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An Exploratory Study of Middle Stone Age and Later Stone Age Site Locations in Kenya’s Central Rift Valley Using Landscape Analysis: A GIS Approach

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Dedication

This work is dedicated to my father, Maina Kabiru, who passed away in May 2017.

Abstract

The Kenyan central rift has witnessed dramatic climatic changes over relatively short periods of time in response to global climatic changes, with the water levels of the lakes within the rift rising and falling with these changing conditions. There is considerable evidence showing extreme wet and dry phases throughout their existence. These wet and dry phases also influenced the vegetation cover, and by extension, the resources available to human and animal populations at any one time. The rise and fall of lake levels is reflected in the settlement patterns and subsistence strategies of different populations through time. Previous studies have been carried out to compare how the Middle Stone Age (MSA) and Later Stone Age (LSA) social and territorial systems differed in their adaptations to similar resource structures, since they are generally found in the same areas. However, earlier comparisons are based on the constitution of lithic and faunal assemblages at individual sites, without considering broader spatial scales that include territories and areas of land use that surround sites and settlements, and more ephemeral features that may influence the choice of site settlements. Since archaeological sites are a part of a cultural landscape within which particular systems of activities take place in space and time, landscape analysis is suggested for a broader approach than just tool types and morphology. Settlement patterns are instrumental in explaining subsistence strategies and spatial organization in relation to ecological and physical resources. The main aim of this study is to use geographical information system (GIS) methods to explore patterns in site locations during the MSA and LSA, and to establish differences and similarities between the periods. GIS is ideal for analyzing social and ritual landscapes by testing proxies for visual perception. Mapping archaeological sites using GIS improves our ability to detect settlement patterns that are not otherwise apparent. Visualization of sites makes it possible to compare their locations in relation to geographic features that may have influenced their locations. The methodology employed includes visibility analysis and statistical analyses that include Spatial Autocorrelation, Average Nearest Neighbor, Multi Distance Cluster, and Directional Distribution. Mapping archaeological sites using GIS improves our ability to detect settlement patterns that are not otherwise apparent. Visualization of sites makes it possible to compare their locations in relation to geographic features that may have influenced their locations.

Results indicate that there are differences in the locations of MSA and LSA sites, with distinct patterning at specific distances. The clustering shown may be an indication of location preference due to availability of resources and security considerations, but may also have been highly influenced by climatic conditions and existing physical features. The locations of view sheds generated from selected sites indicate different target areas and therefore suggest differing visibility considerations. It is suggested that more intensive surveys and research should be concentrated in areas of site clustering, and in viewshed areas to determine factors that may have influenced this patterning. Site location patterns may give us insights into how sites were chosen and give us an idea on where to look for new sites to explore in future.

Key words: Geography, Geographical Information Systems, Archaeology, Kenya, Central Rift Valley, Landscape analysis, Middle Stone Age, Later Stone Age

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Abbreviations used in the text

LSA – Later Stone Age

MSA – Middle Stone Age

BP – Before Present

GIS – Geographical Information Systems

NMK – National Museums of Kenya

DEM – Digital Elevation Model

DTM – Digital Terrain Model

SASES – Standardized African Sites Enumeration System

EDA – Exploratory Data Analysis

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To all the above who I have never met face to face, I say Karibuni Kenya.

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Angela Kabiru

Chapter 1: Introduction

1.1 Problem Statement

In a paper titled ‘Settlement Dynamics of the Middle Paleolithic and Middle Stone Age’, Ambrose (2001) reviewed existing evidence for settlement patterns during the Middle Stone Age (MSA) in the Central Rift Valley of Kenya, and attempted to draw comparisons with settlement patterns of the Holocene Later Stone Age (LSA). One objective of the comparison was to evaluate the degree to which the MSA and LSA social and territorial systems differed in their adaptations to similar resource structures, and their responses to climate change. According to Ambrose, the degree to which MSA and Mid Paleolithic humans differed from LSA Upper Paleolithic humans in their ability to use the landscape and make effective use of resources has not been established, and he theorizes that strategic positioning of settlements to maximize efficiency of resource exploitation may have been perfected at the end of the MSA (Ambrose, 2001).

According to Ambrose (2001), MSA sites are rare, probably due to poor exposure and poor visibility. Rapid alluvial and lacustrine sedimentation may have buried some sites, while deeply incised water courses may have destroyed others through erosion; but behavior and demographic factors may also account for this gap. This is mainly because MSA sites are concentrated within a narrow elevation range (2000-2200m), leading Bower et al. (1977) and Isaac (1972) to suggest a microhabitat preference for an ancient forest/savannah ecotone. A second reason may be due to low site debris resulting from higher residential mobility and less intensive occupation of sites; it may also have been due to low population densities during glacial periods. The areas where MSA sites are located are the lower slopes of escarpments and volcanic mountains, and are highly prone to erosion. LSA zones are mainly concentrated at (1940-2000m), although some are found above 2400m, meaning that the ecotone shifted depending on general climatic conditions. During dry periods it could have shifted to higher elevations while in wetter periods it may have shifted to lower elevations (Ambrose, 2001). Though MSA site surveys and excavations in the Central Rift have been carried out in the past, settlement systems within the MSA remain poorly understood for several reasons such as too few systematic surveys, few excavated sites, and most sites have not yet been recorded.

The transition from the MSA to the LSA is complex and has not been fully explained. Apart from lithic technology which has received considerable attention (for example Ambrose, 1998), there are now studies to compare subsistence strategies, ecological relationships and spatial organization (Cochrane, 2008).

1.2 Rationale: Landscape Archaeology in Africa

According to Fleisher (2013), landscape archaeology in Africa is still in its infancy. He questions why ‘on a continent with so much landscape, have space and spatial practices not been the focus of research?’ He suggests that the problem is a terminological matter, as many African archaeologists have not engaged specifically with landscape related theory. Fleisher defines landscape archaeology as ‘primarily the inclusion of a broader spatial scale into archaeological interpretations to include regions, territories, areas of land use that surround sites and settlements, and more ephemeral features not normally included when discussing sites, such as roads, paths, fields, shrines and graves’ (ibid, pp. 189). He also argues that for African Archaeology, a broader approach has always meant more than just a wider spatial scale, and he has interpreted this in 3 ways:

1. Exploring ways in which people transformed the environment, thereby remaking it into a landscape
2. Providing insights into spatial practices such as foraging and farming, and also power and authority
3. Influencing how we view the African past and how it affects the present.

Further, he suggests that new applications of spatial complexity serve to challenge colonial claims of a stagnant and primitive African past, in addition to aiding in the formulation of environmental and social policy to fit into patterns of continuity and change.

Fleisher (2013) also notes that research in Africa has tended to concentrate on sites with obtrusive features or the richest finds. Since the 1970s and 1980s, research has emphasized larger territories that contain these sites through ‘off site’ approaches (Foley, 1981), and territorial or regional approaches (Sinclair, 1987; McIntosh and McIntosh, 1980). All these approaches however rely on archaeological surveys (Bower, 1986), but most archaeological surveys remain unsystematic (Fleisher, 2013). This means that surveys have mostly been focused on finding sites, rather than a comprehensive effort to understand the relationships between sites. Fleisher argues that for results to be considered regionally representative of landscape patterns, surveys need to be systematic.

Isaac (1989) formulated the ‘home-base’ and ‘central place foraging’ models. He argued that data should be analyzed as distributions across the landscape, that ‘the value of stone tools lies not so much in the details of morphology as in the fact that these objects are crucial markers of the places where early man was active’ (pg. 77). His work was based on research in the Koobi Fora area in Kenya, which has a very rich collection of hominid fossils and associated artifacts. Other researchers, such as Cachel and Harris (2006) and Bunn (1994), have brought out similar arguments. Through their analyses of different territories, they aimed to understand how perception has influenced individual choices as people moved around the landscape in the early periods of the African past, making land use and resource mobilization important frameworks of study. In later periods, ecological contexts of landscape have been studied through ethnographic study of hunter gatherers to determine seasonal mobility (Mitchell, 2005; Parkington 2001). These kinds of studies, in addition to mapping typologies and technology, aim to address how people used space, made decisions based on their environment and exploited the resources around them.

Although the Central Rift Valley has remained central to discussions of the LSA and MSA traditions of eastern Africa, not much has been done in the contexts of landscape archaeology. Archaeologists are now stressing the need for greater contextualization, quantitative comparisons and temporal span of analyses, in order to test models of affinities and functionality of the prehistoric record (Fleisher, 2013).

1.3 Aims and objectives

This thesis seeks to reexamine the site location criteria within the MSA and LSA using the sites recorded and used in the Ambrose (2001) paper and to make a comparison of the two, in order to try and establish any differences in settlement patterns. The aims are therefore to map site locations within the MSA and the LSA, and to determine if there are any differences in relation to physical features in each period. Landscape and statistical analyses using Geographical Information Systems (GIS) are used for this study. Landscape archaeology is used because it is still a relatively new concept in Africa and its usage has been rather limited. This analysis is suggested to test the applicability of this method of analysis in this context and to hopefully generate questions that can be answered in the future. The statistical analysis is included to generate values that are useful in explaining variation and distribution in a way that is not theoretical. The main advantages of GIS in this context is its ability to integrate various spatial data into the analysis process and to enable visualization of results for better interpretation The use of scientific mapping tools can be used to pattern human settlements, the construction of archaeological features, as well as to provide insights into how human agency expresses itself onto a landscape (Wright et al., 2014).

Aim

The main aim of this study is to use GIS methods to explore patterns in site locations during the MSA and LSA, and to establish differences or similarities between the periods.

Objectives

- To establish spatial patterning in relation to physical features
- To explore differences or similarities in the settlement patterns
- To explore the use of statistical methods in explaining differences in settlement patterns.

The two methods suggested for use are visibility and statistical analysis. I generate viewsheds of the areas surrounding the sites to determine areas that will be seen from the sites, and then apply statistics to establish any patterning to the site locations. Viewshed is considered a tangible cultural asset that enhances or restricts for socially important reasons such as site visibility, resource acquisition or for political reasons (Wright, 2014).

This study is an attempt to add to the contextualization of some of these sites and to make quantitative comparisons in their settlement patterns. The outcome will be a contribution to understanding the dynamics of past land use, and how man shaped his environment and adapted according to climatic and ecological variations.

Chapter 2. Literature Review: Landscape Archaeology

2.1 Definition

Landscape archaeology can be broadly defined as the study of cultural and environmental variables influencing the way humans interacted with their landscape (Ingold, 1993; Yamin and Beschere, 1996). It can be defined at two levels- on the practical level as the study of human remains between sites (Knapp and Ashmore, 1999) and also at a theoretical level, which is more difficult to define due to differing concept of space and therefore landscape (Witcher, 1999).

Metheny (1996:384) defines landscape archaeology as:

> *'...concerned with both the conscious and unconscious shaping of the land; with the processes of organizing space or altering the land for a particular purpose, be it religious, economic, social, political, cultural or symbolic; with the unintended consequences of land use and alteration; with the role and symbolic content of landscapes in its various contexts and its role in the construction of myth and history, and with the enactment and shaping of human behavior within the landscape'*.

Rapopoort (1992) defines a cultural landscape as a system of settings within which particular systems of activities take place in space and time, incorporating particular proximities, linkages, separations and boundaries among settings. He further notes that the term landscape is used by archaeologists to categorize an activity, mental or physical, that is engaged by hominids with their surrounding environment in terms of subsistence or ritual; therefore landscape is the integration of natural and human phenomena related to human life and primarily for living in.

Tilley (1994:14) views landscape as (1) quantifiable, universal, objective, neutral, a-temporal, static, absolute and also as (2) qualitative, experienced, contextual, relative, temporal and dynamic. Ingold (1993) sees this second view as real, as it is 'the world as it is known to those who dwell therein, who inhabit its spaces, and journey along the paths connecting them' because space is not a neutral receiver of human action but a product of human action (Wheatley and Gillings, 2002).

We can therefore look at space as socially constructed, subjectively experienced, and tied to multiple meanings at different times (Bender, 1993; Boaz and Uleberg, 1995; Hirsh, 1995).

But the two conceptions of space are not mutually exclusive. As Witcher (1994:140) notes, integral to such hermeneutic and phenomenological approaches is a de-quantification of space, permitting landscape to be social and qualitative, as well as geometric and economic. Therefore the landscape is a context in which humans survive, recognize the world, act and make meaning. Thus simply put, landscape is the natural environment shaped by the human factor for the purposes of resource utilization and exploitation. This shaping of the environment satisfies both the physical and mental requirements that human populations need to survive. In studying the landscape therefore, we seek to understand the reasons why archaeological populations altered the environment the way they did, and how this helped them survive adverse conditions, and from a cognitive point of view may help us understand how prehistoric populations viewed the world the way they did.

Butzer (1964) held the view that the ultimate goal in archaeology is to determine the inter-relationship between culture and environment, with archaeological research being directed towards a better understanding of the human ecology of prehistoric communities. He however admits that such relationships proved difficult to identify, partly due to a lack of empirical data but also due to a lack of adequate conceptual frameworks within which to analyze these relationships using various phenomena. This has now changed due to an increase in the information base that allows the formulation of sound hypotheses. Furthermore, systems theory has had a large influence in suggesting models to analyze complex relationships. The basic principles of systems theory are perfect for integrating the environmental dimension within contextual archaeology (Butzer, 1964).

2.2 A short history of Landscape Analysis

In the late 1980's and early 1990's, uses of archaeological research using GIS fell mainly into three categories - those using predictive models to find site locations, those examining potential uses of GIS in archaeology, and those focusing on spatial relationships between humans and the environment (Hu, 2012). But most studies were done without the application of archaeological or social theory, with exceptions of research carried out by archaeologists such as Savage (1990), where he used Thiessen polygons to model site catchment areas.

As spatial analysis became more complex and detailed, theoretical applications improved and new studies became possible; line of sight/viewshed analysis, cost surface generation, optimum corridor creation, watershed delineation, and predictive modeling were applied (Madry and Rakos, 1996; Gaffney et al., 1996; Llobera, 1996; Wheatley, 1996; Maschner, 1996). Then came the application of a combination of mathematical functions for analysis (Armstrong et al., 2009; Bell et al. 2002; Swanson, 2003; Whitley, 2002, 2004). This was caused by an increase in the use of spatial statistics and the increasing use of GIS. It is argued that the reason GIS in Landscape Archaeology has not generated new theory is because of the limited availability of user friendly software that enables Exploratory Data Analysis (EDA). EDA can according to Hu (2012), help us understand the range of variation in social organization and space. EDA has the potential to empirically develop ‘post-structural’ multiple causes for a phenomenon, none of which are necessary nor sufficient (Voss, 2008:4). GIS has the ability to characterize these phenomena by spatial manifestation, thereby enabling us to test assumptions (Hu, 2012). According to Conkey (1991), there is in general an increase in integrative and GIS based archaeological studies that will hopefully lead to a generation of new theory.

2.3 Methods of Analysis used in Landscape Archeology

2.3.1 Cost Surface Analysis

Cost surface analysis is a technique based on the ability to assign a cost to each cell in a raster map and to accumulate costs by travelling over the map (van Leusen, 1993). It is rooted in site catchment analysis, first introduced by Vita-Finzi (1970) to study the economy by looking at resources available within a territory associated with a settlement. Researchers such as Verhagen et al. (1999) calculated cumulative travel time in order to construct accessibility catchments, which were then used as inputs for predictive settlement models.

2.3.2 Visibility analysis

The GIS environment offers three main methods of computing visibility analyses. These methods are called differently in different applications.

a) Line of Sight

Line of sight analysis determines whether two points in space are inter-visible. The basic technique involves determining which areas are visible from a given location or whether two points are inter-visible (van Leusen, 1993).

b) Viewshed

Viewshed is created over a digital terrain model (DTM) and estimates the difference in elevation in the observer’s cell and the target cell. To determine the visibility of the target cell, each cell that lies on the line connecting the observer and the target must be examined by Line of Sight. The observer feature class can contain points or lines. The nodes and vertices of lines will be used as observation points. The viewshed analysis tools are useful when you want to know how visible objects might be, for example, from which locations on the landscape will certain objects be visible if they are placed in a particular location, or what will the view be from a road (ESRI, 2013). Practical applications have been used in visual impact analysis (Katsaridis and Tsigouragos, 1993) and explorations of how prehistoric landscapes were perceived by the people living then (Wheatley, 1995).

The basic viewshed can also be used to derive areas of specific activities such as hunting (van Leusen, 1993; Krist and Brown, 1995), security (Madry and Rokos, 1996). Viewshed analysis has now been refined to study inter-visibility (Haas and Caremer, 1993) and visual alignment (Ruggles et al, 1993). Single viewsheds (area that can be seen from one point) can be merged to produce multiple viewsheds (common areas that can be seen from more than one point) (Jacobson et al., 1994; Wheatley, 1995) for instance to determine combined areas from several points. Apart from studying visibility, (van Leusen, 1998), it is also used to build cumulative viewsheds to provide an idea of how hidden a particular locations is (Lock and Harris, 1996).

c) Visibility

Visibility is the last view method offered by the software ArcGIS. In other applications this tool can be called Multiple Viewsheds. The Visibility function provides answers to two basic questions: "What places are visible from the given observation place?" and "From how many observation places is the given object/place visible?”

Visibility analysis has been used in archaeology to understand the significance of built environment and local topography to ancient peoples. Visibility can be determined by several methods- creating line of sight (LOS), viewsheds or intervisibiliy between two or more sites. Visibility is an important factor in locating and constructing archaeological monuments such as hill forts and burrows (van Leusen, 1998).

Visibility analysis has also been used in Cognitive archaeology, the science that studies cognitive aspects of past geographic and human landscapes or the perception of their significance (van Leusen, 1998). According to Zubrow (1994), it is used to show that people had preferences independent of economic requirements and that some decisions have nothing to do with utility; that one of the ultimate goals, then, is to extract cultural ideals from the complicated pattern of prehistoric materials.

Supernant (2014) used visibility analysis to examine the inhabitant and outsider view of the landscape to test whether landscape features were built for either internal or external signaling. The results of the analysis indicate that neither internal nor external signaling was the singular purpose behind building rock feature sites in this region. Visibility analysis has also been used to explore inter-visibility between networks or sites (Čučković, 2014). Here it was used to investigate inter-visibility among 480 hill fort Bronze and Iron Age sites in Croatia and Slovenia. Several degrees of relationships are proposed to establish the degree of distribution to see how sites relate to one another.

In antiquity, visibility would have been an important aspect of communication, and therefore critical for site location strategies. Less obvious than a system of defensive towers, inter-visibility may have been important for small hinterland sites.

2.4 Applicability of GIS in Landscape Archaeology

Due to its ability to analyze spatial data, GIS is ideal for studying landscapes, space, time, and form simultaneously (Gillings and Mattingly, 1999; Green, 1990; Allen et al., 1990). Wheatley (1993, 1996) argues that in addition to analyzing economic and environmental factors in culture change, GIS is also ideal for analyzing social and ritual landscapes by testing proxies for visual perception. He further argues that that this can help researchers explore social organizations more spatially using unambiguous terms. Crumley (1995) and Daly and Lock (2004) argue for the use of multi-scalar approaches in the study of social organization and landscapes. It can also be used to study social space and meaning from practice based approaches (Llobera, 1996; Kvamme, 1999).

Van Leusen (1998) argues that GIS can be used in reconstructing past landscapes because the latter is structured by the fact that resources are distributed unequally; that people’s choices structure their landscape, and in turn are structured by it, so that archaeological remains then exhibit this structuring. It has been suggested that applications of theory in GIS cover wider theoretical debates, and that other methods existed before the advent of GIS. Examples cited here include Renfrew (1979) for viewshed analysis, site catchment analysis (Ericsson and Goldstein, 1980) and cost distance calculations by Gorenflo and Gale (1990).

The major debate has been whether GIS is a methodology that can advance new theory (Lake and Woodman, 2003; Lock and Harris, 1997; Ruggles et al., 1993; Wheatley, 1993), especially in the areas of ritual, cognition and viewshed analysis. Maschner (1996) argues that investigating how humans used the landscape might be a future major contribution to social science, in addition to advancing archaeological and social theory; its use in archaeology may become more sophisticated through the use of archaeologists incorporating it into research agenda. There is, however, agreement that GIS can contribute to understanding Middle Range Theory (e.g. Bevan and Conolly, 2002).

Chapter 3. Literature Review: The Middle and Later Stone Ages

The East African Rift system is an extensive geological feature on the earth's surface. Its formation had a great effect on long-time climates in East Africa. It has also been shown that lake levels rose and fell over time in line with varying climatic conditions, which should be reflected in the subsistence strategies of different occupants through time. This is further supported by the fact that there is considerable data that show extreme wet and dry phases throughout its existence (Shultz and Maslin, 2013).

A major wet phase is recorded at 25,000-22,000 years before present (BP) while Lake Victoria overflowed its banks around 12,500 years BP (Adamson et al., 1982; Livingstone, 1980). The region was generally humid with a few periods of aridity at 8,000; 7,500 and 6,500 years BP (Butzer et al., 1972; Richardson, 1972; Hamilton, 1984). Besides enlarging the rivers, lakes and swamps and creating new ones, the extreme wetness made it possible for drainage basins to connect to each other. Lake Chad is said to have overflowed into the Atlantic Ocean. In the Rift Valley south of the Equator, lake levels rose 60 m above present levels; Lake Elementaita and Nakuru overflowed their basins and made one big lake with lakes Baringo and Turkana in the north about 7,000 years BP (Sutton, 1974). By 4,000 years BP, the lakes had retreated to their current levels (Hamilton, 1982) (Figure 3.1).

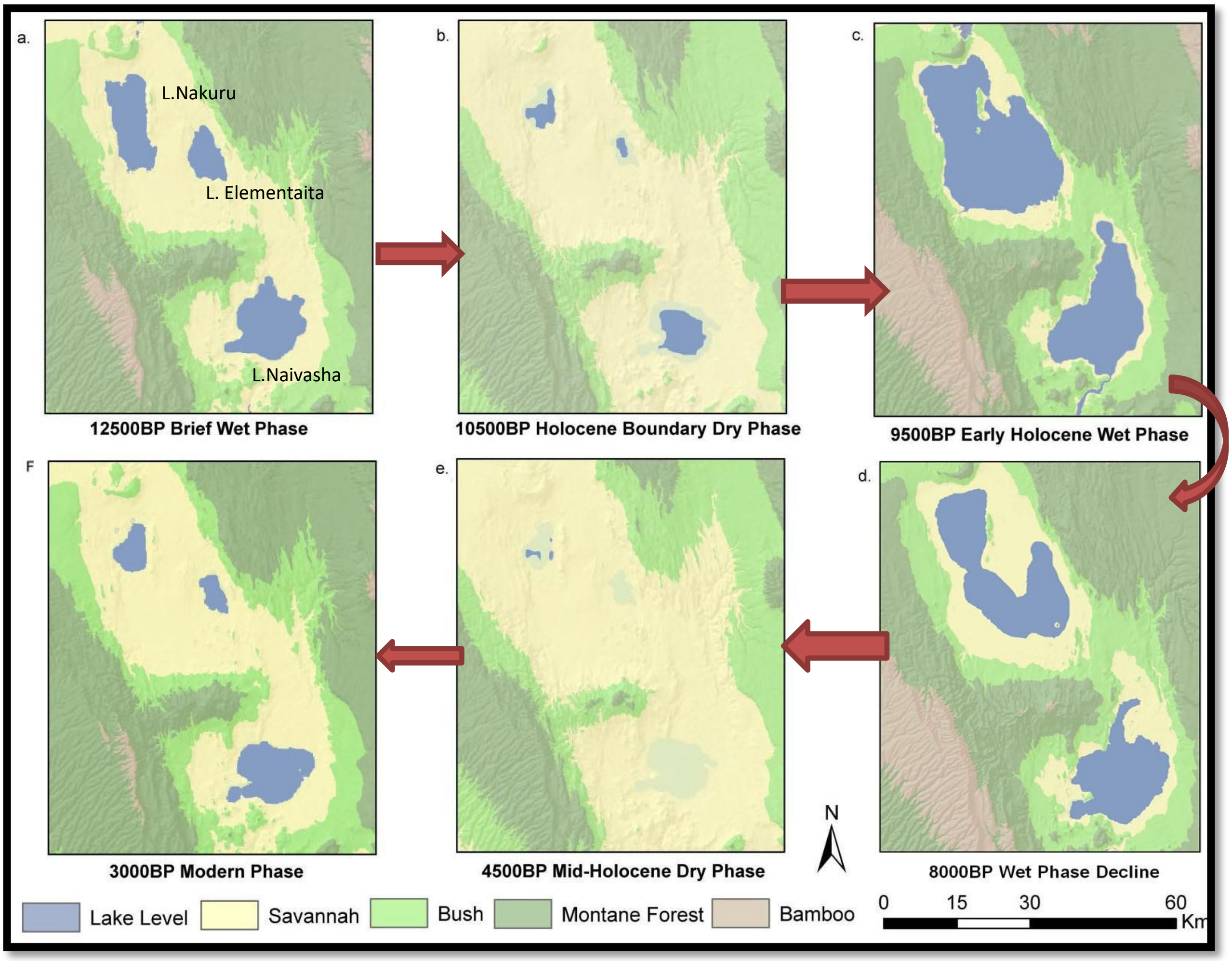

Figure 3.1: Lake level fluctuations in the Kenyan central rift during the Holocene (after Wilshaw, 2014; with permissions). The lakes are from top: Nakuru, Elementaita and Naivasha.

