Abstract

Decision-Making in the face of Unpredictable Climate and Intergroup Conflicts in Southwest Madagascar, Sixteenth to Nineteenth Centuries CE.

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This research aims to establish a narrative of human decision-making in the face of unpredictable climate and intergroup conflicts along the Middle Sakamarekely Valley, in arid southwest Madagascar. This is pertinent to the anthropological question of how a society can adapt or be resilient to climate variability and intergroup violence. Since climate variability and internecine conflicts also happened in the past, the study considered the strategies that (pre)historic societies used to adapt to their challenges. To do so, I worked within the framework of historical ecology using cultural niche construction theory to investigate why riverine communities preferred to occupy specific parts of a valley over others in the face of unpredictable climate and intergroup conflicts during the $16^{th} – 19^{th}$ centuries CE in southwest Madagascar.

I drew on settlement patterns, intrasite layout, features, ceramics, faunal remains, and ethnohistorical data to answer my research question. I gathered these data through regional survey, intrasite spatial patterning survey, excavation, and ethnohistorical

inquiries. I examined data through spatial analysis using GIS program, stratigraphic analysis, ceramic analysis, archaeozoological analysis, stable nitrogen isotopes ($\delta 15N$) and amino acid $\delta 15N$ patterns analyses.

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CHAPTER ONE: INTRODUCTION

1.1.Research Problem

The world is currently facing critical social-environmental issues (Moran 2009: xvii). One of them is how a society can adapt or be resilient in the face of climate change (Diamond 2005; McAnany and Yoffee 2009; Moran 2009: xvii; Redman 2005: 71). This is an issue of concern in world archaeology, and my thesis is the first to address it for the case of Madagascar. I investigate why riverine communities preferred to occupy specific parts of a valley over others in the face of unpredictable climate during the $16^{th} – 19^{th}$ centuries CE in southwest Madagascar. I explore the ideas of anthropological theorists with regard to decision-making by people in the face of unpredictable climate. How did communities choose where to settle during a period of unpredictable climate, and what environmental or economic factors influenced their choice? Although studies have increased our understanding of this (Berkes *et al.* 2003; Brondizio and Moran 2013; Gunderson and Holling 2002; Liu *et al.* 2007; Redman 2005; Sutton and Anderson 2010), the intricacy of the interaction between people and their biophysical environments as well as the biocultural nature of humanity make it difficult to explore the issue only on an environmental basis. Sociopolitical events also influence people's decisions about where to settle (Ingold, 1993; Llobera, 1996, 2001; Maschner, 1996; Hatch and Bondar, 2001; Tilley and Bennett, 2001; Jones, 2006), and it is difficult to ascertain whether environmental or sociopolitical factors or both influence these decisions, especially during a period of both unpredictable climate and intergroup conflicts (Bocinsky 2014: 38-; Jones 2010: 2; Maschner and Stein 1995). It is important to consider the choices of (pre)historic societies who faced these challenges (Butzer 1982; McAnany and Yoffee 2009; McIntosh et al. 2000; Redman 2005).

Archaeology, with its long-term perspective and integrated transdisciplinary framework, may offer the best approach to this issue (Bocinsky and Kohler 2014).

Paleoecology and paleoclimatology have uncovered a long history of unpredictable climate in southwest Madagascar, especially since the late 16th century CE (Burney 1993; Dewar and Richard 2007; 2012; Dewar and Wallis 1999; Virah-Sawmy et al. 2010; 2016; Zinke *et al.* 2004). Historical documents and oral traditions mention cyclical droughts and unpredictable rainfall regimes that caused crop failures and episodic famines (Faublée 1942: 165, 167; 1947; Harvey et al. 2014: 2; Mahatante *et al.* 2015). My goal is to ascertain whether the communities at two sites – Keliangebo (16th-17th centuries CE) and Ankilivalo (late 17th -19th centuries CE) – were driven by these factors to choose the Middle Sakamarekely Valley (hereafter MSV) as a sanctuary. What environmental factors attracted them to settle along the MSV? It should be noted here that a river valley is typically an area of fertile land with access to water.

Occupation of the sites also coincided with the emergence and development of inequality and social complexity in the southwest (Fagereng 1971; Kent 1970), documented by historical reports of intergroup conflicts (Duarte Barbosa, Diogo do Couto, and André Thevet in Grandidier and Grandidier 1903: 54, 89, 99, 147, 152, 440). Did such conflicts drive the occupants of Keliangebo and Ankilivalo to seek refuge in the MSV? Are the reported intergroup conflicts of the 16th – 19th centuries CE reflected in the positioning of archaeological sites along the MSV? Apart from being an area of fertile land with access to water, sociopolitical attributes such as defensibility can also be associated with a valley landscape (see Bocinsky 2014: 56; Sakaguchi *et al.* 2010).

