with guidance from the author of this thesis. The students and locals were trained in basic survey and material culture recovery techniques, to demonstrate the ease in which a short survey can generate 100s of points of information, hoping that this may encourage and inspire future initiatives.

The gazetteer and archaeological record created as part of this research has ample scope to be expanded by researchers working in Benin. The ceramic sherds that were kept and analysed for this project will be returned to the country with their adjoining geographic information openly available for the research to be taken further. Additionally, 1000s of photographs are available of the archaeological sites and all of the ceramic material uncovered. Therefore, a thorough integration of ceramic decoration could be undertaken. This project set out to demonstrate the potential of different methods in analysing the historic landscape and provides some preliminary views and findings. The data obtained from this thesis could produce another two or three more research projects, particularly in the avenues of either satellite remote sensing and GIS use, or ceramic and material culture analysis.

7.3. Future possibilities for GIS and remote sensing research

As discussed previously, the use of remote sensing and GIS in Africa in relation to archaeological research is slim. This void in research is slowly being filled, particularly in North Africa with projects such as *Endangered Archaeology in the Middle East and North Africa* (EAMENA), who recently recorded their c. 100,000th archaeological site using only remote sensing methods. The work of the EAMENA project illustrates that digital methods are at the forefront of preserving cultural heritage. However, the EAMENA project was created out of necessity because of the obvious cultural heritage destruction that is taking place in war zones, and this can be seen through ample news and media coverage. The archaeology in sub-Saharan Africa is also under threat, if not from the changing environment, then from urban development which destroys entire sites, but unfortunately receives less attention from researchers and Western audiences. Using methods from remote sensing, such as those demonstrated in this project, there is an opportunity to monitor sites under threat and there is scope to further develop the site catalogue constructed within this research.

Additionally, there is ample scope and possibilities to develop the methodology using the high resolution satellite imagery. The data presented in this thesis gives the accurate coordinates of over 800 archaeological sites in the region. If these points are paired with high resolution satellite imagery, the spectral responses of the archaeology from the air can be isolated and identified. Therefore, a future consideration would be the production of an archaeological database of spectral signatures created from sites in the region. This would mean that high resolution satellite imagery could be used in areas that have not been investigated in order to pinpoint archaeological anthrosols, with the potential to identify hundreds more sites. Furthermore, testing the NDVI algorithm on imagery of different time scales may illustrate altered results, as this process is dependent on soil moisture, and thus different seasonal climates will affect the outcomes. It was not a successful method for identifying the site of Birnin Lafiya in the high resolution imagery, but the method has shown success in other regions of the globe.

There are other avenues that could be explored using remote sensing. CORONA declassified imagery features stereo pairs of imagery, where one camera is front facing and the other back, so elevation can be realised. This type of remote sensing satellite data was not used in this research for site identification. However, it could be used to identify large settlement mounds in the landscape. Furthermore, there is the possibility of using this imagery in conjunction with high resolution satellite imagery to establish the location of sites. Finally, this data would be useful to see changes in the landscape as the satellite was launched in 1959.

There is sufficient opportunity within the data collected in this research to further develop the GIS methods. For example, there is scope to analyse inter-site patterns in terms of site size and material culture patterns, on a smaller scale than demonstrated in this research. This in turn, may highlight subtle differences in settlement structure from one area to the next that may have been missed through the regional approach carried out within this research. Furthermore, the use of GIS offers a rapid, low-cost solution in comparing large datasets in this way, so there are endless opportunities in comparing and contrasting different variables and patterns.

Predictive modelling using GIS is hoped to be carried out in the future; firstly for the potential in locating more sites, and secondly modelling of past populations. This type of analysis will further our understanding on how urban, or not, this area was in the past. Does the sheer volume of ceramic sherds found across the region represent a flourishing population?

7.3. Avenues for further research

This research is only the beginning of a much larger research agenda that is hoped to evolve in the region. Not only in terms of site discovery through field survey, but also the use of high resolution satellite imagery and the further analysis of material culture, beginning with the assemblage recorded here. Hundreds of new sites were discovered, and this work only begins to scratch the surface of their complexity. This research has put landscape archaeology in Africa a step closer to those better documented examples across on the globe. However, more work is to be done.

Considering Africa is a large continent with complex geopolitical dynamics, it warrants far more landscape and geomorphological work in relation to archaeology to be carried out.

Material culture in the region could be further analysed and more patterns can be realised if scrutinising the ceramic decorations more closely. For example, separating different types of Folded Strip Roulette, comparing ceramic colour, and analysing vessel type are avenues to be explored. Furthermore, it is hoped that the ceramic sherds collected on the survey can be later compared to radiocarbon dated pottery from the excavations of the *Crossroads* project. This is still a task in progress, and for the time being does not fit within the scope of this research thesis. However, substantial photographs and records were made of the ceramic finds and this can be seen in the Appendix. These small finds found during the survey illustrate that material culture in the area is not confined to ceramic and slag fragments and there is the potential to discover a greater wealth of material culture, which could certainly be achieved through excavation in the region. Also, in the discussion of urbanism, mainly ceramic material cultures, discarded pottery sherds are considered as the main evidence to see homogeneity between settlements. However, this does not consider other artefacts that may be lost in the archaeological record, such as fabric and clothing, which may infer a different social status.

There is definite need for more environmental work to be undertaken. Geoarchaeology and geomorphological work will determine post-depositional processes that are occurring in the landscape. Sediment analysis will allow proxies for past climates. There is also a need to further analyse the interplay of geological process creating the geomorphology shown, which may give further clues as to why the land is eroding.

Different survey zones should be considered away from fluvial systems. The survey zones delimited in this research coincided with the water channels. However, some transects led away from water zones. This was implemented as there was already prior knowledge that most sites existed along the tributaries of the Niger and these needed to be recorded, in order to protect the aid in cultural heritage management. Further work is needed to explore areas with no surface water or fluvial systems.

It could be suggested that the degree of correlation between archaeological sites and palaeochannels/river systems has been over stated and there is significant scope to conduct further surveys in the landscape which demonstrate no fluvial activity. However, the survey here wanted to demonstrate the wealth of sites in the area and in doing so, record them accurately before degradation and erosion sets in. A next option would be to explore sites that are not close to any visible water source. It is simple to suggest that past populations were environmentally deterministic and settled by the river courses, but these people possibly had to stay resilient in times of flooding and possibly tough weather changes, so did the climate really cause collapse here?

Shovel testing was originally planned for this research to obtain carbon dates from sub surface contexts on sites. There are two reasons why this was abandoned. Firstly, an objective of this project was to obtain a regional understanding of the placement of settlements, therefore identifying as many of them as possible in a short space of time was imperative. Secondly, obtaining carbon dates on a level that would have been useful would have been costly.

To finish with some concluding remarks, the Niger River Valley in the Republic of Benin, West Africa, archaeologically was a *terra incognita* until my research and the research of the Crossroads of Empires project. As it was a completely unknown area, apart from a few historical sources after 1800, this was a fantastic opportunity to explore the realms of using GIS and remote sensing to investigate the region. Generally, work in West African archaeological contexts had not used this type of technology, therefore methodologies were attempted that had been used elsewhere, such as Mesopotamia and were applied to see if they work in this study region. One of the major outcomes of this survey work is the compilation of a comprehensive gazetteer of sites and material culture found in the region by this project and *Crossroads,* which totals 832 sites. This collection of data and its comprehensive analysis in this thesis opens new horizons for both the field of study, the region itself, and the inhabitants.

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