In Africa, from 250,000 years BP to about 10,000 years BP, there was an accelerated shift from broad cultural uniformities towards distinct regional traditions (Phillipson, 2005). This period is referred to as the Middle Stone Age (MSA) and the Later Stone Age (LSA), and although there was no sharp divide between the two, the main tool types show distinct differences in workmanship and size. The MSA in Africa dates from between 250,000 and 25,000 years ago and the LSA 25,000 and 2,000 years ago (Cochrane, 1998, but see also Ambrose, 1998; McBrearty and Brooks, 2000). The MSA covers the period referred to by Clarke (1969) as Mode 3 technology and the LSA Mode 5 technology. Mode 3 technology is based on the prepared core technique and the eventual production of radial cores; Mode 5 technology tools are smaller in size with the resulting microliths and backed blades being hafted onto handles with mastic to create composite tools (Phillipson, 2005).

Throughout the MSA and LSA, people remained hunter-gatherers but their material culture became more elaborate with regional differences (Phillipson, 2005). In the LSA there were tools made from organic materials, fishing and hunting tools, personal adornment, art and ceremonial burials (Deacon, 1984). The production of non-functional objects is thought to be one of the indicators of modern human behavior, and is now a focus of many studies (Klein, 1989; Ambrose, 1998; Deacon, 1984; Cochrane, 2008). There have been arguments that MSA foragers were scavengers (Binford, 1984) but this has been refuted and it is now agreed that they hunted prey (Klein, 1989; Marean, 1998; McBrearty and Brooks, 2000). It has also been argued that MSA hunters were less effective than LSA; still others argue that they were proficient hunters (McBrearty and Brooks, 2000).

It has not been established who made MSA tools, although it is agreed that it was an archaic form of *Homo sapiens*, compared to the LSA which is ascribed to fully modern humans (Phillipson, 2005; Brauer et al., 1997). Phillipson (2005) argues that modern people originated in Africa 280,000 to 140,000 years ago during the MSA, a suggestion first made by Cann et al. (1987). According to Cochrane (1998), these time periods are thought to cover the evolution of modern humans in Africa, during which modern human behavior also evolved. Initially the distinction was purely based on stone tool technology and morphology (Deacon, 1984) but recently the attention has turned to explaining the transition in terms of modern human behavior since the LSA does not correlate with the evolution of Anatomically Modern Humans (Klein, 1989; Ambrose, 1998; Deacon, 1984; Cochrane, 2008).

The differences between the MSA and LSA tool assemblages are well understood, but the process of change has not been clearly explained (Barut, 1994). In many parts of Africa industries that are considered transitional have been found in Tanzania at Nasera and Mumba cave (Mehlman, 1989), at Enkapune ya Muto in Kenya (Ambrose, 1992), and the Tshangalan in Zimbabwe (Walker, 1990). The problem with these so called transitional phases is that assemblages may have been mixed, microliths have been found together with tools made by core reduction, others have a mix of both standardized microliths and levallois cores. Still other assemblages such as the one at Lukenya are separated by geological unconformities (Merrick, 1975). The lack of clear transitional lithic stone tools makes it difficult to study the process of transition between these two technological stages. It is therefore not known how long this transition took, but Ambrose (1992) argues that it may have taken several thousand years. It is clear that by 20,000 years ago LSA industries were widespread throughout much of Africa (Barut, 1994) with plenty of the characteristic backed pieces and microliths widely in use (Gramly, 1976; Brooks and Robertshaw, 1990; Mehlman, 1989; Leakey et al., 1972). More formalized and standardized tool types led to a more widespread use of hafted tools. Advantages brought by the use of smaller tools include lighter projectiles (Clarke, 1970), thereby increasing efficiency and reducing time spent in pursuit of animals, more was therefore captured (Foley, 1989), and it was also easier to replace broken microliths (Torrence, 1990).

Although the difference in stone tool technology between the MSA and LSA is widely acknowledged, the archaeological record covering the transition from the MSA to the LSA is thin (Klein, 1989) and it has been argued that there was little difference in terms of subsistence strategies (Cochrane, 2008). Mitchell (2002) has referred to the transition as an issue of stone technology, but many archaeologists agree that this transition involved both changes in technology and other means of adaptation (Nelson, 1971). Cultural changes included lithic technologies that were more efficient in design and organization (Binford, 1989; Clarke, 1970) more efficient food procurement and patterned land use (Klein, 1975), and more structured social relations (Gamble, 1986). To further explain differences in subsistence behaviour between the MSA and LSA, Klein (1995) and Gamble (1994) note that the key features of MSA behavior include simple material culture with no formal bone tools, basic subsistence and symbolic behavior.

The transition from the MSA to the LSA is complex and has not been fully explained. Apart from lithic technology which has received considerable attention (e.g. Ambrose, 1998) there are now studies to compare subsistence strategies, ecological relationships and spatial organization (Cochrane, 2008). Detailed studies of differences in subsistence strategies, ecological relationships and spatial organization (Klein, Cruz-Uribe and Skinner, 1999; Wadley, 2001; Parkington, 2003) within the MSA and LSA are being carried out to do more detailed comparisons for a better understanding

It is towards this goal that this thesis aims to explore possible differences in settlement patterns between the two time periods in an area that has been continually inhabited for millions of years. Settlement patterns are instrumental in explaining subsistence strategies and spatial organization in relation to ecological resources. In this study I intend to look at differences in settlement patterns between the MSA and LSA in the Kenyan central rift. Although both MSA and LSA sites are generally found in the same general locations, mapping the sites could help bring out patterns in settlement locations not yet apparent.

Visualizing the sites will make it possible to compare site locations in terms of geographic factors that may have influenced their locations. Site location patterning may give us insights into how sites were chosen and give us an idea on where to look for new archeological sites.

Chapter 4: Materials, Method and Data

4.1 Introduction

This chapter outlines the data used for this project, data types and sources and the methodology employed. This analysis has been performed using ArcMap 10.2.2.

The area under analysis lies around the lakes Naivasha, Elementaita and Nakuru at the bottom of the Rift Valley (Figure 4.1), bounded on the western margin by the Mau escarpment and on the East by the Aberdare Ranges. The Nakuru/Elementaita and Naivasha basins are closed lake basins separated by Mt Eburu (Ambrose, 2001). The bottom of the rift is still volcanically active, and contains numerous obsidian concentrations, a raw material that was widely used during the Middle and Later Stone Age periods in Kenya and Tanzania. The vegetation at the bottom is mainly Acacia woodlands around the lakes, savannah grasslands on the plains that morph into montane forest above 2,400m. Montane grasslands and bamboo appear at 2,500m (Ambrose, 2002). The current altitudes of the Nakuru/Elementaita and Naivasha basins stand at 1,760m and 1,890m, respectively (Figures 4.1 and 4.2).

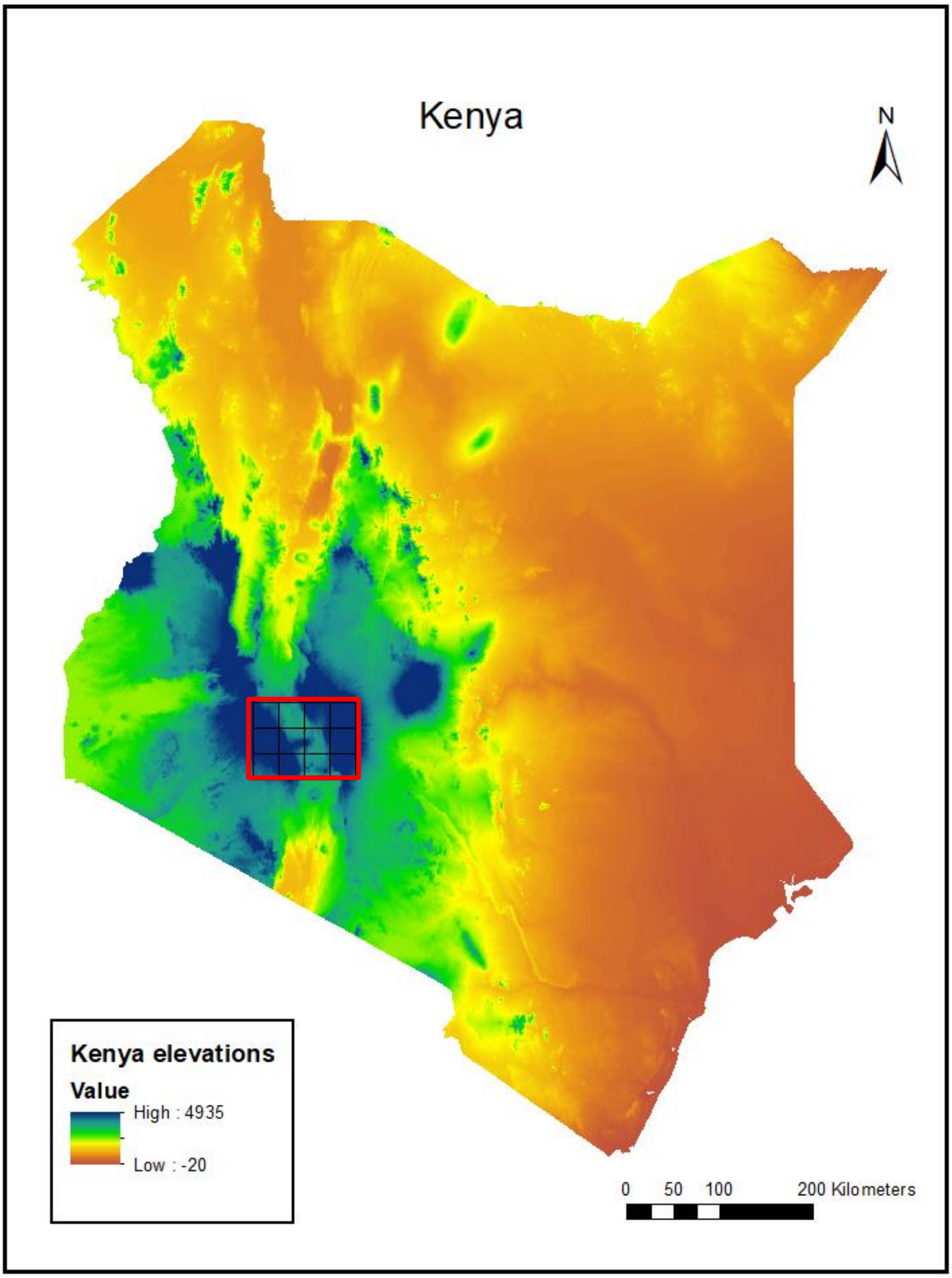

Figure 4.1 Map showing elevations in Kenya (GTOPO30 maps). The area under analysis is outlined in red.

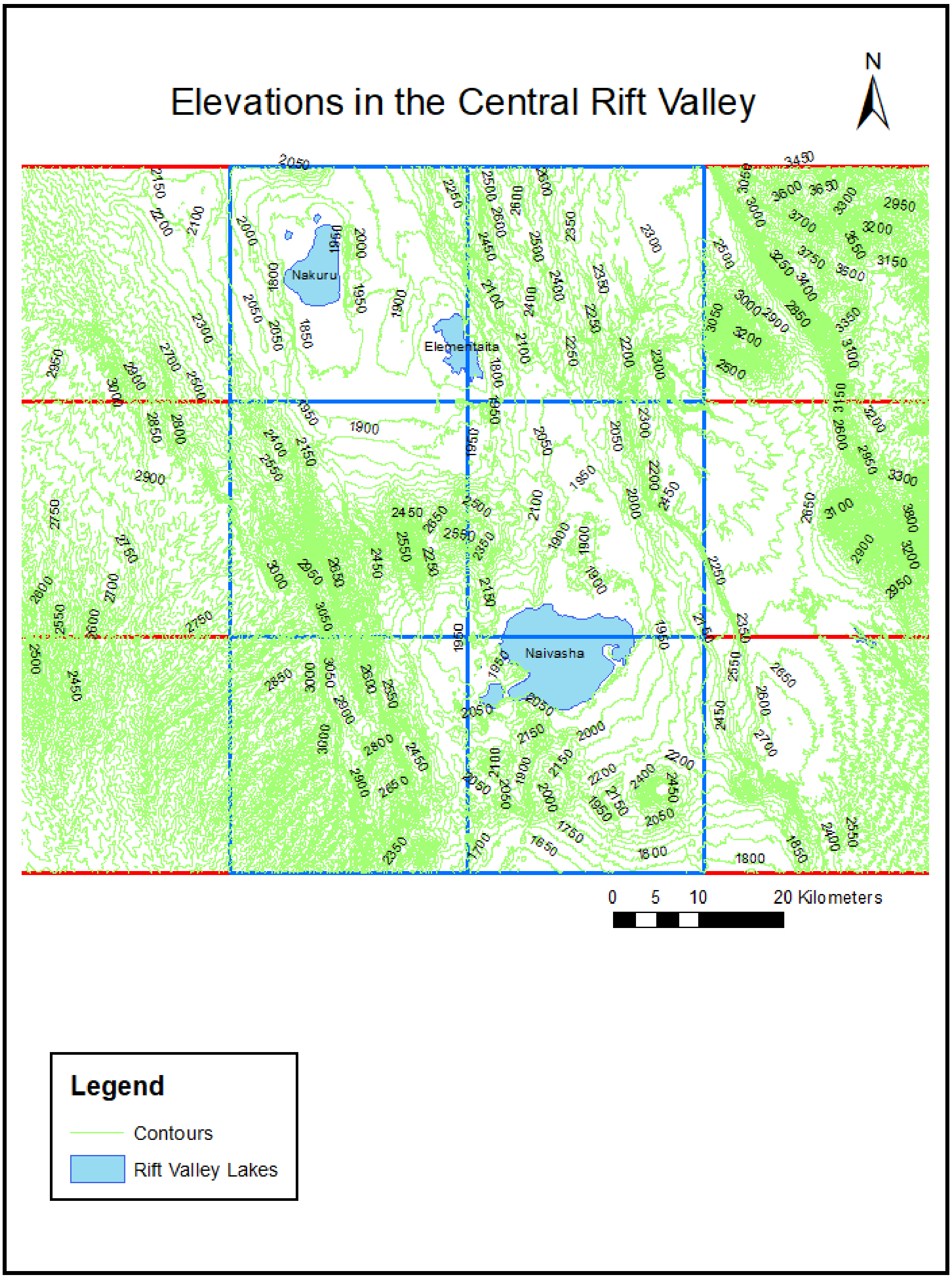

Figure 4.2: Map showing elevations in the central rift. (Units: meters)

4.2 Data

The data used for this analysis includes:

- Archaeological sites
- Digital elevation model (DEM)
- Lakes
- Administrative boundaries

4.2.1 Archaeological sites

Information on archeological sites has been compiled from the National Museums of Kenya Division of Archaeology’s archaeological sites database. The database includes sites that have been recorded over a period of nearly 40 years and range from light scatters to dense concentrations, some of which have been excavated. A detailed list of sites is provided in Appendix I. The sites used are those recorded in topographical maps number 119/3, 133/1, 133/2, 133/3 and 133/4, also named GtJi, GtJj, GsJi, GsJj and GrJi under the Standardized African Sites Enumeration System (Nelson, 1972).

The Standardized Site Enumeration System (SASES) for the continent of Africa was first proposed by Charles Nelson in 1971 during the Pan African Congress on Prehistory and the Study of the Quaternary Commission on Nomenclature and Terminology (Nelson, 1993). This was in response to the growing number of archaeological investigations and the corresponding artifacts and collections. He recognized the need to design new and better methods of documenting primary data and coordinating research. The new system is easily applied, prevents duplication of designations and promotes efficient handling of large amounts of data. The system is designed after similar systems that are used in the United States such as the Smithsonian River Basin Survey system that is based on state and county boundaries; In Canada, a grid system based on latitude and longitude is used (Borden, 1952: after Nelson, 1993); it is this latter system that has been adopted for Africa.

The SASES grid originates at 40°N latitude and 20°W longitude, extending east and south of this point (Nelson, 1993). It has a primary grid that consists of areas specified by capital letters (Figure 4.3). The secondary grid consists of internal subdivisions within the 6° grid, into 576 0^o 15’ squares specified by lowercase letters (Figure 4.4). According to Nelson, the 15’ units were selected because they are the smallest areas that can be accurately defined from 1:250,000, 1:100,000 and 1:50,000 maps which are readily available for any part of Africa. Site numbers are standard Arabic numerals assigned within internal grids. Full site numbers are in the order –latitude- longitude- site number. Primary grid square is listed first, internal grid square second; in the example given, the notation GsJi2, ‘G’ is latitude of primary grid, ‘s’ is latitude of secondary square, ‘J’ is longitude of primary square while ‘i’ is longitude of secondary square; 2 is the second site recorded from the square. The analysis extent is defined by the squares GrJh, GrJi, GrJj, GrJk, GsJh, GsJi, GsJj, GsJk, GtJh, GtJi, GtJj and GtJk.

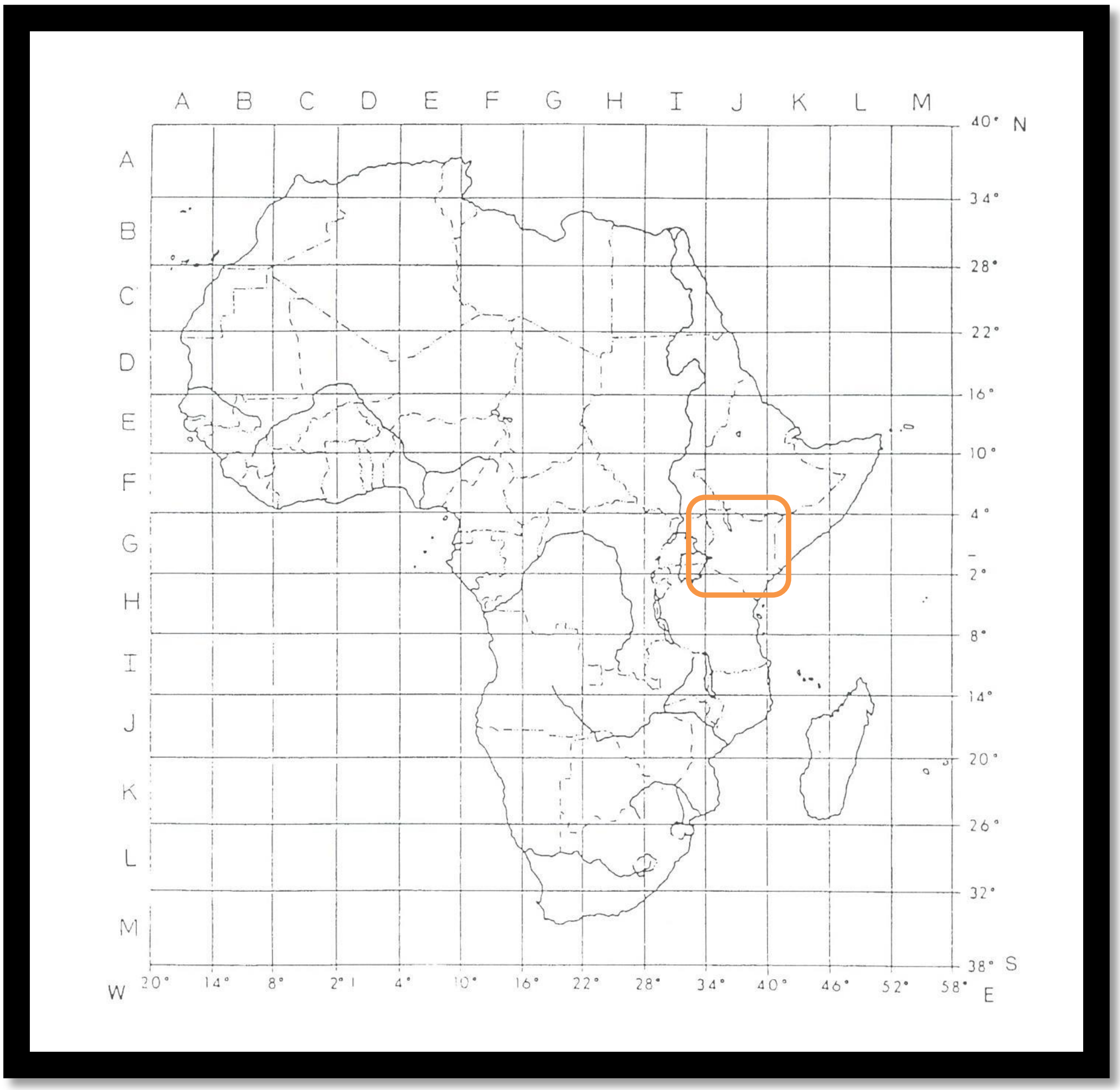

Figure 4.3: The primary SASES grid showing location of Kenya (Nelson, 1993).