1.2. Research framework:

This study investigates whether environmental or sociopolitical factors or both influenced the decision-making of communities when they chose to settle along the MSV during a period of unpredictable climate and internecine violence of the 16th – 19th centuries CE. Its aim is to uncover relationships or connections between variables that could be either correlations or causally related, and so analyses are necessarily exploratory.

I explore these questions by examining the evidence for three alternative scenarios for the settling at the MSV. I start with describing a scenario that could have happened, then outlining evidences that are expected to be found under such scenario.

Scenario 1

Communities were influenced by prolonged unpredictable climate and episodic droughts to seek a location that offered access to permanent water sources, pastures, arable land, and forest resources depending on their subsistence mode. In this case, both climate unpredictability and proximity to resource-rich microenvironments influenced the decision-making of communities.

Under this scenario, I expect sites to be located close to resource-rich microenvironments that could be exploited during different seasons and periods. The strategic location of such sites would demonstrate that communities had a fair judgement of the suitability of the surrounding environments, and carefully chose where to settle in order to manage resources efficiently and respond to the unpredictability of the climate (Old-Smee *et al.* 2003). In addition, I expect to find within sites ethnobiological traces (especially animal remains) that reflect concern about the unpredictable climate.

If proximity to resource-rich ecozones did not influence the decision of the community even during a period of variable climate, I expect the environmental contexts of actual archaeological sites to be no different from a random distribution of site locations within the same landscape (see Jones 2010; Maschner and Stein 1995; Nathan 2017).

Scenario 2:

The insecurity caused by intergroup conflicts worried communities and led them to search for defensible landforms that kept them safe. That is, intergroup conflicts and site defensibility influenced the decision-making of the settling communities.

Under this scenario, I expect sites to be naturally difficult to access (e.g. steep landform and high elevation hill) (Martindale and Supernant 2009; Mitcham 2002; Moss and Erlandson 1992), and/or secluded (Martindale and Supernant 2009; Mitcham 2002), and/or having a commanding view of the surrounding area (Mardy and Rakos 1996; Martindale and Supernant 2009; Maschner, 1996b; Mitcham, 2002; Moss and Erlandson, 1992). Within sites, I expect to find defensive features such as walls or ditches, and warfare paraphernalia.

If the defensibility of sites did not influence the sociopolitical decision-making of the community even during a period of intergroup conflicts, I expect their positioning to be no different from random site locations within the same landscape (see Jones 2010; Maschner and Stein 1995).

Presence of sacrificial items such as incense-burner or a sacrificial knife, and absence of warfare paraphernalia would imply that the site was instead a ritual/ceremonial place. A hard-to-access hill and secluded place could also be associated with rituals and ceremonies.

Scenario 3:

Communities were troubled by the insecurity caused by the intergroup violence and sought locations that offered defensive positions but, at the same time, unpredictable climate and cyclical droughts favored locations that offered access to permanent water source, pastures, arable lands, and forest resources. In this kind of situation, both intergroup violence and unpredictable climate influenced community decision-making.

Under this scenario, I expect sites to be both naturally defended by their position in relation to topography and surrounded by resource-rich microenvironments that could be exploited during different seasons and periods. I also expect to find within sites defensive features such as walls and warfare paraphernalia, and food remains reflecting concerns about unpredictable climate.

If proximity to resource-rich ecozones and the defensibility of sites did not influence decision-making even during a period of variable climate and intergroup violence, I expect the location of archaeological sites to be no different from random site locations.

In order to investigate whether there is archaeological evidence for one of these scenarios, I conducted several analyses: ethnohistorical analysis (Chapter 4), faunal analysis and pottery analysis (Chapter 6), and spatial analysis using georeferenced 3D and 2D data (Chapter 7). In Chapter 3, I draw on paleoenvironmental proxies to determine the extent of climate unpredictability: decadal records of instrumental weather data, 400-year records of coral proxies, historical documents and oral traditions, and nitrogen isotope values from cattle bone collagen, which reflect regional variation in aridity (see Crowley and Godfrey 2012; Gröcke et al. 1997).

1.3.Middle Sakamarekely Valley as a Field Site

The riverine landscape of the Middle Sakamarekely River, a 15km long section of a tributary of the upper Onilahy River, in arid southwest Madagascar is the site of this study covering the period between 16^{th} – 19^{th} centuries CE. The area and period are important and well suited for this study:

1. The cultural history of southwest Madagascar is still based on limited historical documents, oral traditions, and archaeology, and the upper Onilahy area including the MSV has been *terra incognita* for archaeological research. Recent research by the author (Rasolondrainy 2012; Fieldworks 2014-2016), however, suggests the archaeological potential of the region is great.