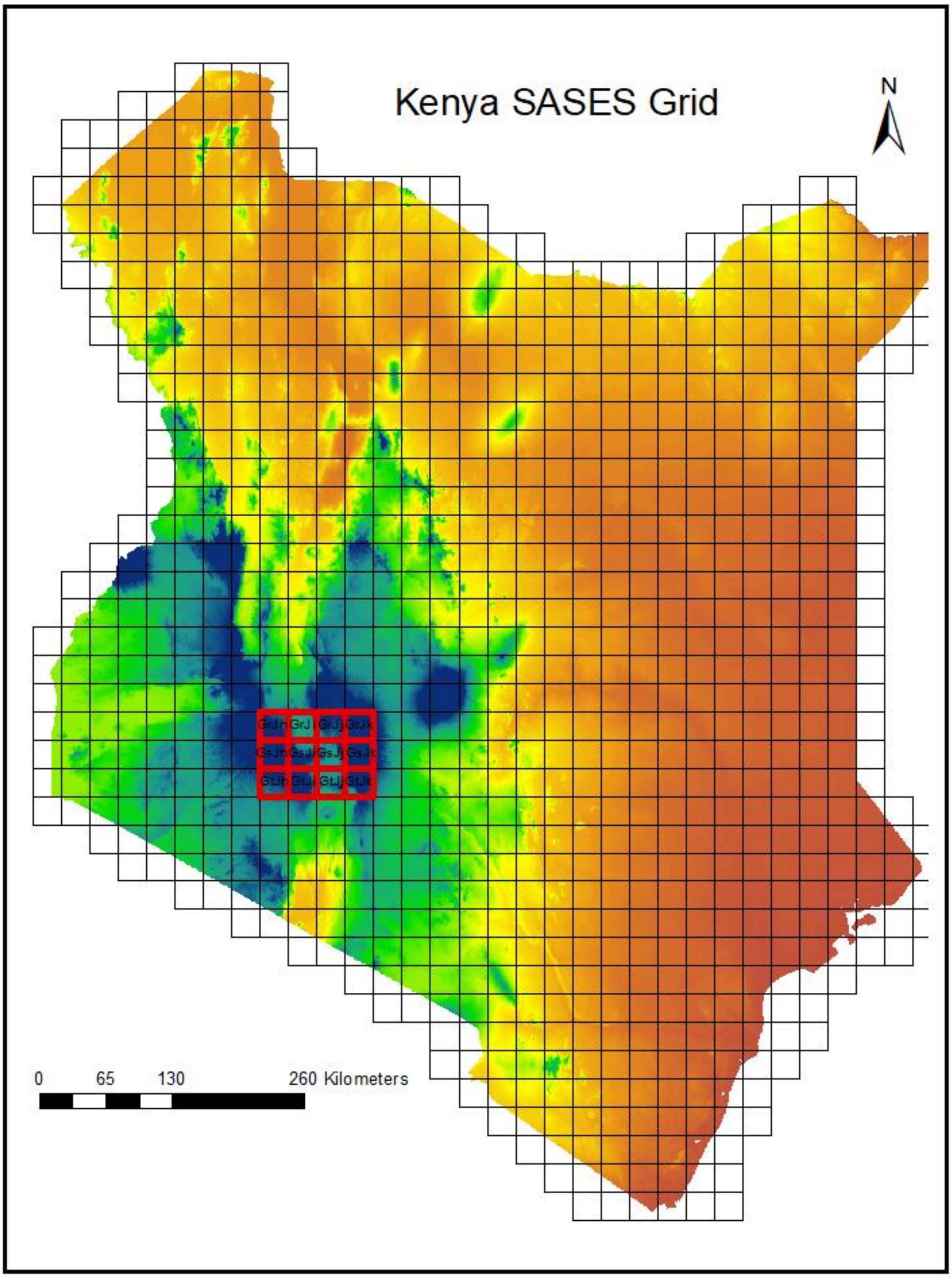

Figure 4.4; The secondary SASES grid. Highlighted square is showing area of analysis.

4.2.2 Digital Elevation Model

The digital elevation model (DEM), used in this exercise was downloaded from http://www.cgiar-csi.org. The NASA Shuttle Radar Topographic Mission (SRTM) DEMs have a resolution of 90m (3 arc second) at the equator, provided in mosaiced 5 degree by 5 degree tiles. The tiles were downloaded in GeoTiff format and then clipped to cover the area of Kenya. The vertical error of the DEM's is reported to be less than 16m. The data is projected in a Geographic (Lat/Long) projection, with the WGS84 horizontal datum and the EGM96 vertical datum.

4.2.3 Lakes

The lake shape file has been downloaded from the datasets made available by World Resources Institute, 2000 on http://www.wri.org/resources/data-sets/kenya-gis-data.

Datum: WGS_1984

4.2.4 Administrative boundaries

The administrative boundaries shape file of Kenya was downloaded from *www.africover.org* with the following details: Reference date of 2002-04-04, with a scale of: 1:100 000, Geographical reference system is in decimal degrees and the Datum is WGS 1984.

The file contains names and areas of provinces and districts within Kenya.The districts used in this map are now referred to as counties after the promulgation of the new Kenya Constitution in 2010.

4.3 Method

4.3.1 Problem analysis, data identification and pre-analysis

In this project, the aim is to explore the patterns of settlement within the MSA and LSA in the Kenyan Central Rift, and their differences or similarities, and to use spatial statistics to further explore the patterns.

4.3.2 Conceptual framework

The following is the summary of steps followed in the analysis (Figure 4.5).

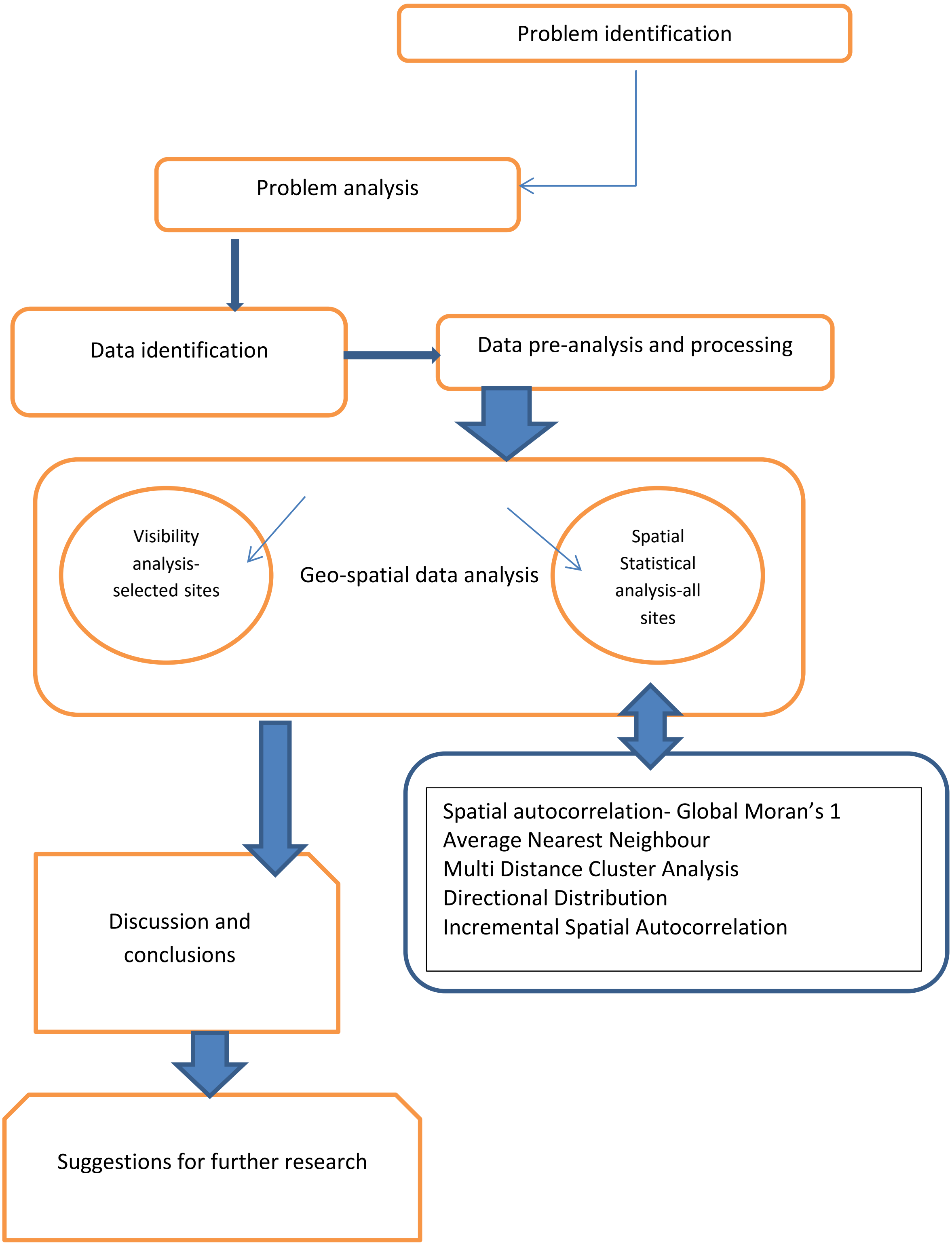

Figure 4.5 Steps taken in the analysis

4.4 Geo-spatial data processing

To prepare the data for analysis, the following was done:

1. Add all shapefiles and DEM to be used in the exercise.
2. Load site coordinates. *From File/Add data/Add X Y data*
Project data: *Data Management Tools-Projections and Transformations-Project*
3. Derive, slope and aspect using *Spatial Analyst Tools- Surface- Aspect, Contour, and Slope,* and elevations using *Spatial Analyst Tools-Extraction-Extract values to points*
4. Separate site layers into MSA, LSA and MSA/LSA.

Since this is an exploratory analysis, a decision was made to select a few sites to work with for visibility analysis. The sampling was based on the number of occupation levels at each site, and it has been assumed that those sites with multiple occupation levels were especially favorable for habitation depending on the condition at the time. However, all sites have been used in the statistical analyses.

MSA

Four sites with several occupation levels, Ol Tepesi Ridge (GsJi 16), GsJi65, Ngunyumu (GsJj85) and Marmonet Drift (GtJi 15) are separated for visibility analysis. These sites are fairly well researched, and published data on them is available. They have been sampled from different sides of Eburru to compare the extents of their viewsheds, and to determine any common areas of interest. Ngunyumu and GsJi65 are located North of Mt Eburru on fairly flat ground. Marmonet drift and Ol Tepesi are located south of Mt Eburru; the former at the foot of the Mau escarpment and the latter on the lower slopes of Mt Eburru.

LSA

Sampling for LSA sites was based on the existence of multiple occupation levels and on their locations: Enkapune ya Muto (GtJi 12) up on the Mau escarpment, Hyrax Hill (GrJi 25) on a hill overlooking Lake Nakuru, and Gambles cave (GsJi 1), Marula Rock Shelter (GsJj 24) and Prospect Farm (GsJi 7) on the northern lower slopes of Mt Eburru. Five LSA sites are chosen in contrast to four for the MSA because there are more recorded sites for the LSA. LSA sites are also located over a wider range of elevations that during the earlier period

Each analysis will be carried out separately on both MSA and LSA sites to determine how they differ in their distribution. The differences or similarities apparent from each analysis will be discussed, after which the results of all the analyses will be compared and combined to reach a conclusion.

MSA/LSA

Some sites are recorded as having occupation levels from both time periods. They are included in the analysis for comparative purposes. All such sites have been used in the exercise.

4.5 Geo-spatial data analysis

4.5.1 Viewshed analysis

Visibility is carried out to determine whether sites are located in specific locations in order to be able to see locations around them. To determine whether sites were situated to maximize view sheds and their visibility, I decided to generate several individual viewsheds to see the area that is visible from the individual sites. This is important from a security point of view. The visibility function determines the raster surface locations visible to a site.

A viewshed is generated by using *Spatial Analyst Tools-Surface-Viewshed* . *(Use earth curvature correction)*

The inputs used are the surface elevation raster (DEM) and site layers. The output raster records the number of times each cell location can be seen by the observation points. The output therefore depends on the number of observation points chosen.

Viewshed analysis is carried out only on the selected MSA and LSA sites.

4.5.2 Statistical analysis

The Spatial Statistics toolbox (Spatial Analyst Tools) contains statistical tools that can be used to analyze spatial distributions, patterns, processes, and relationships. The main difference between these and non-spatial traditional statistics is that although they are similar in terms of concepts and objectives, spatial statistics were developed specifically for use with geographic data. That means they incorporate space (proximity, area, connectivity, and/or other spatial relationships) into the calculations. The tools in the toolbox allows one to summarize the salient characteristics of a spatial distribution, identify statistically significant spatial clusters (hot spots/cold spots) or spatial outliers, assess overall patterns of clustering or dispersion, group features based on attribute similarities, identify an appropriate scale of analysis, and explore other spatial relationships. The information explaining the usage and interpretation of these functions is derived from (ArcGIS 10.5.1. Help). The methods selected for analysis are Average Nearest Neighbour, Incremental Spatial Correlation, Spatial Autocorrelation (Global Moran's I), Multi Distance Cluster Analysis (Ripley's K function) and Directional Distribution.

Statistical analysis has been carried out on MSA, LSA and MSA/LSA site clusters.

4.5.2.1 Spatial Autocorrelation (Global Morans I)

The spatial autocorrelation (Global Moran's I) measures spatial autocorrelation based on both feature locations and values. It evaluates whether the pattern expressed is clustered, dispersed, or random. It calculates the Moran's I Index value and both a z-score and p-value to evaluate the significance of that index. The tool is an inferential statistic; that the results of the analysis are always interpreted within the context of its null hypothesis which is that the attribute being analyzed is randomly distributed among the features in the study area (arcgis pro.com).

If the p-value is statistically significant and the z-score is positive, the null hypothesis may be rejected because it means the dataset is more spatially clustered than expected if spatial processes were random. If the p-value is statistically significant and the z-score is negative, the null hypothesis may be rejected because the spatial distribution of values is more spatially dispersed than expected. The null hypothesis cannot be rejected when the p-value is not statistically significant because it is quite possible that the spatial distribution of feature values could be the result of random spatial processes.

The attribute of analysis here is elevation. This is because the sites seem to be located around the main physical feature, Mt Eburru, and on the slopes of the escarpment. This method has been selected due to its ability to define feature patterns based on locations and other values. The patterns are defined as clustered, dispersed or random; in this case clustering will indicate a preferential elevation.

Method: ArcToolbox-Spatial Statistics Tools-Analyzing patterns-Spatial Autocorrelation (Morans I)
Inputs: Feature Class-MSA, LSA, MSA/LSA;
Field: elevation

4.5.2.2 Average Nearest Neighbor

The average nearest neighbor measures the distance between each feature centroid and its nearest neighbor's centroid location. It then averages all distances and if the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered. If the average distance is greater than a hypothetical random distribution, the features are considered dispersed. The average nearest neighbor ratio is calculated as the observed average distance divided by the expected average distance (with expected average distance being based on a hypothetical random distribution with the same number of features covering the same total area). If the average nearest neighbor ratio is less than 1, the pattern exhibits clustering. If the index is greater than 1, the trend is toward dispersion. The tool may be used to quantify and compare the spatial distribution of a plant or animal species within a fixed study area or to monitor changes over time by evaluating changes in spatial clustering (arcgispro.com). The reason for using this method is to bring out any patterns in the site locations that are not apparent through simple visual inspection.

Method: ArcToolbox-Spatial Statistics Tools-Analyzing patterns-Average Nearest Neighbor.
Inputs: Feature Class-MSA, LSA, MSA/LSA;
Parameters: Euclidean Distance

4.5.2.3 Multi Distance Cluster analysis

The multi-distance spatial cluster analysis, based on Ripley's K-function, is another way to analyze the spatial pattern of incident point data. Ripley's K-function is applied to detect clustering and relationships between points. An advantage of this method is that it summarizes spatial clustering or dispersion over a range of distances because patterns change when the neighborhood size changes. This is useful when exploring spatial patterns at multiple distances and spatial scales. If the average number of neighbors for a particular evaluation distance is higher/larger than the average concentration of features throughout the study area, the distribution is considered clustered at that distance, and *vice versa.*

Method: ArcToolbox-Spatial Statistics Tools-Analyzing patterns-Multi-Distance Spatial Cluster Analysis.
Inputs: Feature Class- MSA, LSA, MSA/LSA;
Parameters: 10 Distance Bands, 0 permutations, minimum Enclosing Rectangle

4.5.2.4 Incremental Spatial Correlation

The Incremental Spatial Autocorrelation tool measures spatial autocorrelation for a series of distance increments and creates a line graph of those distances and their corresponding z-scores. The results include, for each distance increment, the associated Moran's Index, Expected Index, Variance, z-score and p-value. Z-scores indicate the intensity of spatial clustering; z-scores indicate distances where spatial processes promoting clustering are most pronounced. These are shown as a series of peaks on the resulting graph. Spatial clustering in the landscape is evidence of underlying spatial processes (ArCGIS 10.5.1 Help).

Method: ArcToolbox-Spatial Statistics Tools-Analyzing Patterns
Inputs: Feature Class-MSA, LSA, MSA/LSA;
Number of Distance Bands:10

Both Multi Distance cluster analysis and Incremental spatial correlation provide data on distances at which clustering occurs; the former detects patterns within a neighborhood, while the latter provides very specific data at each specific distance. The methods provide evidence of clustering if any, values of intensity of this clustering, and the distances of interest in this patterning. The results provide very specific values that can be used in defining areas and distances to work with. This way, it is easy to identify and map areas for further survey and excavation.

4.5.2.5 Directional Distribution

The directional distribution (Standard Deviational Ellipse) creates a new feature class containing an elliptical polygon centered on the mean center for all features. The attribute values for these output ellipse polygons include two standard distances (long and short axes); the orientation of the ellipse; and the case field, if specified. When the features have a spatially normal distribution, they are densest in the center and become increasingly less dense toward the periphery. Then one standard deviation encompasses approximately 68 percent of all input feature centroids. Two standard deviations will encompass approximately 95 percent of all features, and three standard deviations will cover approximately 99 percent of all feature centroids. This tool may be used to map distributional trends that might identify a relationship to physical features. The results may be used to determine whether Mt Eburru was a major determining factor in the choice of site locations.

Method: ArcToolbox-Spatial Statistics Tools-Measuring Geographic Distribution-
Directional Distribution (Standard Deviational Ellipse)
Inputs: Feature Class-MSA, LSA, MSA/LSA;
Parameters: Ellipse Size-I Standard Deviation

Chapter 5: Analysis Results

This chapter presents the results of the analysis, resulting maps and graphs with explanations of what they represent.

5.1 Topographical setting

5.1.1 Profile

The Mau escarpment and the Aberdare Ranges rise rather steeply from the rift floor, and therefore form a trough when viewed in cross section (Figure 5.1). The dramatic rise in altitude is shown by the profile generated for the area. When viewed in cross section, the Rift valley resembles a trough as the escarpment walls are steep while the valley bottom is fairly flat. The lowest altitude for the area of analysis is 1750m while the highest is 3950m. Elevations of the area are shown in the contour map in Fig. 5.1, and the terrain profile of the area under analysis is shown in Fig. 5.2.

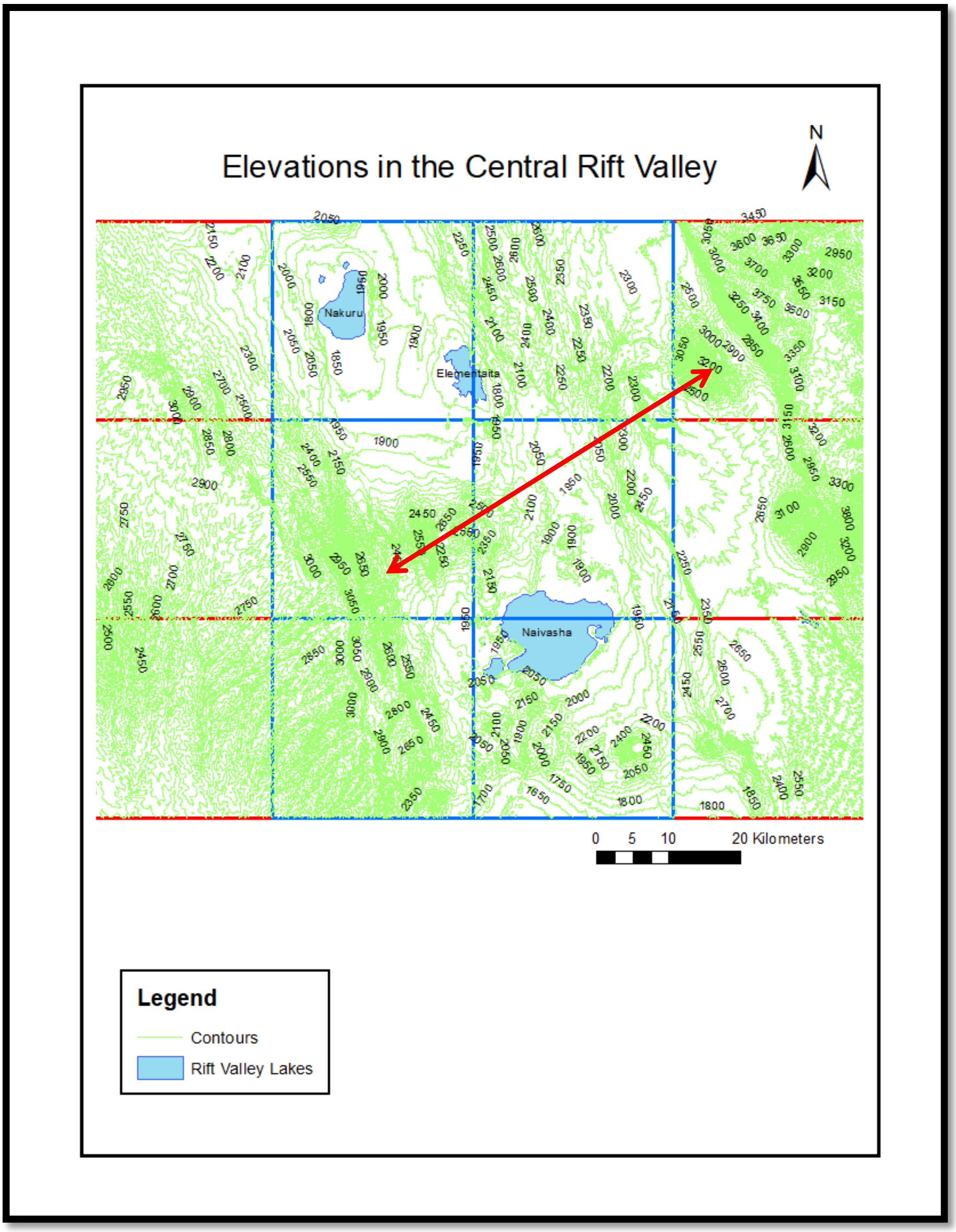

Figure 5.1: Contour map showing elevations for the central rift. The line across indicates profile line.

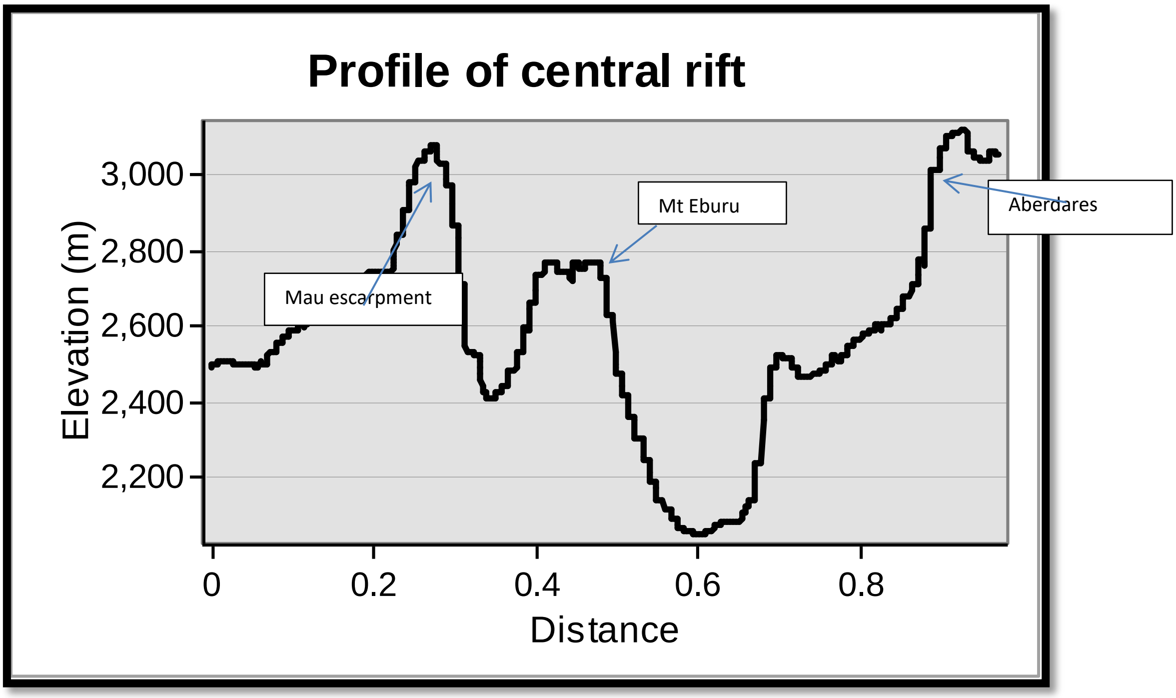

Figure 5.2: Profile of the Central Rift valley west to east with Mt. Eburru in the middle. Scale of horizontal distance is 20km (0.1 distance units = 10 km)

When the slope is generated for the area under analysis, it can be seen that the steepest areas are the escarpment walls while the valley bottom is flat (Fig. 5.2).

5.1.2 Slope

The slope angle was also generated to determine if there was any preferred slope for any of the periods. All MSA sites falls within the range of 0.52-6.28 %, while those within the LSA lie between 0.15 and 8.62%. Although some of the slopes used are steeper during the LSA, most of the sites are still situated on the more gentle slopes and only a few are on very steep slopes (see Fig. 5.3).

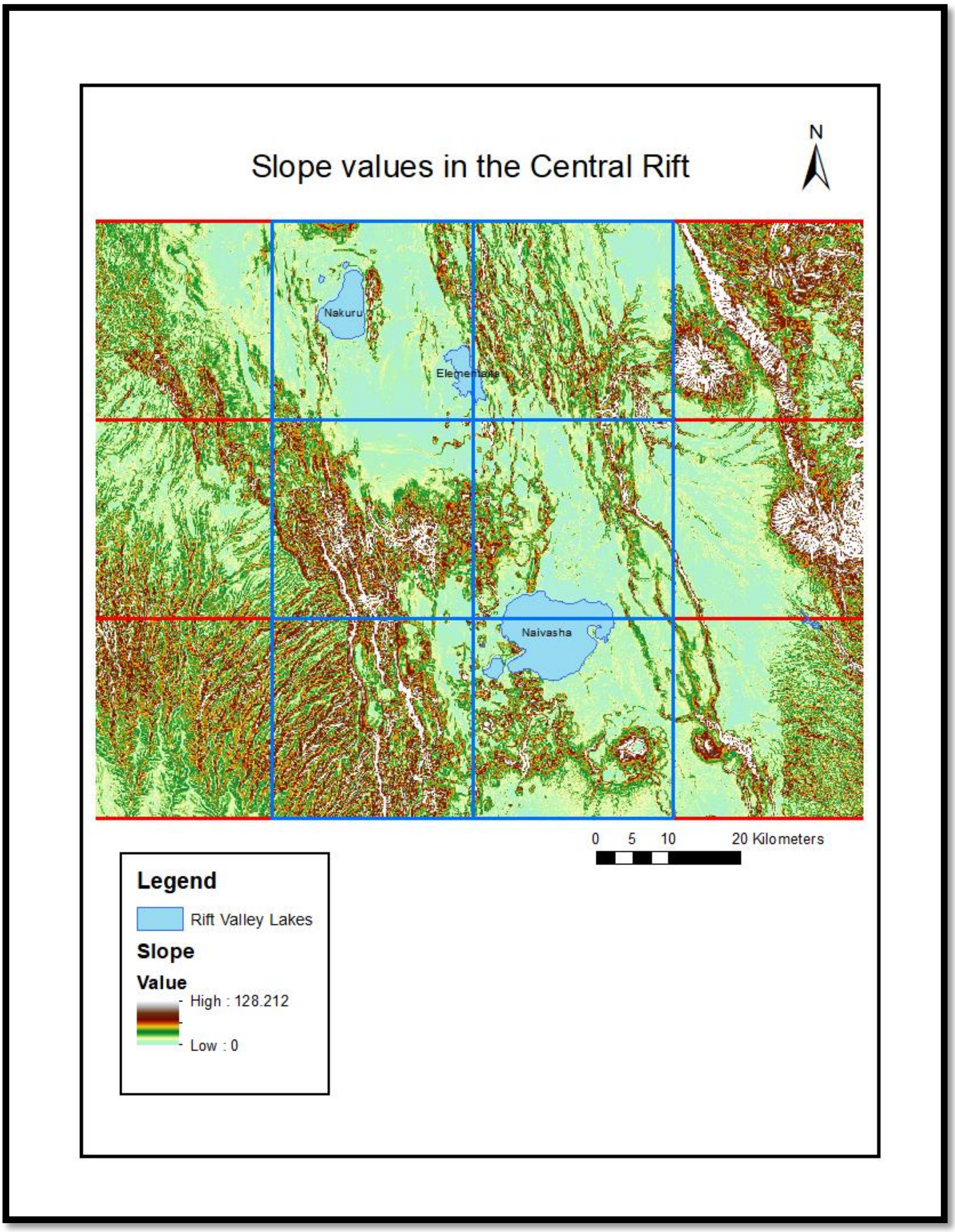

Figure 5.3: Map showing slope (%) of the area under analysis

5.1.3. Aspect:

Most sites both within the LSA and MSA are located on flat ground. In both time periods only a few sites have an aspect value greater than 1 degree; a few have values of 90 and 180 degrees but these are less than 10% of the total number of sites. It is assumed that aspects have not changed significantly to influence the result. The complete table of calculated aspects for the sites can be found in the Appendix II.

5.2 Descriptions of site locations

1. Site elevations:

The general distribution of the sites shows that all of the sites occur between around 1800 and 3000m above sea level, but that most of the sites are concentrated between 1800 and 2200m (Fig. 5.4).

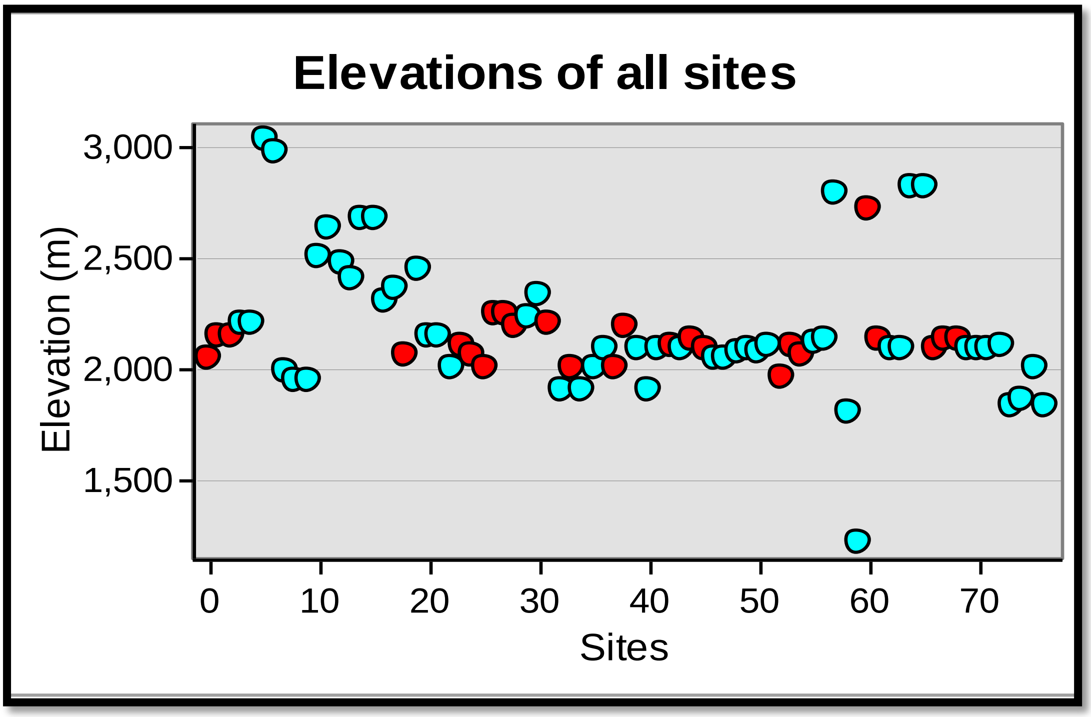

Figure 5.4: Graph showing distribution of site elevations; MSA sites are shown in red.

When analyzed separately, it is can be seen that LSA sites fall between 1800m to over 3000m but a majority of them are between 2000m and 2400m (Fig. 5.5). In contrast, MSA sites (Fig.

5.5) are concentrated within a narrow belt between 2000m and 2200m, although a good number of them are recorded at 1800m. This distribution has been discussed in Chapter 3.

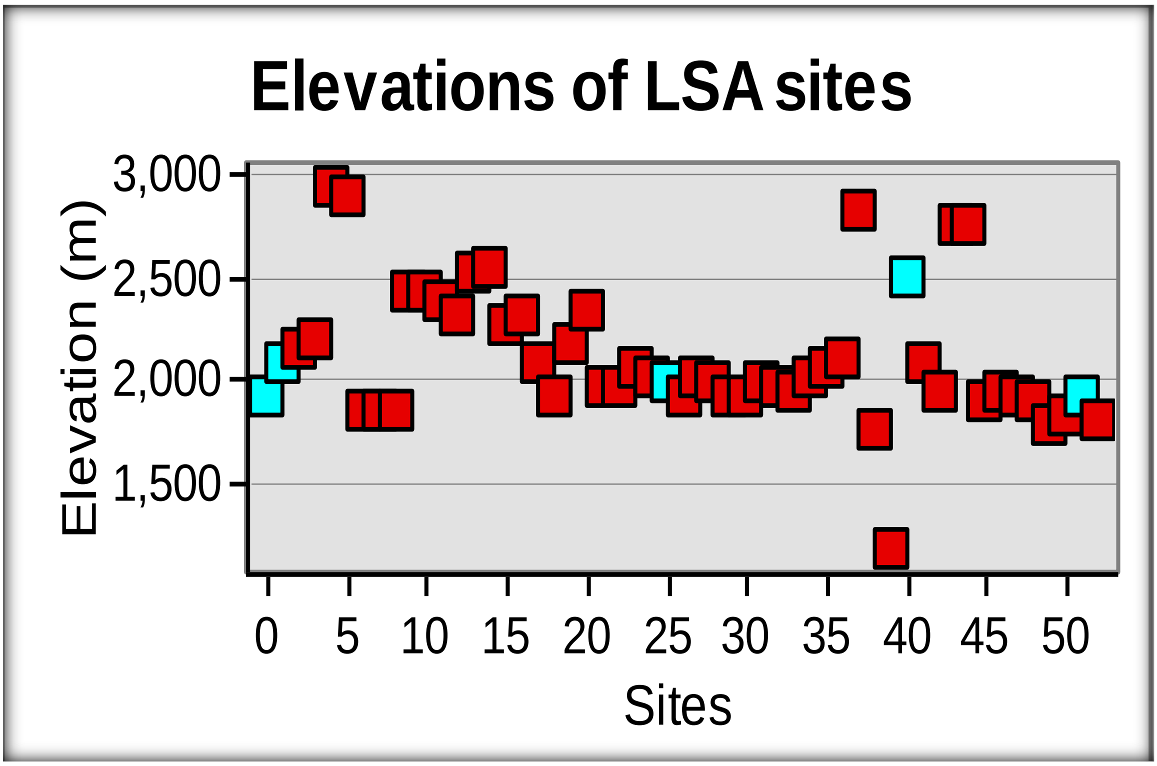

Figure 5.5: LSA site elevations. Selected sites for analysis are highlighted in green.

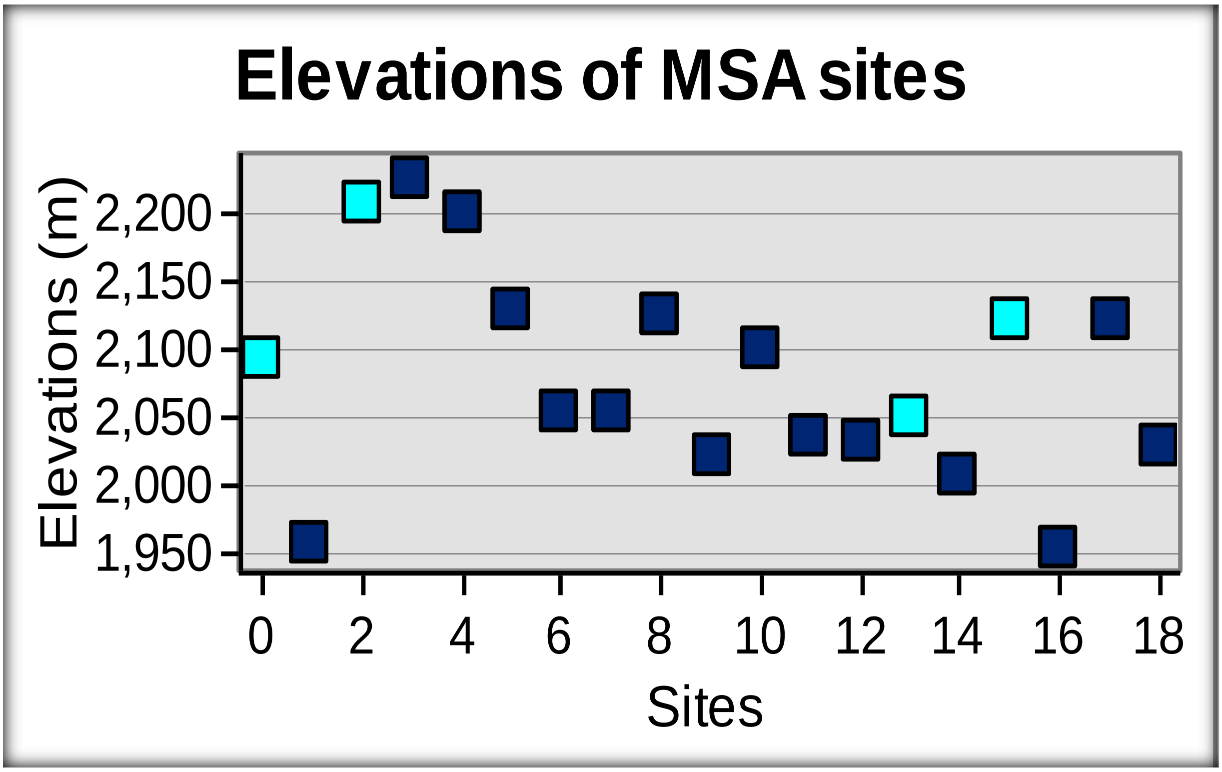

Figure 5.6: MSA Site elevations. Selected sites for analysis are highlighted in green.

The comparison between the locations of MSA and LSA sites (Figures 5.6) shows that sites within the MSA were mainly concentrated around the floor of the rift, surrounding Mt Eburu. It can also be seen that none of the MSA sites are located very close to the lakes. In contrast, LSA sites are distributed over a wider range of altitude from very close to the lakes to high up on the escarpment and all the way to the edge of Lake Nakuru. In general, that LSA sites seems to be spread over a larger area compared to the MSA sites but they show a similar distribution pattern as both types are mainly concentrated around the base of Mt Eburru.

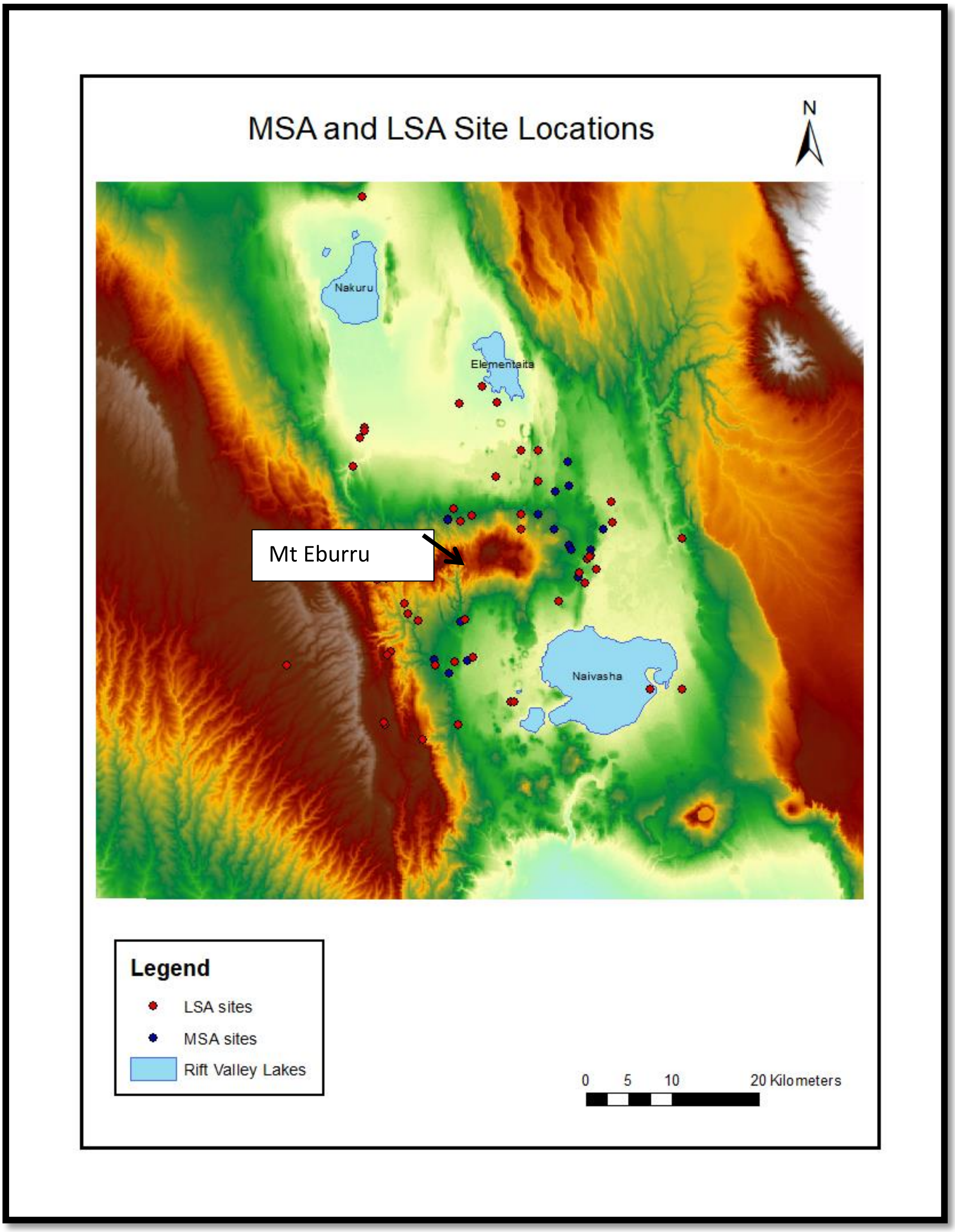

Figure 5.7: Map showing locations of MSA and LSA sites. Most of the sites are clustered around Mt. Eburru.

5.3 Visibility analysis

The viewsheds generated for the 9 selected sites are presented and discussed below.

5.3.1 Ngunyumu (MSA site 1)

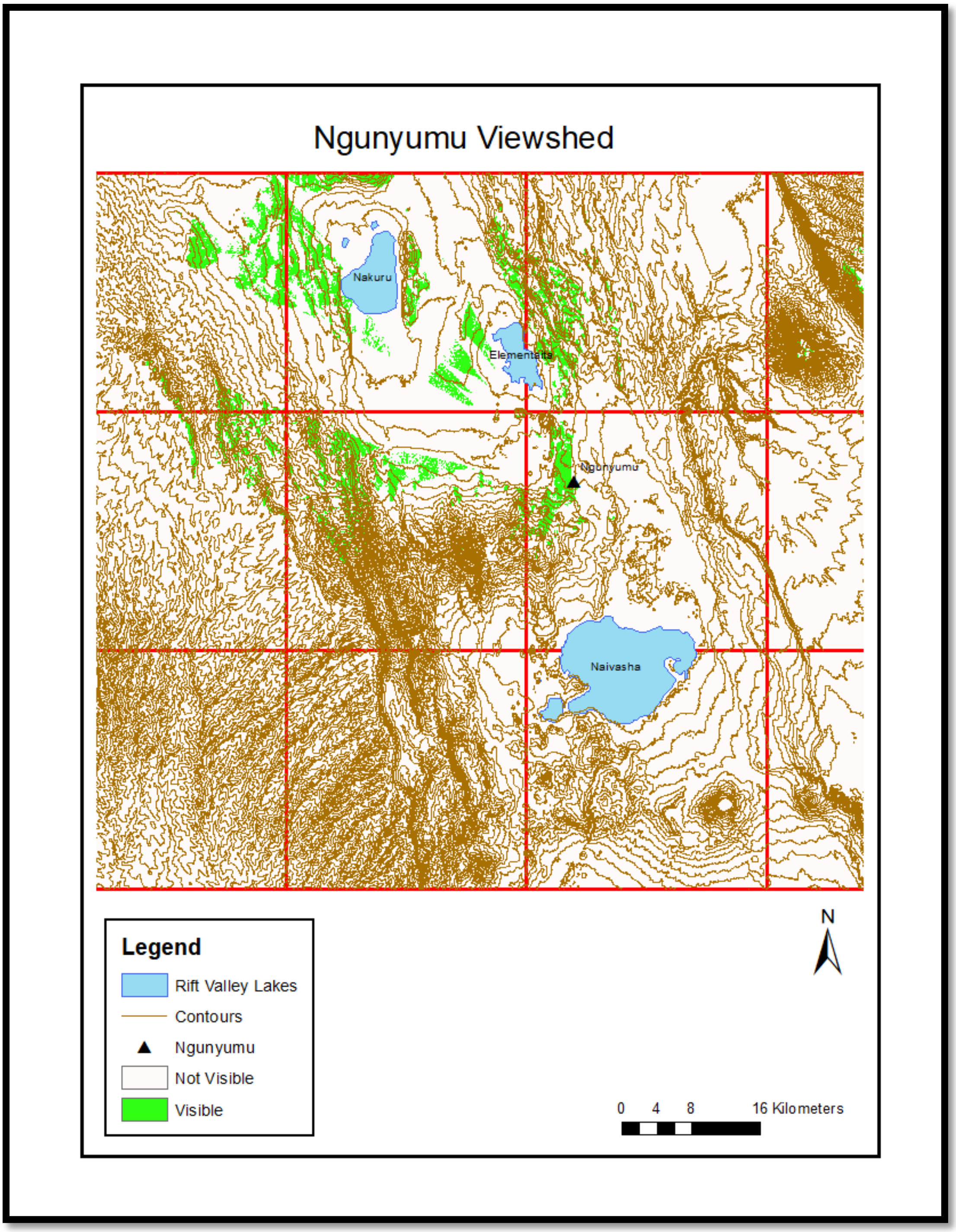

Figure 5.8: Map showing viewshed for Ngunyumu site.

The Ngunyumu site viewshed (Fig. 5.7) covers areas around Lakes Elementaita and Nakuru. This site at 2051m is located higher than the highest lake levels at 1900m so it could have been occupied even during very wet periods. The viewshed covers areas very close to the two lakes and sections of both escarpments. The south side of Mt Eburru cannot be seen from the site.

5.3.2 Marmonet Drift (MSA site 2)

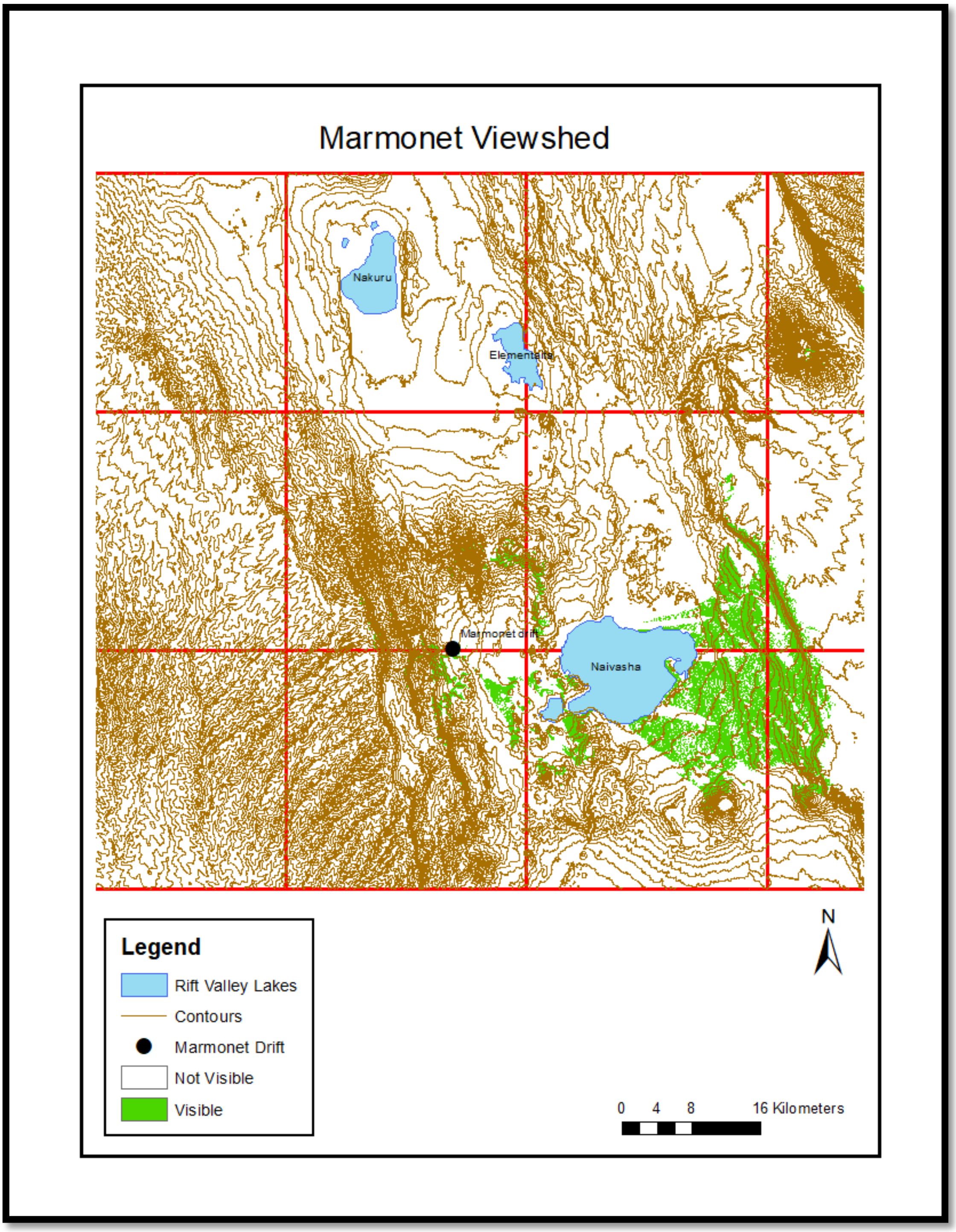

Figure 5.9: Map showing Marmonet Drift viewshed

In the viewshed generated for Marmonet Drift (2120m) large areas on the extreme side of Lake Naivasha are visible (Fig 5.8). Only a few areas immediately around the site are visible. The viewshed covers mainly low lying areas with limited visibility on higher elevations.

5.3.3 Ol Tepesi Ridge (MSA site 3)

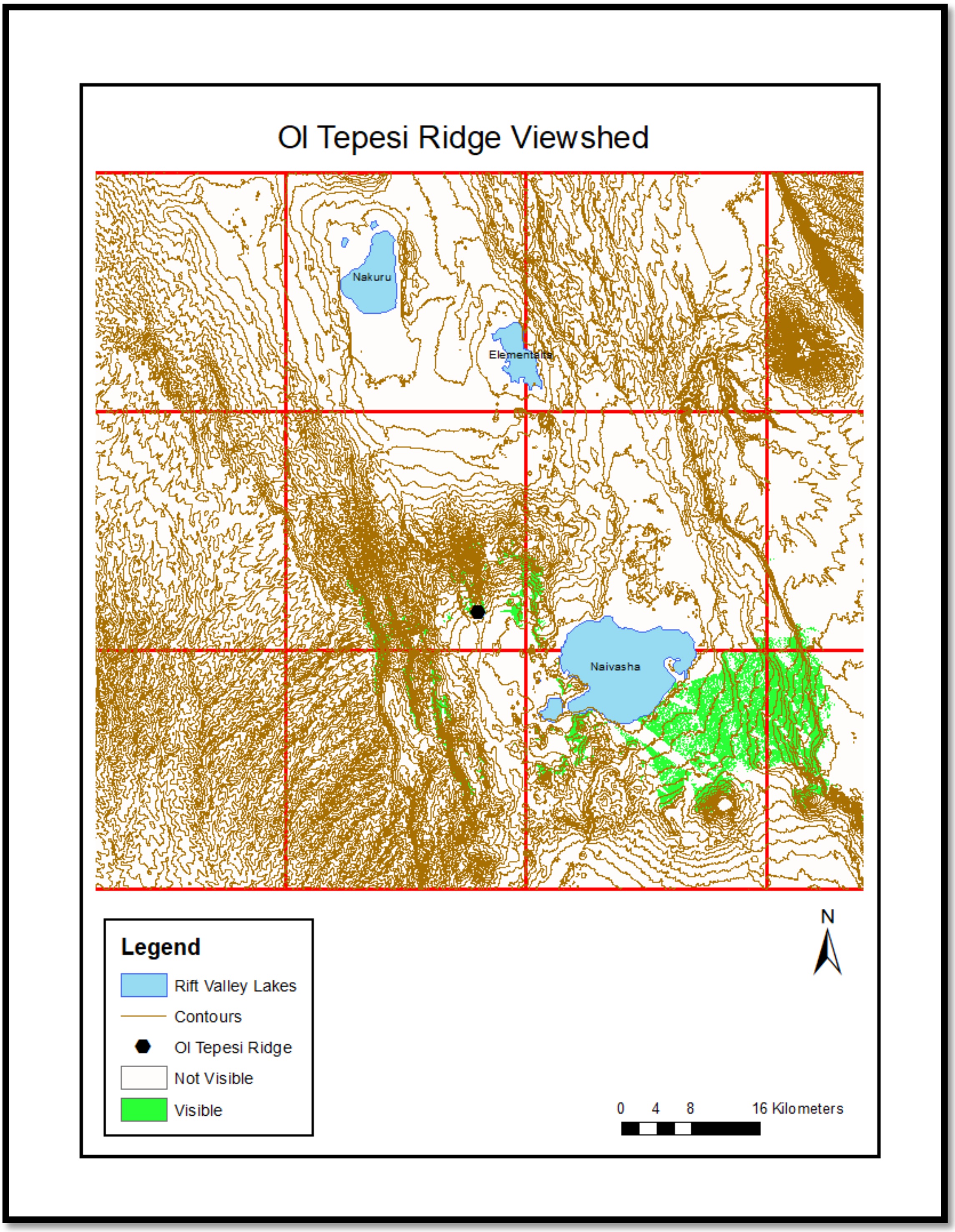

Figure 5.10: Map showing Ol Tepesi Ridge viewshed

The viewshed of Ol Tepesi Ridge (2093m) is quite extensive, covering the areas mainly to the south and east of Lake Naivasha. The viewshed extends across the valley floor all the way to where the slope begins to rise (Fig. 5.9). It is interesting to note that the Marmonet Drift viewshed looks very similar to the Ol Tepesi Ridge viewshed although the sites are not located close to one another. A small section of the southern slopes of Eburru is also visible.

5.3.4 GsJi 65 (MSA site 4)

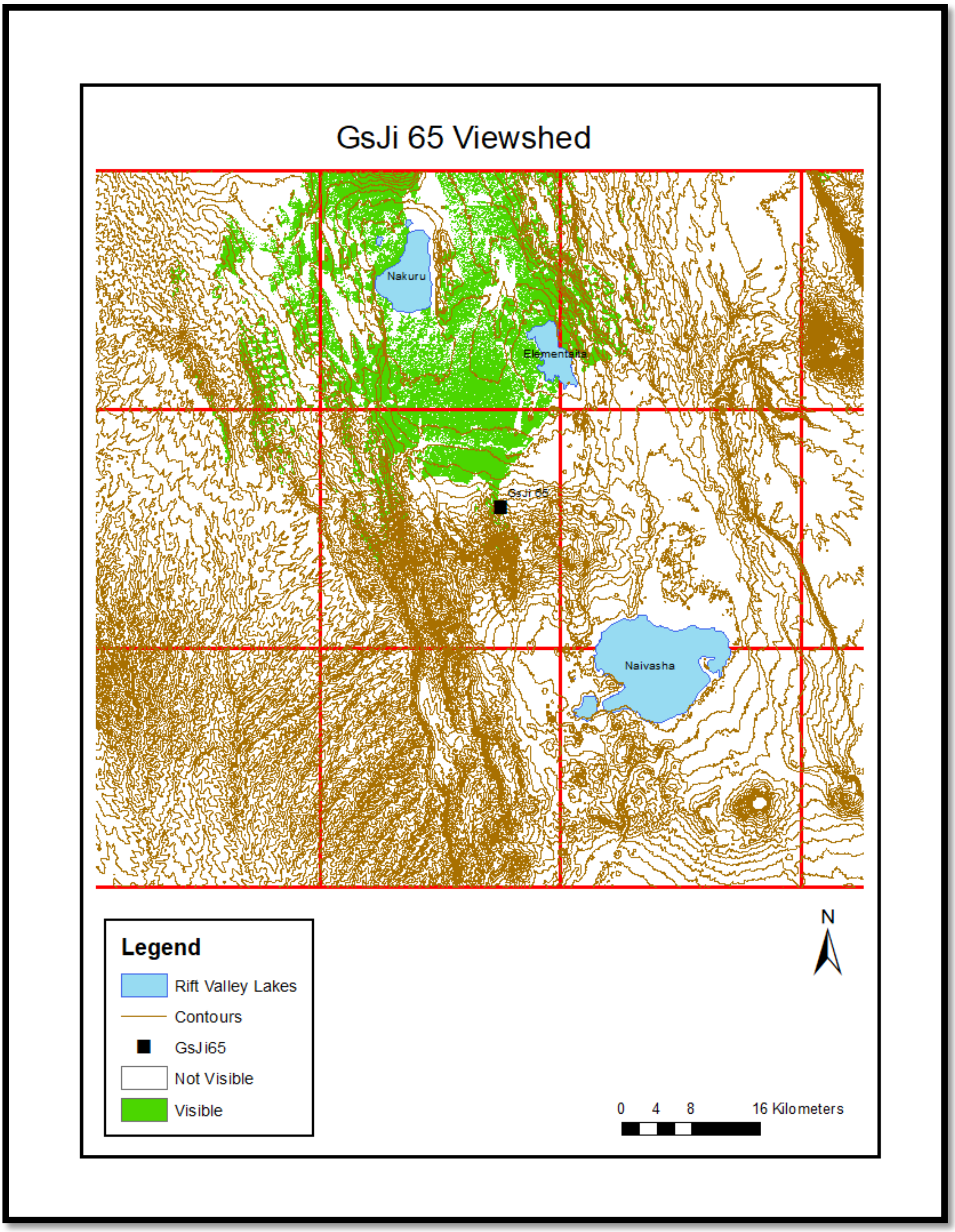

Figure 5.11: Map showing GsJi 65 viewshed

This site, located on the northern lower slopes of Mt Eburru, commands a good view of the plains surrounding the two northern lakes. The viewshed (Fig. 5.10) stretches all the way from the site to the northern shores of Lake Nakuru, and also covers the plains btween the two escarpments. The Ngunyumu site viewshed (Fig.5.7) fits completely into this one. GsJi 65, at 2206m above sea level, is well above the upper limit for recorded MSA sites, and would have been a suitable habitation during wet climates when water levels were very high.

5.3.5 Enkapune ya Muto (LSA site 1)

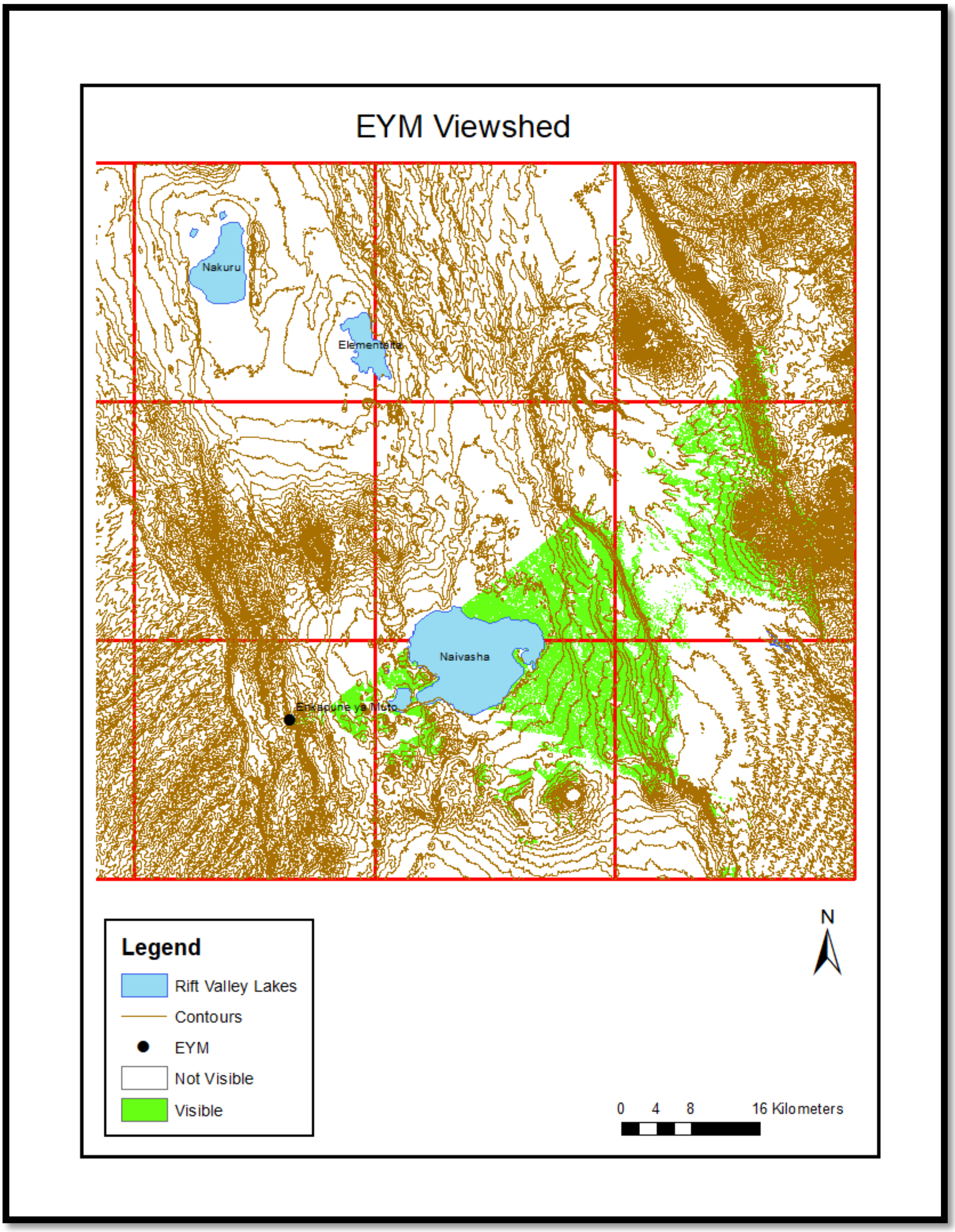

Figure 5.12: Map showing viewshed of Enkapune ya Muto

The area visible form Enkapune ya Muto (EYM) (Fig. 5.11) is extensive. The site commands a very good view of the surrounding plains because it is situated high up on the escarpment. The viewshed extends east from the site and widens to cover the western, northern and eastern shores of Lake Naivasha, as well as a large section of the escarpment up into the Aberdare Ranges. It also includes the southern slopes of Mt. Eburu. EYM is a cave site located at a height of 2493m.

5.3.6 Marula Rockshelter (LSA site 2)

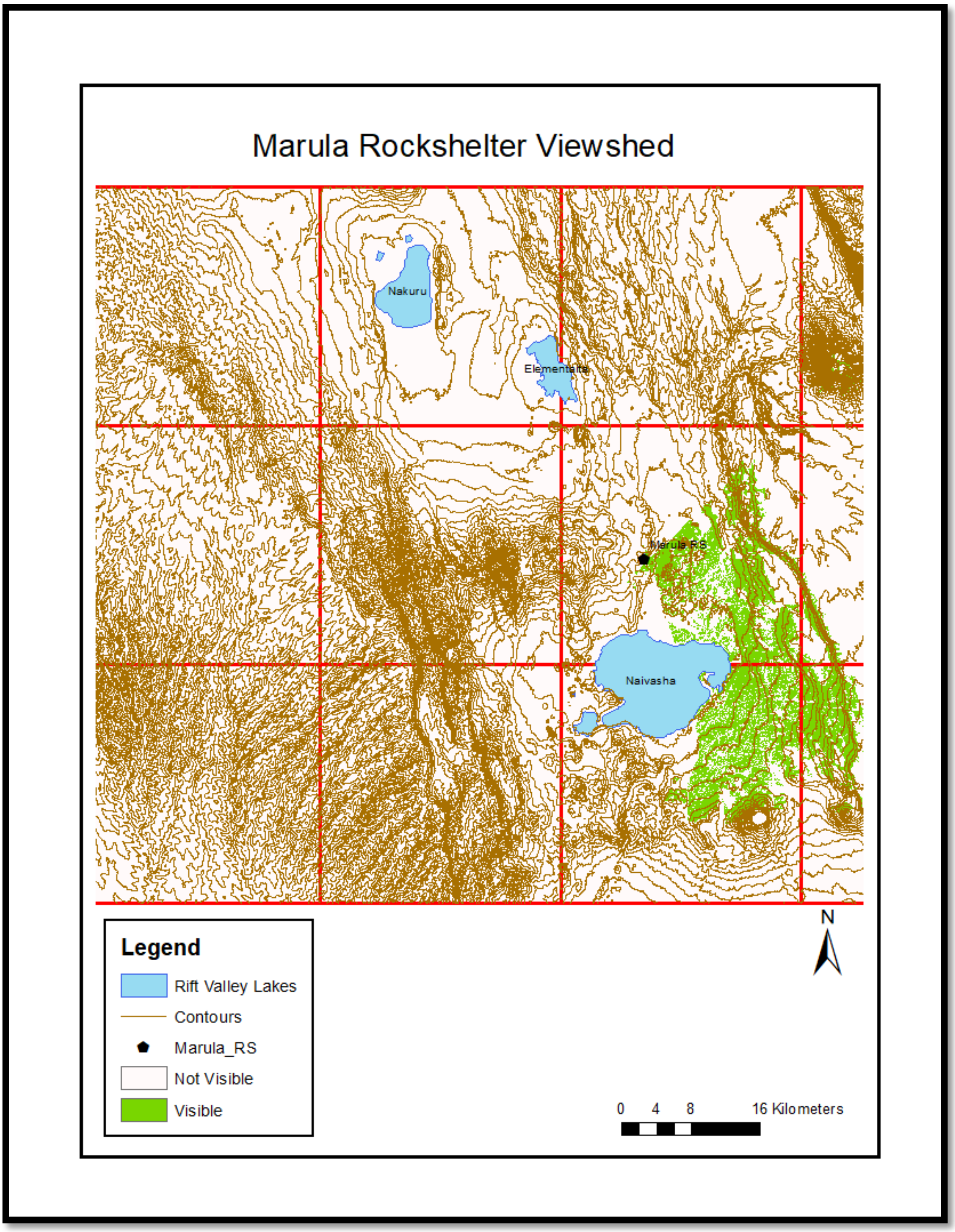

Figure 5.13: Map showing viewshed for Marula Rockshelter

Marula rockshelter (1991m) is situated between Mt Eburru and Lake Naivasha. The viewshed covers the entire east side of the lake and stretches westwards to cover parts of the northern and southern shores and surrounding grasslands. Some of this area is also covered by the Marmonet Drift viewshed.

5.3.7 Hyrax hill (LSA site 3)

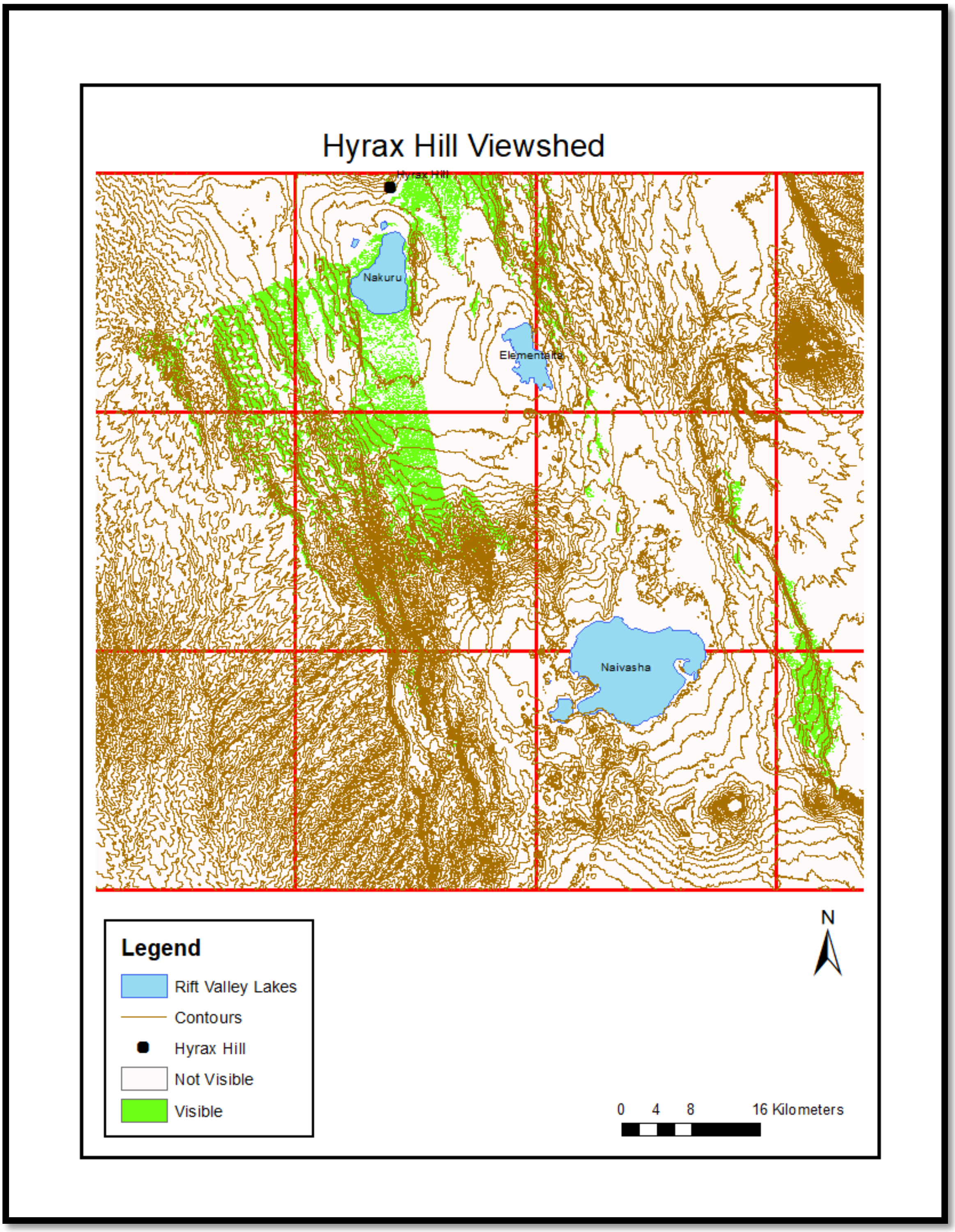

Figure 5.14: Map showing viewshed for Hyrax Hill

From Hyrax Hill (1922m) it is possible to see large areas around Lake Nakuru all the way to the escarpment in the west. The viewshed includes small sections of the escarpment to the east of the Nakuru-Elementaita basin and the Naivasha basin. None of the areas around Lake Naivasha are visible from this site.

5.3.8 Gamble's cave (LSA site 4)

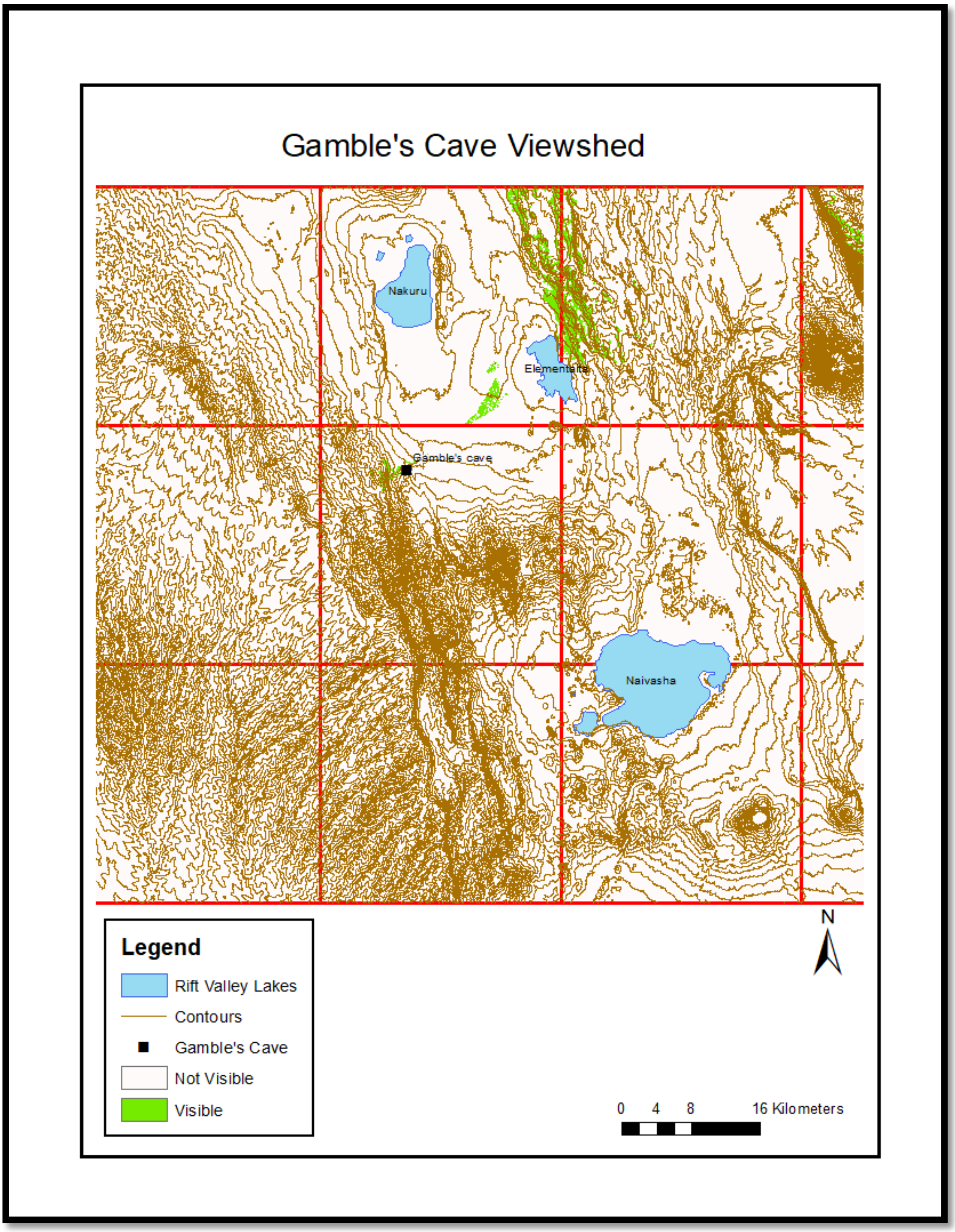

Figure 5.15: Map showing viewshed for Gamble's Cave

The viewshed for Gamble’s cave (1918m) is surprisingly small. Apart from a small area very close to the cave and small patch near Lake Elementaita, most of the visible areas are on the eastern side of lakes Nakuru and Elementaita.

5.3.9 Prospect Farm (LSA site 5)

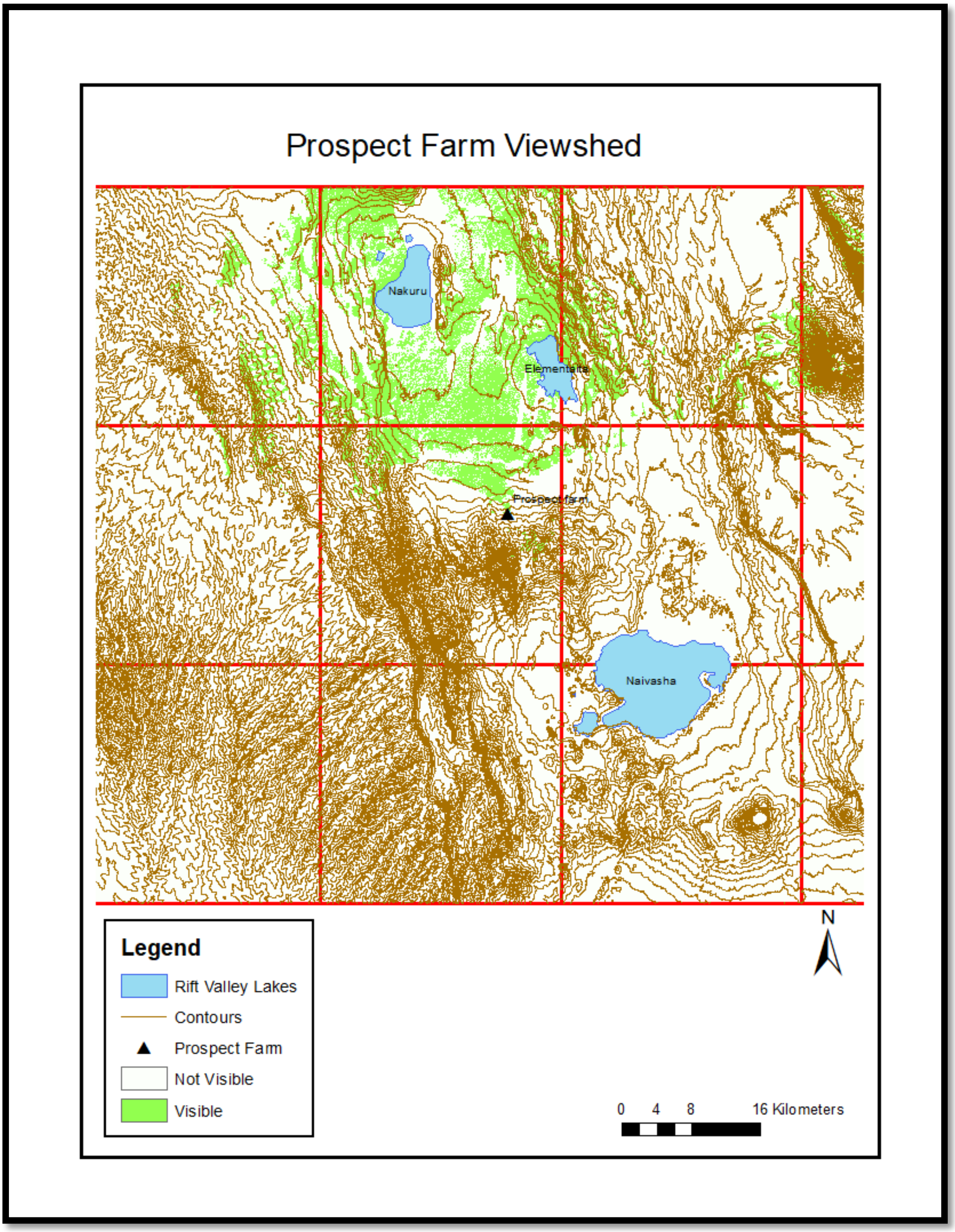

Figure 5.16: Map showing viewshed for Prospect Farm site

Just like GsJi 65, the area visible from Prospect Farm site (2085m) covers most of the Nakuru-Elementaita basin all the way to Mt Eburru and to the edges of the escarpments.

5.4 Statistical Analysis: Analyzing patterns

Presented in this section are results of analyses discussed in the preceeding chapter, on three site clusters: MSA, LSA and MSA/LSA which has been added for comparison.

5.4.1 Global Moran's I autocorrelation

Global Moran's I was applied to altitudes of all sites and the resulting values are shown in table 5.1.

Table 5.1: Table showing values of Moran's I Autocorrelation

	MSA	**LSA**	**MSA/LSA**
Moran's index	0.21	0.21	0.22
Expected Index	-0.06	-0.02	-0.09
Variance	0.46	0.76	0.13
Z-score	0.40	0.27	0.86
P-value	0.69	0.79	0.39

According to the results, the patterns do not appear to be significantly different than random. The p value of the LSA is higher than that of the MSA, but the z score of the former is lower than that of the latter. In both cases the p value is not significant so the null hypothesis cannot be rejected. Small p values coupled with very high /very low z scores indicates it is unlikely that the observed spatial pattern reflects the theoretical random pattern represented by your null hypothesis of complete spatial randomness (CSR).The null hypothesis states that the attribute being analyzed is randomly distributed among the features in the study area or that the spatial processes promoting the observed pattern of values is by random chance. Both results therefore show no difference from randomness between location and elevation. Values for the MSA/LSA cluster, which is added for comparison, are different from those of individual clusters, but still the patterns do not appear to be significantly different than random.

5.4.2 Average Nearest Neighbour

The average nearest neighbor analysis shows very small p values (Table 5.2) which indicates that it is unlikely that the spatial pattern is random; therefore the Null hypothesis of Complete Spatial Randomness may be rejected. The results also indicate that there is less than 5% ($p < 0.05$) likelihood that the clustered pattern could be the result of random chance for the MSA and 1% for the LSA ($p < 0.01$). The average nearest neighbor analysis shows that LSA sites were located much closer to one another indicating that the clustering was heavier within the LSA than within the MSA. Or the MSA/LSA group of sites, there is also a less than than 5% likelihood that this clustered pattern could be the result of random chance.

Table 5.2: Average Nearest Neighbor results

	MSA	**LSA**	**MSA/LSA**
NN Ratio	0.72	0.72	0.67
NNZ score	-2.32	-3.89	-2.16
P-value	0.02	0.00	0.03
NN Expected	2238.60	8263.23	4253.25
NN observed	1616.99	5955.96	2869.77

5.4.3 Multi Distance Cluster Analysis

The Ripley's K function determines whether features or the values associated with features exhibit statistically significant clustering or dispersion over a range of distances. When the observed K value is larger than the expected K value for a particular distance, the distribution is more clustered than a random distribution at that distance or scale of analysis. When the observed K value is smaller than the expected K value, the distribution is more dispersed than a random distribution at that distance.

In both instances, the observed values are higher than expected values, an indication of some form of clustering. Within the MSA, there is significant clustering over short distances, and significant dispersion at larger distances. There are consistently small differences between expected and observed values, which shows light clustering up to about 5000m from where it becomes more dispersed (Figure 5.16 (b)). At 2000m there is an interesting balance which shows neither randomness nor clustering. Within the LSA there is a significant degree of clustering between 20,000 and 40,000 after which it decreases but observed values are still higher than expected values. (5.17 (a). This shows that most of the sites within the LSA were situated much closer to one another, and significantly more than during the MSA. LSA sites are spread out over much larger distances than the MSA as indicated by the larger values on the x axis. Site within the MSA/LSA cluster show significant clustering up to 5000m just like within the MSA.

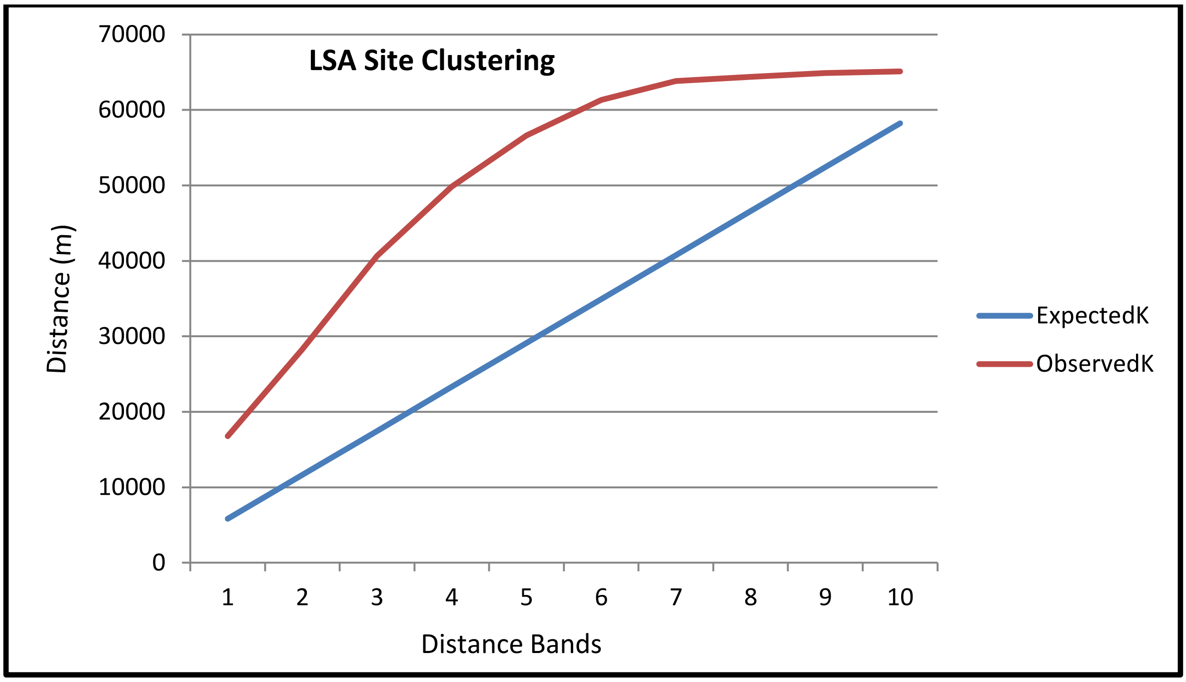

Figure 5.17 (a): Clustering of LSA sites. 10 distance bands were used in the analysis.

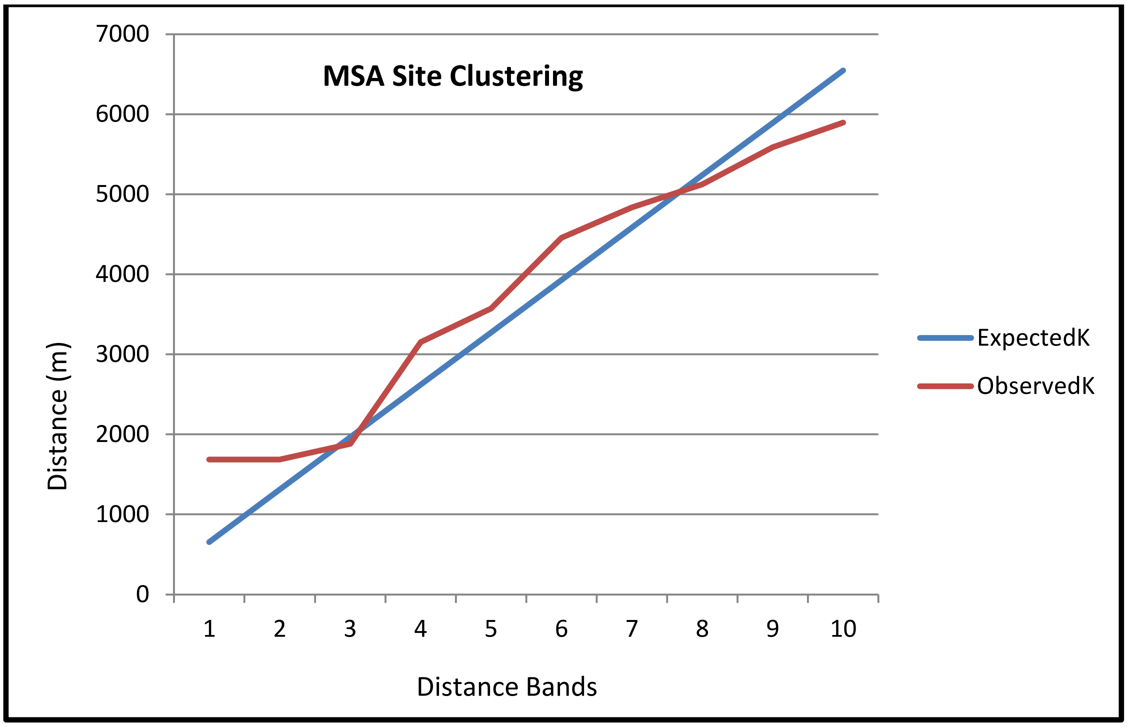

Figure 5.17 (b): Clustering of MSA sites

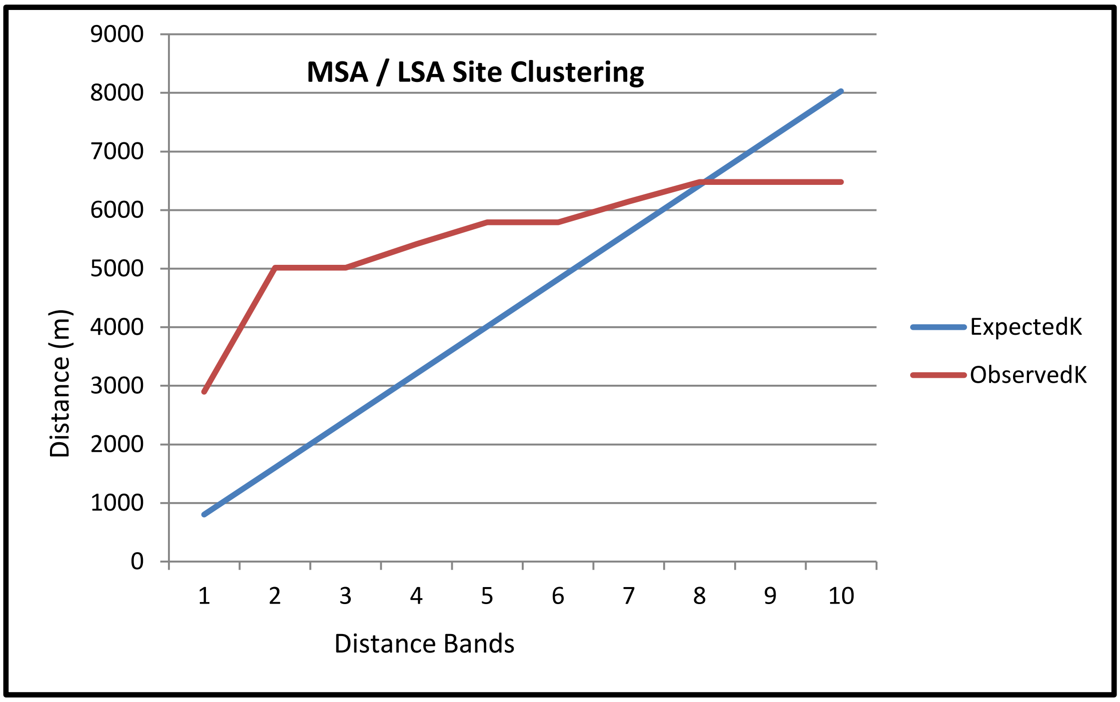

Figure 5.17 (c): Clustering of MSA/LSA sites

5.4.4 Incremental Spatial Autocorrelation

This analysis measures spatial autocorrelation for a series of distances and optionally creates a line graph of those distances and their corresponding z-scores. Z-scores reflect the intensity of spatial clustering, and statistically significant peak z-scores indicate distances where spatial processes promoting clustering are most pronounced. 10 distance bands were used for the analysis. Results indicate that z scores are higher over larger distances during the LSA, contrasting with the MSA where z scores are higher over short distances. In the combined cluster, there are consistently high z scores over a short distance after which they fall.

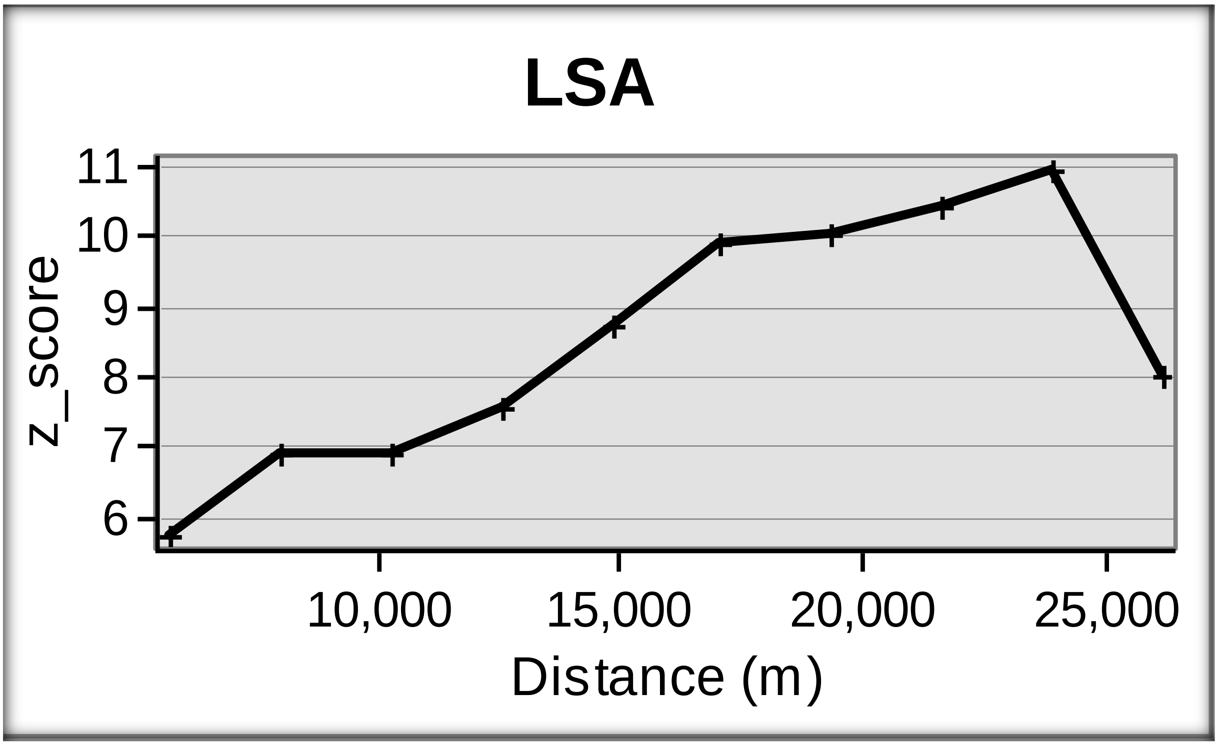

Figure 5.18 (a) Incremental Spatial Autocorrelation for the LSA

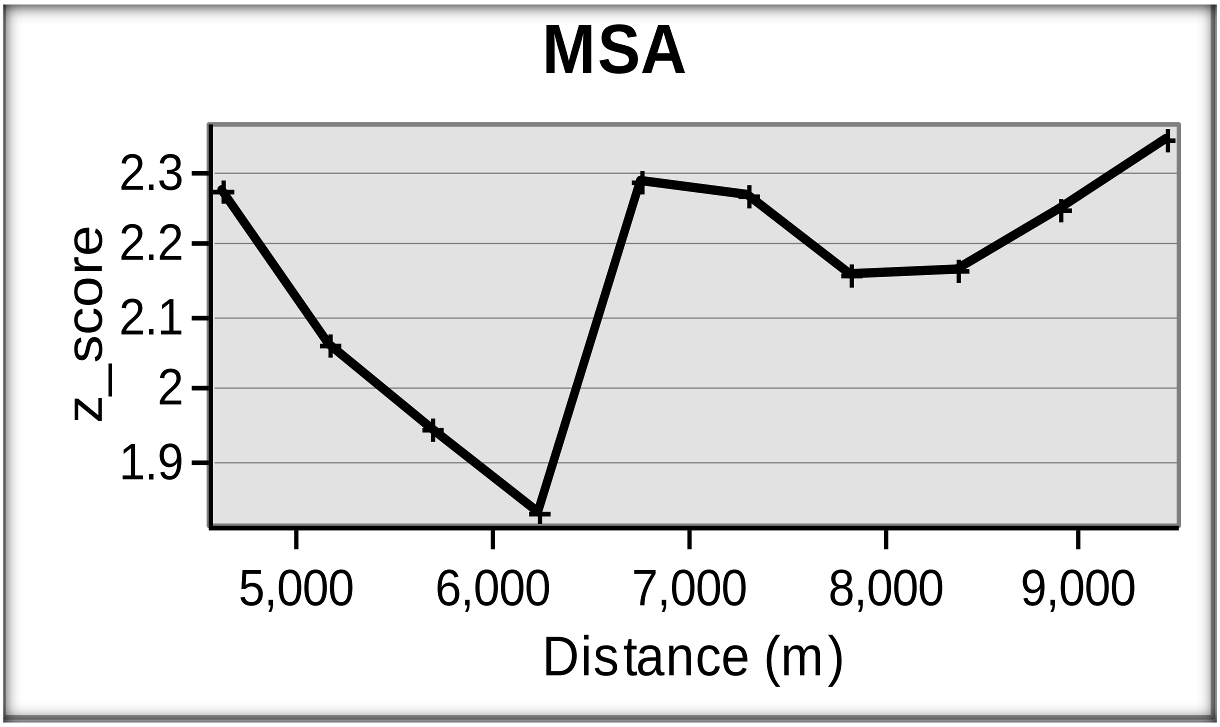

Figure 5.18 (b) Incremental Spatial Autocorrelation for the MSA

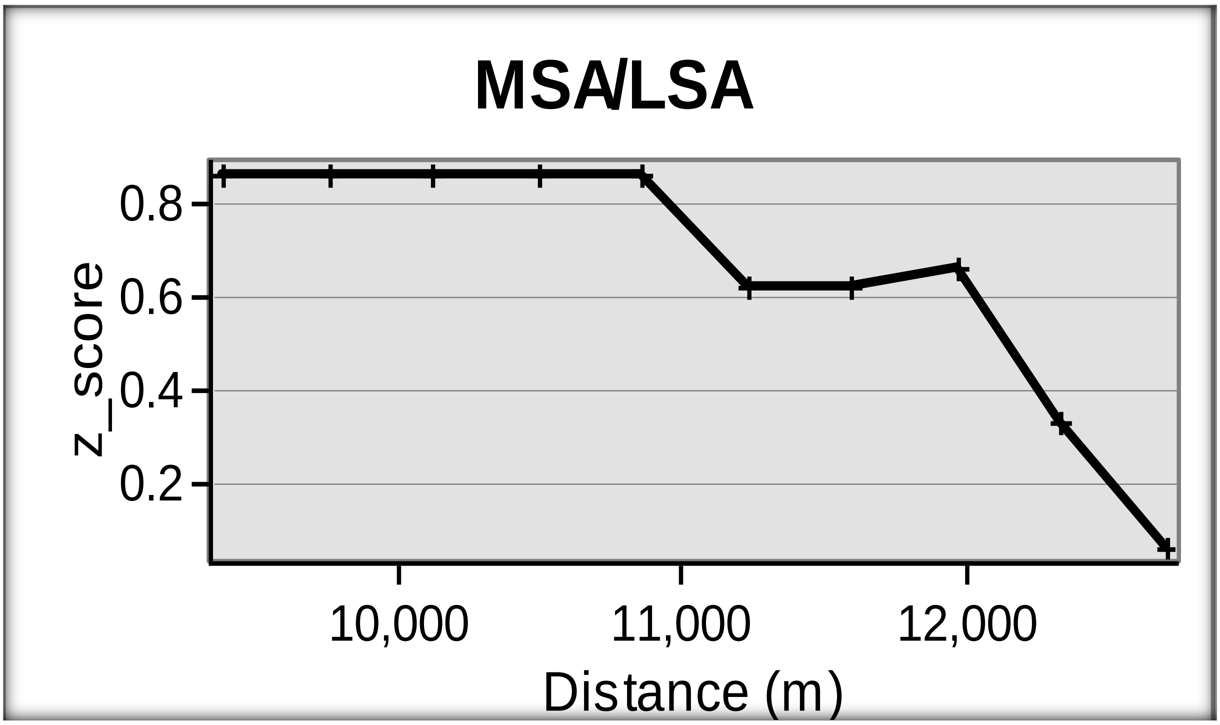

Figure 5.18 (c) Incremental Spatial Autocorrelation for the MSA/LSA

5.4.5 Measuring Geographical distribution: Directional Distribution.

5.4.5.1 LSA

Although LSA sites are spread over a wide area, most of them are found close to the base of Mt Eburru. The Directional Distribution trend is west to east (Fig. 5.18), following the shape of the mountain. There are a few outliers but most of the sites fit into the general pattern.

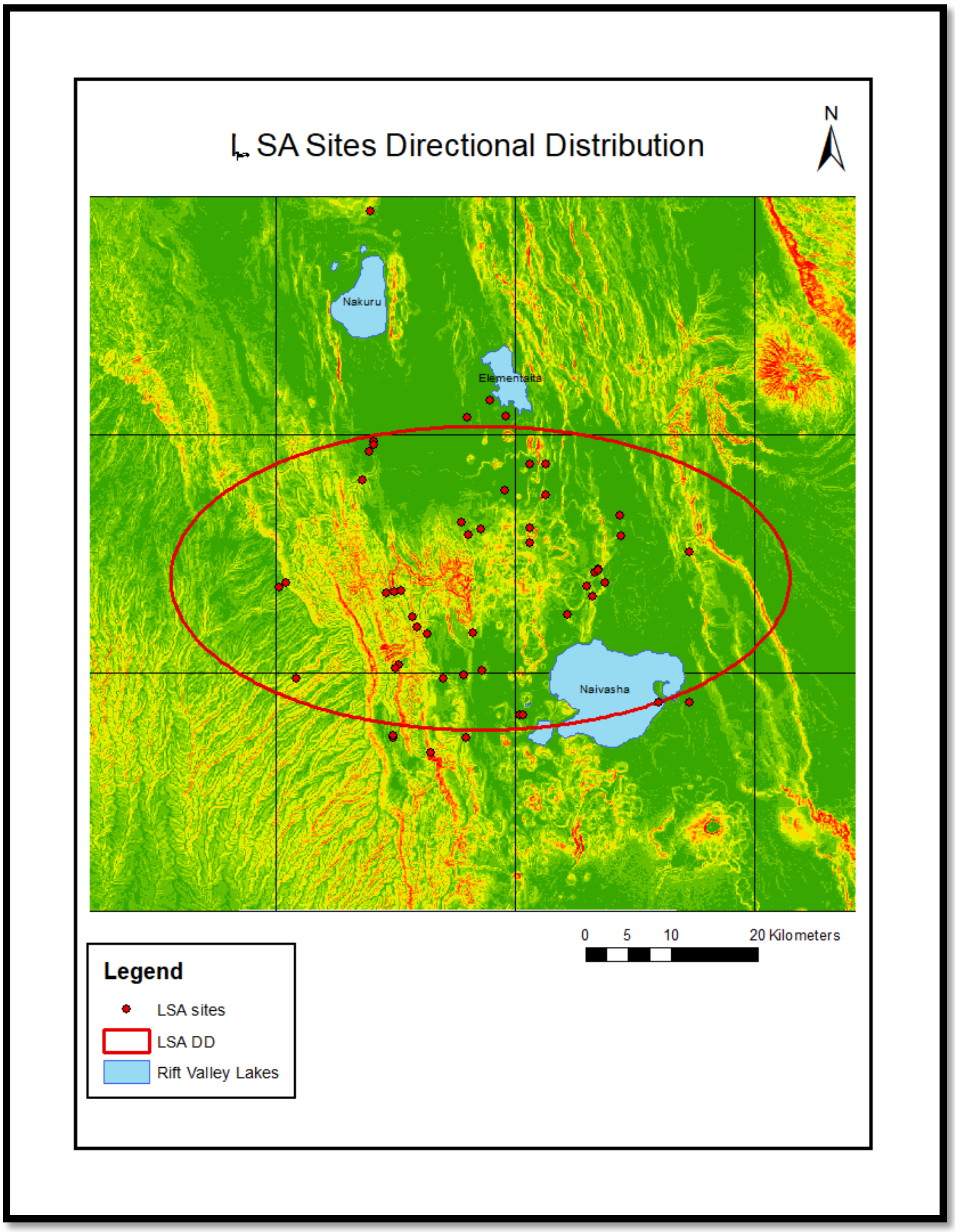

Figure 5.19: Map showing directional distribution of LSA sites. The site locations seem to follow the base of Mt Eburru.

5.4.5.2 Directional Distribution: MSA

The pattern of distribution of MSA sites does not seem to evenly follow the slopes of Mt Eburru. The ellipse (Fig. 5.19) lies in a North-East to South-West direction.

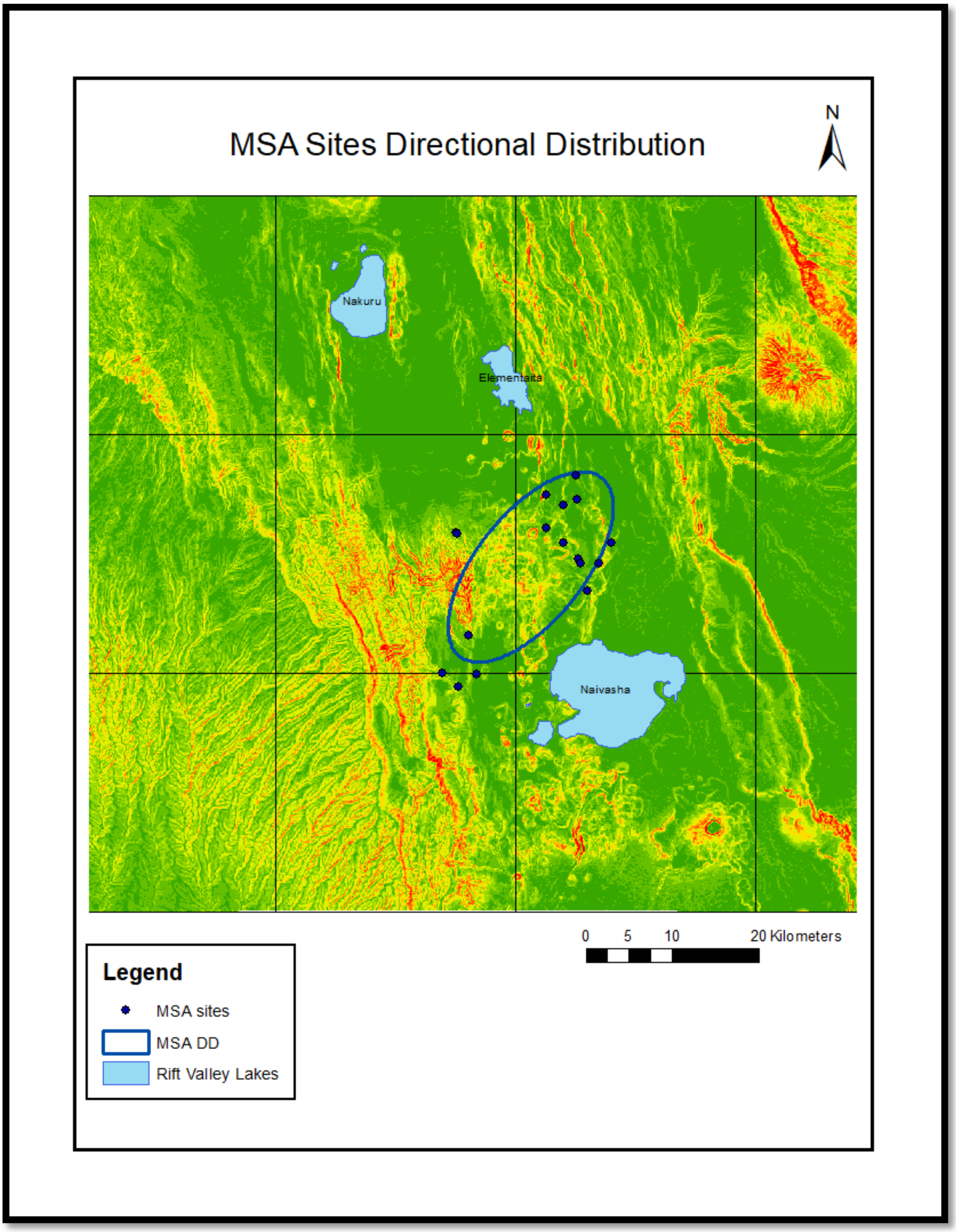

Figure 5.20: Map showing directional distribution of MSA sites.

5.4.5.3 Directional Distribution: MSA/LSA

The pattern of distribution for MSA/LSA sites is different from the other two discussed previously. MSA sites are represented by the smallest ellipse, indicating they are restricted to a smaller are than sites in the other two categories.

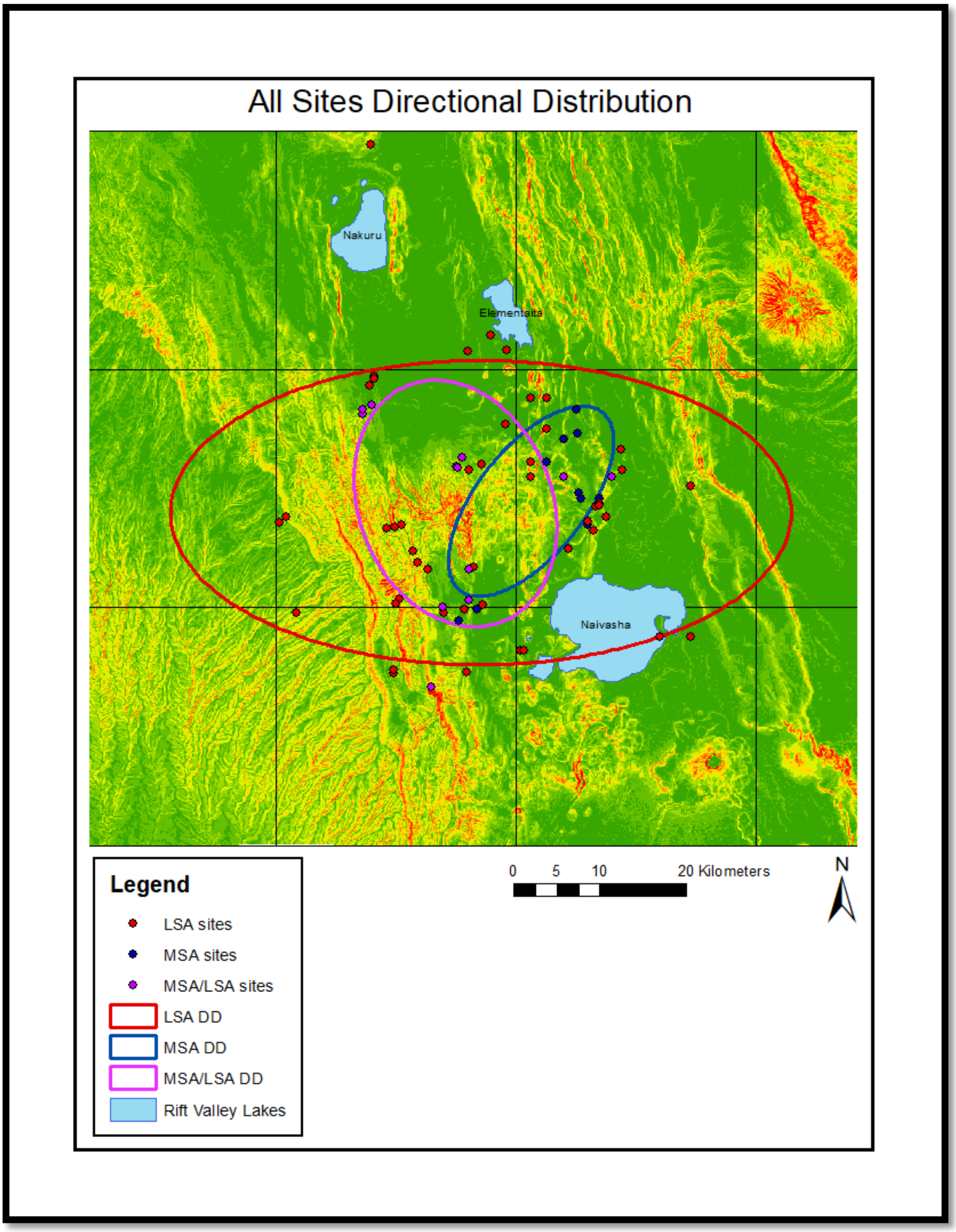

Figure 5.21: Map showing directional distribution of all sites.

5.5 Overall result

It was possible to generate viewsheds for all selected sites, and the sizes of viewsheds from these locations differ considerably. Some viewsheds cover common areas, especially those that are located on the same side of Mt Eburru. Viewsheds generated from the selected LSA sites cover different areas of the valley floor. Enkapune ya Muto and Marula Rockshelter have viewsheds covering large areas east of Lake Naivasha that of Hyrax Hill is mainly around Lake Nakuru, from Gamble's cave one can see small areas around Lake Elementaita, while from Prospect farm large areas around Lakes Nakuru and Elementaita can be seen. For the MSA sites, GsJi65 has a large viiewshed around Lakes Nakuru and Elementaita, while from Ol Tepesi a large Naivasha can be seen, similar to that of Marmonet Drift. The Ngunyumo viewshed is small and restricted around Lakes Nakuru and Elementaita. It is important to note that viewshed of both MSA and LSA sites cover the same areas and sometimes overlap. Marmonet Drift, Ol Tepesi, Enkapune ya Muto and Marula Rockshelter all have viewsheds covering the eastern side of Lake Naivasha, some extending northwards and some southwards around the lake. These sites are all located south of Mt Eburru. GsJi65, Ngunyumu and Prospect Farm have viewshed covering the areas around Lakes Nakuru and Elementaita. All the latter sites are located on the norther side of Mt Eburru. Hyrax Hill and Gamble's Cave have totally different viewsheds; the former covers substantial areas around Lake Nakuru while the latter only cover small sections of the Nakuru-Elementaita basin. The variety in size and locations of the different viewsheds generates interesting debate about what factors were considered important in the establishment of sites, and whether these factors were physical or ideological.

While the autocorrelation results based on altitude show complete randomness for the MSA, LSA and MSA/LSA, Average Nearest Neighbor analysis indicates that the spatial pattern of the sites is not completely random and that there is some degree of clustering. The difference in the degree of clustering is quantified by Ripley's K function, Incremental Spatial Autocorrelation shows the distances at which clustering occurs, while Geographic distribution analysis result shows the general patterns followed by the site localities. These will be discussed further in the next section.

Chapter 6: Discussion and Conclusions

This section discusses in detail the results from the previous section, and what the results might imply.

6.1 Discussion

The Kenyan central Rift Valley has a long history of human habitation. Archaeological sites range in age from the Acheulian at Kilombe (Gowlett, 1978) to the Iron Age at Hyrax Hill (Kyule, 1995; Sutton, 2000). This part of the Rift Valley had undergone many climatic fluctuations that also influenced the kind of vegetation available and what kind of animals this would support. Many studies have been conducted here to document the environmental changes throughout the Pleistocene, and especially during the Holocene (eg. Gasse, 2000; Kiage and Liu (2006); Butzer et al, 1972; Hamilton, 1982). Resources available to humans varied according to the prevailing climatic conditions and this is thought to have influenced the site locations and the way the people adapted to resource availability (Ambrose, 2001). As Blome et al (2012) point out, hominin populations in East Africa responded to environmental change by minor shifts in settlement locations.

Ambrose (2001) suggests that the locations of their settlements roughly followed the ecotonal boundaries when it moved in relation to elevation, and were additionally situated in locations that were most convenient for the procurement of existing resources. Currently, the forest is rich in bio-diversity and hosts several indigenous tree species like *Olea africana, Dombea goetzenii, Acacia* spp, and *Bamboo* spp. It has been described as being a part of the Afromontane archipelago-like, comprising of Afromontane forest and Afromontane bamboo at the higher altitude. Among the large animals found in this forest are bongo, yellow backed duiker, golden cat, giant forest hog, leopard, hyena, buffalo, colobus monkey, and impala (Obare and Wangwe, undated). The montane forest on the escarpment is also rich in fruits and honey. The grasslands in the plains below are home to many herbivores and carnivores, and the lakes support many species of birds including lesser and greater flamingoes. The rift valley lakes also contain several types of endemic *tilapia* sp. (Vareschi, 1979) and support large hippo populations. In addition, The Mau escarpment is an important water catchment and has several major and minor rivers flowing down its slopes therefore ensuring a constant supply of fresh water.

This area can therefore be considered very well supplied with food and natural resources, and conditions may have been like this for many thousand years. Indeed, the prehistoric faunal assemblage at several of the archaeological sites was diverse and included a mix of forest, bush and savannah dwelling animals (Ambrose, 1984, Gifford-Gonzalez, 1985). This may explain why the central rift was especially favorable for human settlement, and why archaeological occupations occur close to one another and in large concentrations.

The concentration of sites around Mt Eburru may be explained this way: that it was the only area that was suitable for habitation during the very wet periods as it was outside of the forest, yet far enough from the lakes, and therefore well placed to keep human settlements dry. This would have meant that the populations were aware of the variables that determined the choice of locations of sites, and would therefore imply ‘an ‘informed’ choice of location, the details of which would have been passed on through several generations. This is consistent with Ambrose’s (2001) theory that strategic positioning of settlements to maximize efficiency of resource exploitation may have been perfected at the end of the MSA. This is because LSA sites are found in the same localities as MSA sites, meaning that the area was especially suitable in terms of availability of food, raw materials and ample security to support many generations of humans. Whether all the sites were occupied through the year or were used seasonally has not been established; what is clear is that the high density of artifacts and other remains through time and space is an indication of the suitability of the area for human habitation. The role of environmental change in site selection can be seen in the way site locations move up and down elevations depending on lake levels and forest lines, as discussed in Chapter 3. The fact that LSA sites are spread over a much wider area than MSA sites is a clear indication of the ability of humans to tame their environments, even though the locations chosen for their sites may have depended to a large extent on the environment around them. Other reasons may include security, population pressure, suitable grazing grounds for their animals and seasonality of food resources.

Ambrose also notes that the degree to which MSA and Mid Paleolithic humans differed from LSA Upper Paleolithic humans in their ability to use the landscape and make effective use of resources has not been established. If resource exploitation had been perfected by the end of the MSA, LSA sites show an improvement in the exploitation strategies already established. Both groups had very good ability to make maximum use of their landscape. That LSA sites are spread over a much wider area is a clear indication of a more effective way to tame the environment and to maximize use of available resources. An improved tool kit is one way to do this, and as explained in Chapter 3, the complexity of tool kits and improved workmanship is a clear indication of more complex brain capacity that enables humans with current challenges.

The deliberate siting of human habitations in the same general areas through many thousands of years indicates the suitability of this area for human habitation, the availability of other resources necessary for human and animal habitation, the absence of disease vectors (even if only seasonally), and the general ability of human to adapt to the changing environment. The fact that their evidence of changing lake levels, yet human habitations persisted, indicates clearly that LSA humans had improved on the ability of MSA humans to make effective use of available resources. If resource exploitation had been established by the end of the MSA, as Ambrose (2001) theorizes, the continued habitation of the area is an indication that the human brain has the ability to continually devise ways of overcoming challenges brought about by adverse environmental conditions, and that man has the ability to tame environmental conditions to suit his needs. After all, climatic conditions are always changing, and since humans have no control over these, it is up to us to change to adapt to those conditions.

6.2 Visibility Analysis

Viewsheds have been generated for all selected sites. Sites to the north of Mt Eburru have their viewsheds within the Nakuru-Elementaita basin, while those in the south have viewsheds mainly covering the Naivasha basin.

As mentioned in Chapter 5, some viewsheds from the LSA are very similar to some viewsheds within the MSA, which could be interpreted to mean that these particular areas had some sort of significance to the people living then. Enkapune ya Muto, Marula Rockshelter, Marmonet Drift, and Ol Tepesi all have viewsheds covering partially, or wholly, the eastern side of Lake Naivasha. GsJi65, Prospect Farm and Ngunyumu have a viewsheds with the Nakuru-Elementaita basin. Hyrax Hill site is located north of Lake Nakuru, and the viewshed generated stretches from the site to the western side of the lake and up the Mau escarpment. Gamble’s cave has a very small area covered by its viewshed, mainly east of Lake Nakuru.

The results show that it is possible to generate viewsheds for this group of sites, but what does this tell us? We may theorize that there were common areas that were of interest to inhabitants both within the LSA and the MSA. This could mean that the sites were strategically located in order to see objects within the viewsheds. Two, the viewsheds cover areas far away from the sites, to be of any practical use, as it would be more useful to see the areas closest to the sites. Even if there was a good reason to be able to see far off areas, it is practically impossible to do so as visibility is hindered by physical distance which affects recognizability of objects to the human eye over long distances (Ogburn, 2006). This might therefore mean that the locations for siting occupation areas had nothing to do with the ability to see lower areas, or only part of the viewsheds were actually used for any purpose. That sites located in low elevations have similar viewsheds to those of sites in higher elevations,- for example, EYM and Marmonet-, may be an indication of commonality of use.

Some viewsheds overlap but it has not been established whether such sites were occupied at the same time. If there are similar viewsheds for sites occupied at the same time, we can then assume that the visibility was for a common reason. If the sites were not occupied at the same time, then there was a compelling reason for visibility from these sites. Visibility however, may have varied with season, or, needs for visibility could have varied with conditions. However as pointed out earlier, most of the viewsheds were far away from the sites, and this may mean that the site locations were not chosen for their ability to afford a certain view for the inhabitants, as nothing can be seen over long distances due to the distance. In terms of security, this visibility would be of no benefit as the areas closest to the sites still remain obscured. This is especially true if the area was covered in forest or tall trees, but even where the area was covered in open grassland, it would not be possible to see anything beyond several hundred meters. The conclusion therefore is that if visibility was a key determinant for security, the sites were not located here for their suitability in terms of security, or that security was not one of the important factors in their siting preferences. If there was another reason for this visibility, more variables need to be added to test this possibility.

6.3 Statistical analysis

A visual evaluation of site locations indicates that most of the sites are situated around the base of Mt Eburu and that LSA sites are spread over a larger area compared to MSA sites. The Global Moran’s I autocorrelation does not show any correlation between locations and elevation, and the conclusion is that the sites seem to be randomly located. Sites within the LSA do not even seem to be located in distinctly different areas from those with MSA sites. Indeed, several sites contain both MSA and LSA assemblages, an indication of favorable conditions for settlement through long periods of time. According to this analysis, MSA, LSA and MSA/LSA sites are randomly located across all elevations. However, according to the Average Nearest Neighbor analysis, the results indicate that it is unlikely that the spatial pattern exhibited is random. This means that site locations are not completely random and there was some pattern to the settlements. There is an indication of clustering. There is more clustering within the LSA than the MSA, and this may be attributed to the fact that there are more LSA sites and are therefore located closer together. This may in turn be due to the fact that the population within the later period may have been higher and were more sedentary than before. There is also clustering within the MSA/LSA group of sites.

The pattern of clustering is explained by Ripley's K function which shows that the density of clustering is heavier during the LSA than the MSA. This can be seen by a visual inspection of the site map. What the analysis informs us is that this clustering is at specific distances, indicating a preference from a certain point. MSA sites are more or less evenly distributed within a small area. In contrast, the concentration of LSA sites rises as one moves away from the center and reaches a maximum at around 50,000m, then gradually tapers off. Again, the heavy concentration of LSA sites may have to do with the large number of recorded sites, but there is definitely a preferred location for these sites. In general, clustering around the mountain is intense but sites are more dispersed the further one moves away from it. The conclusion is that conditions around the base of the Mt Eburru may have been especially conducive for occupation (assuming this is the physical feature determining their distribution), and that these conditions grew less and less as one moved away from the mountain. The attraction could have been the mountain itself, resources around the mountain or sources of raw material around its base. Therefore, although the pattern is not apparent, some kind of reasoning was behind their siting.

The Incremental Spatial Correlation shows the intensity of clustering at set distances. The peaks in the resulting graphs indicate the distances at which there is significant clustering. We can see that there is clustering within short distances in the MSA, and within longer distances in the LSA. This is because MSA sites were concentrated within a small area, in contrast to LSA sites that were spread over a wider area. Areas with significant clustering would be considered specific areas of interest in future research. Distances at which clustering occurs provide an excellent guide for conducting more extensive surveys and possibly excavations. In areas with heavy clustering, research would be centered on establishing why there is a high concentration of sites, and what conditions may have determined the site locations. This way, even in the absence of additional physical attributes, it may be possible to discover attributes that have not been reported yet. Areas with low clustering may be used as a guide for more intensive surveys; this would establish whether the lack of sites is due to the absence of sites due to erosion or other environmental factor. It may also be due to the actual absence of sites because the location is simply not suitable, or resources are hard to get. Another reason for the paucity of sites may just be an issue of incomplete survey due to many factors.

The directional distribution of LSA sites indicates that their locations followed the direction of the mountain slope, while that of MSA does not strictly follow the slope direction. It is interesting to note that directional distribution of MSA/LSA sites lies in a north-south direction. The difference in distribution may act as a guide when looking for more sites; surveys would be intensified in the directions indicated by the ellipses. This would also serve to establish what other physical features may have influenced distribution of the sites.

In carrying out these analyses, an assumption is made that there is a complete record of sites. There is however a possibility that the record is incomplete due to omission of sites. This would be because some areas are skipped in the course of surveys due to any number of reasons, or simply that the sites do not exist; nobody lived there or the sites have been destroyed by human activities or washed away in the floods. For instance, the lack of MSA sites close to the lakes may possibly be due to the fact that some MSA sites were destroyed during the early Holocene when the lake levels were very high. LSA sites older than 10,000 years old would also have been affected especially if they are of the open type. Deposits in cave sites are more likely to survive natural calamities, and so these would appear in the record while open ones do not. It therefore follows that true clustering of all MSA and older LSA sites can never be truly established because the sites do not exist anymore. If early LSA sites were located in the same places that MSA sites were found in prior to the flooding, this partly explains why there are not many sites with evidence of this transition. As discussed elsewhere, site locations may also have been heavily dependent on the climatic conditions. During periods of heavy rainfall, people may opt to move away from the forest in search of drier conditions. This makes the area suitable for habitation limited, as the high lake levels also discourage settlements close to the water.

Higher clustering of LSA sites may also be due to higher population levels, so that there were more sites that could be located in preferred locations and the multiple occupation levels in some sites is a good indication that those sites were especially suited for habitation. The fact that sites were located close to each other also means that the resources available were enough to support a large population, one of the reasons why the area was occupied over long periods of time. The clustering at certain distances may point to the fact that there was a preferred location or distance for certain reasons.

Only during the LSA do many sites start appearing on the escarpment, probably due to population pressure and drier environmental conditions. Even though environmental conditions may have changed over time, other factors may have contributed to the suitability for human occupation. The appearance of sites further away from the assumed center supports Ambrose's (2001) idea that strategic positioning of settlements to maximize efficiency of resource exploitation may have been perfected during or at the end of the MSA. The fact that sites appear at higher altitudes during the LSA may be an indication of resource diversification and a reaction to adverse environmental changes at the time.

6.4 Conclusions to be drawn from the analysis

The objectives of this study were

- To establish spatial patterning in relation to physical features
- To explore differences or similarities in the settlement patterns
- To explore the use of statistical methods in explaining differences in settlement patterns.

The following conclusions can be made from the analysis

1. The main physical feature in this case is Mt Eburru, and it is apparent that it may have played an instrumental role in the siting of settlements. Most of the sites are located around the lower slopes of the mountain, and the direction of the slope may have determined the site locations, depending on which area was visible from the site. It is possible to study visibility from sites in the central rift by generating viewsheds, and whose extent may inform us about what the sites were sued for, and by extension, activities that early man was involved in. The view sheds generated mainly cover areas on the floor of the rift, and their extents show they may have been useful for yet undetermined reasons. Results of the statistical analysis indicates some form of

patterning in both time periods, and there is a possibility that this patterning was influenced by physical features that are not on record.

2. There is a pattern to the sites overall distribution. MSA sites are more dispersed than LSA sites, and there is substantial clustering of sites at different distances. This is clearly demonstrated by statistical analysis.
3. Statistical methods can be used to explain differences in ancient settlement patterns. There are significant statistical differences in the locations of MSA and LSA sites. Clustering has been shown to occur at different distances; there is a possibility that other physical features may have influenced this settlement patterns. The statistical analysis therefore answers the research question, which was to determine whether there are differences between MSA and LSA settlement locations. Even though the site database may not be complete, we can now tell that there is a pattern to the site locations, and that there are actual difference in the settlement patterns within the MSA and the LSA. What remains to be established are the reasons behind these differences.
4. The general conclusion is therefore that the differences in settlement patterns may have been influenced by climatic conditions, but may also be as a result of unidentified physical features.

6.5 Limitations of the study and prior assumptions

The main limitation of this study is that we are dealing with sites that have been recorded over a long period of time by different people. This means there is no uniformity in terms of defining what constitutes a site, as different recorders subscribe to different schools of thought. Does a thin surface scatter constitute an archaeological site as opposed to a site with clear multiple occupation levels? Although I lumped all of them together, I think it is important to treat them separately based number of occupation layers visible. Open sites have also been analyzed together with caves deposits, but clearly the dynamics of site preservation and occupation differ. In addition, because the sites were recorded by different researchers using different instruments, the accuracy cannot be assumed to be equal. An assumption is therefore made that all sites are equal.

Site distribution is not free of bias due to the inaccessibility of some areas. There are protected areas such as Lake Nakuru National Park and private ranches around the three lakes further limit the land available for surveying. The rest of the land is used for small holder farming and therefore disturbed. The remaining land available for archaeological survey is badly eroded, and according to Ambrose (2002), most MSA sites are found in this region. This probably means that many sites have been eroded away and what is left is a poor sample of the true state of affairs. During the high lake levels, sites sited close to the lakes may also have been destroyed. As Ambrose (2001) points out, the true distribution of sites is not known because few systematic surveys have been done, most of the sites are not yet reported, and very few sites have been excavated.

The lack of more variables for use in this analysis is certainly a limitation. Information such as the location of rivers or other sources of fresh water, sources of raw materials, localities of disease vectors or dominant vegetation types would be useful in bringing out patterns associated with these variables. This kind of information is not available right now so their inclusion for analysis is not possible.

It is also possible that some coordinates may be erroneous or not accurate because the GPSs that were in use many years ago were not very accurate. In some cases coordinates were estimated from approximate locations on topographical maps, and no actual effort to re-record the sites has been made.

It has been assumed that elevations, slope and aspect have not changed much over time, and that any changes are not considerable as to affect the results significantly.

6.6 Suggestions for further research

Areas covered by viewsheds generated in this study require to be investigated further to establish their relationship to the applicable sites. More information about the importance of these areas during specific time periods would greatly enrich data and the literature on this topic. It would also be interesting to analyze viewsheds of sites at similar elevations to see how they compare.

Areas of clustering need to be surveyed intensively to establish factors leading to this clustering, while areas with no clusters need to be researched to establish reasons for lack of sites. In both cases further survey will lead to a more complete database.

The application of more variables would be useful in a more detailed study of this nature. It is possible that new patterns will become apparent once new variables are introduced. It is also suggested that in order to get more accurate results this kind of analysis should be carried out on similar sites within a smaller time scale, as both the MSA and LSA cover many thousands of years. This would be especially useful in the establishment of how site locations change for instance, throughout the LSA in relation to minor changes in factors such as vegetation cover. Limiting the analysis to a smaller time period is also useful when dealing with visibility and intervisibility between sites, as the prevailing conditions may also determine what feature requires visibility. Since the reasons for intervisibility also vary over time, this needs to be investigated based on more specific research questions. For example, it would be useful to compare viewsheds from sites that were occupied at the same time because the environmental conditions would have been similar, and the humans occupying these sites were likely to have adapted in a similar manner. Thus the uncertainties would be reduced considerably.

There is a need for more systematic survey of MSA sites to establish the full extent of their distribution. As Tryon and Faith (2014) point out, the irregular distribution of MSA sites is due to the discontinuous nature of their investigation. Even in areas that have been surveyed (Merrick, 1975; Ambrose, 1986; Barut, 1994) many have not been recorded mainly due to the thin scatters that mark most of these sites. A comprehensive database of MSA sites would provide the data required for a detailed study of this nature. More areas not previously covered also need to be surveyed.

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Appendix I: List of LSA sites and their elevations

	SASES	Site Name	X	Y	Elevation
1.	GtJj23		36.225	-0.467	1824
2.	GtJj24		36.201	-0.484	1824
3.	GrJj25	Hyrax Hill	36.1	-0.268	1824
4.	GtJj27		36.241	-0.483	1824
5.	GtJj4		36.433	-0.783	1825
6.	GtJj5		36.255	-0.797	1851
7.	GsJj4		36.266	-0.616	1904
8.	GsJj6		36.283	-0.533	1904
9.	GsJi23		36.098	-0.52	1949
8.	GsJi29		36.103	-0.51	1949
9.	GsJj48		36.344	-0.658	1958
10.	GsJi20		36.005	-0.663	1988
11.	GsJi1	Gambles Cave	36.091	-0.55	2046
12.	GsJi48	Ildamat cave	36.148	-0.705	2054
13.	GsJj45		36.305	-0.691	2070
14.	GsJj42		36.361	-0.609	2076
15.	GsJj29		36.332	-0.672	2078
16.	GtJi12	Enkapune ya Muto	36.163	-0.836	2079
17.	GsJj19		36.283	-0.533	2080
18.	GsJj44		36.36	-0.587	2080
19.	GtJi31	Ngomut Ngai	36.133	-0.817	2083
20.	GsJj16		36.433	-0.625	2089
21.	GsJj24	Marula RS	36.338	-0.643	2090
22.	GtJi25		36.124	-0.821	2091
23.	GtJj3	Causeway Site	36.4	-0.783	2096
24.	GsJj14		36.266	-0.533	2097
25.	GsJj47		36.337	-0.645	2097
26.	GsJj49		36.326	-0.662	2098
27.	GtJi11	Ndabibi Crater	36.219	-0.753	2125
28.	GtJi26		36.123	-0.818	2125
29.	GsJi7	Prospect Farm	36.195	-0.595	2135
30.	GsJi2	Nderit Drift	36.1	-0.517	2144
31.	GsJj25	Masai Gorge RS	36.334	-0.647	2183
32.	GsJi17		36.215	-0.602	2195
33.	GsJj3		36.266	-0.6	2196
34.	GsJi54	Tepesi Ridge	36.207	-0.71	2246
35.	GsJi55	Eburu Cave	36.24	-0.561	2246
36.	GsJi46	Leluwali Cave	36.126	-0.748	2299
37.	GsJi47	Ngororo Caves	36.159	-0.712	2360
38.	GsJi43	Marmonet Valley	36.132	-0.666	2391
39.	GsJi42		36.116	-0.669	2463

40.	GsJi30		36.103	-0.513	2503
41.	GsJi41		36.125	-0.668	2619
42.	GsJi44	Marmonet Valley2	36.144	-0.694	2673
43.	GsJi45	Leluwali	36.13	-0.744	2673
44.	GtJi10	Enkapune ya Sauli	35.122	-0.756	2707
45.	GtJi7	Marmonet Drift1	36.197	-0.755	2778
46.	GtJi16	Ngunyumu1	36.2	-0.82	2809
47.	GtJi18	Ndabibi crater west	36.216	-0.75	2809
48.	GsJi19		36.012	-0.658	2963
49.	GsJi18		36.202	-0.608	3023

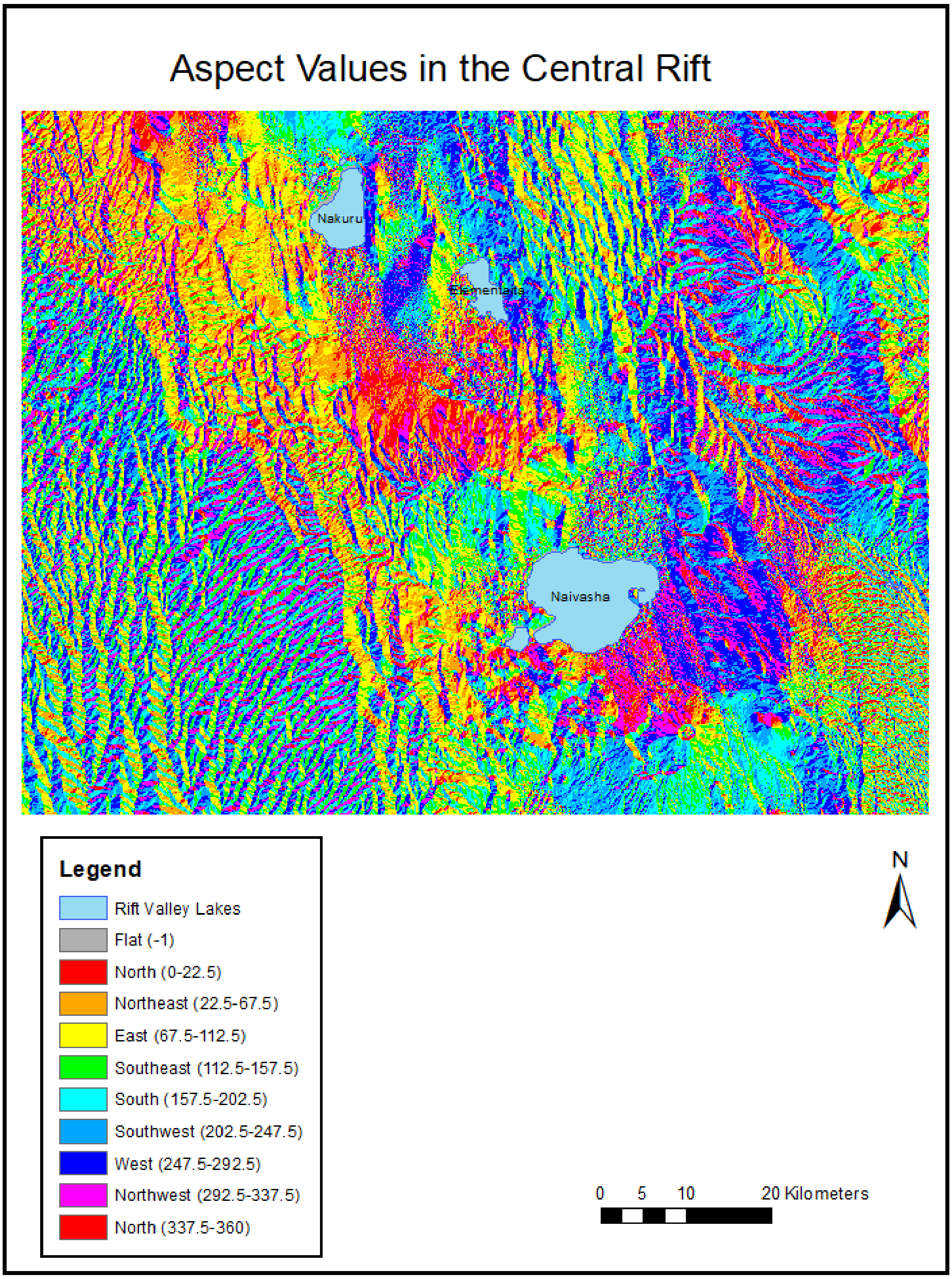
Appendix II: List of MSA sites and their elevations

	SASES	SITE NAME	X	Y	ELEVATION
1.	GsJi6	Prospect farm loc1	36.091	-0.55	1824
2.	GsJi2	Nderit drift	36.1	-0.517	1824
3.	GtJi12	Enkapune ya Muto	36.163	-0.083	1824
4.	GrJi21	Kariandusi	36.004	-0.258	1824
5.	GsJj53	Marula Valley 1	36.3	-0.6	1824
6.	GsJj54	Marula Valley 2	36.333	-0.633	1824
7.	GsJj79	Marula Valley 3	36.333	-0.633	1824
8.	GsJj81	Marula Valley 4	36.316	-0.617	1824
9.	GsJj22		36.316	-0.316	1897
10.	GsJj5		36.283	-0.6	2006
11.	GsJj7		36.283	-0.566	2006
12.	GsJj39		36.338	-0.638	2045
13.	GsJj38		36.318	-0.638	2046
14.	GsJj84		36.314	-0.545	2059
15.	GsJj21		36.283	-0.566	2080
16.	GtJi34	Marmonet Drift SE	36.175	-0.752	2086
17.	GtJi41	Ole Polos	36.191	-0.767	2089
18.	GtJi15	Marmonet Drift	36.175	-0.752	2091
19.	GsJj85	Ngunyumu	36.301	-0.576	2110
20.	GsJj88		36.315	-0.57	2125
21.	GtJi32	Uruu East	36.21	-0.754	2125
22.	GsJj28		36.325	-0.666	2132
23.	GsJi32	Gambles Cave	36.351	-0.616	2135
24.	GsJi65		36.189	-0.605	2183
25.	GsJi16	Ol Tepesi Ridge	36.202	-0.202	2196
26.	GsJi66		36.19	-0.606	2227
27.	GsJj2		36.3	-0.616	2325

Appendix III: List of MSA/LSA sites

	SASES	Site Name
1.	**GsJi 1**	**Gamble's Cave**
2.	**GsJi 7**	**Prospect Farm**
3.	**GsJi 16**	**Ol Tepesi Ridge**
4.	**GsJi 32**	**Gamble's Cave**
5.	**GsJi 57**	**Ol Tepesi Ridge N**
6.	**GsJi 60**	**Miti Mingi**
7.	**GsJi 61**	
8.	**GsJi 65**	
9.	**GsJi 66**	
10.	**GsJj 2**	
11.	**GtJi 12**	**EYM**
12.	**GtJi 15**	**Marmonet Drift**

Appendix IV: Aspect values



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