2. A resource-rich mosaic of microenvironments is found in the area. These include the Sakamarekely River valley with its water, arable land and gallery forests; the adjacent Isalo massif with its wild plants and animals as well as its grassland; and the neighboring Horombe plateau with its pastures and arable land.

3. The valley is naturally protected on both sides by high cliffs of the Isalo massif and the Horombe plateau, making it an ideal place for a refuge.
4. Ethnohistorical studies of the southwest between the 16th and 19th centuries are available, allowing a comparative analysis between ethnohistorical records and archaeological data of this period.
5. A decades long record of instrument weather data is available from nearby meteorological stations, and paleoclimatic data for neighboring areas are available from previous studies (Burney 1993; MacPhee and Burney 1991; Vallet-Coulombe *et al.* 2006; Zinke *et al.* 2004).
6. The local people are sociable, and I am knowledgeable about their current culture and traditions.

With the support of Yale University, the CEDRATOM Museum of the University of Toliara, and the *Musée d'Art et d' Archéologie* of the University of Antananarivo, I was persuaded that a study of decision-making in the face of unpredictable climate and intergroup conflicts along the MSV was not only feasible but might also yield an important case study for Madagascar archaeology, and world archaeology.

1.4. Significance of the Study

The present archaeological study makes a significant contribution to the history of this archaeological *terra incognita*, and will help researchers plan and conduct future work in the region. A deeper understanding of human decision-making in the face of unpredictable climate and intergroup violence may also help policy-makers develop well-informed policy decisions for the management of natural resources and response to local insecurity (see Moran 2009: 53); This study also promotes the importance of archaeology and ethnohistory as essential disciplines within the global framework of research on resilience (Crumley 2007: 18; Hudson 2013; Redman 2005; Tainter 2000: 348-349; Winterhalder 1994: 40), and helps build a bridge between archaeologists and ecologists doing socio-ecological research in Madagascar.

My research is relevant to theoretical debates in anthropology concerning human decision-making and resilience in the face of climate change. Last but not least, it has fostered interdisciplinary collaboration between researchers and specialists from different disciplines and institutions by offering field and lab-based training to undergraduates and graduate students from Yale University and the University of Toliara.

1.5. Thesis Outline

This chapter introduces the research problem and framework, the field site, and the significance of this study. Chapter 2 outlines the theoretical foundations of the study through an overview of historical ecology and the concept of niche construction, social memory, and decision-making. It emphasizes that within the research program of historical ecology, niche construction is a useful concept to understand the decision-making of relocating communities. Chapter 3 describes the (paleo)environmental contexts of the study area. Chapter 4 presents the historical and cultural backgrounds of communities in the study area based on historical documents, oral traditions, and archaeology. It also summarizes previous archaeological and socio-ecological research in the southwest. Chapter 5 describes specific research strategies and methods employed in the fieldwork and lab analysis undertaken. Chapter Six presents data collected and examined during three field seasons conducted along the MSV between 2014-2016, including analyses and interpretations of pottery and faunal remains. Chapter 7 details the geospatial analysis conducted on the landscape of the MSV. Chapter 8 presents a concluding discussion of decision-making by the occupants of the MSV in the face of unpredictable climate and intergroup violence. The chapter also makes suggestions and recommendations for future research.

CHAPTER TWO: DECISION-MAKING AND LOCATIONAL ANALYSIS IN HISTORICAL ECOLOGY

This chapter outlines the theoretical frameworks of this study. I primarily framed my thesis within the research program of historical ecology.

2.1. Historical Ecology as the Basic Framework

Historical ecology is a research program that studies the cumulative effects of the interaction between people and their environments over long-term periods (Balée 1998; 2006; Balée and Erickson 2006; Crumley 2007; McIntosh 2005: 45-100). Historical ecologists argue that people not only adapt to their environment but also actively shape it through social activities such as controlled fire burns, soils alteration, watercourse modifications, opening agricultural fields, and so forth (Balée 1998; 2006; Brondizio and Moran 2013; Crumley 2007; McIntosh 2005: 50; Rogers et al. 2012). Historical ecology advocates the importance of historicity and human agency in the study of social ecological systems.

Considering the importance of historicity, historical ecologists hold that the shape of contemporary landscapes has been affected by the history of events and conditions that have occurred from long ago to the present (Balée 1998; 2006: 80; Crumley 2007: 17; Kirch and Hunt 1997; McIntosh et al. 2000). These events and conditions have left 'fingerprints' that still can be seen as palimpsests of the cumulative interactions between people and their biophysical environments.

The temporal dimension of historical ecological perspectives is relevant to this study in that it allows investigation of the past use of a landscape from its current features. In this thesis, I assess specific characteristics of a current landscape (the proximity of sites to natural resources as well as the defensibility of sites) to answer questions about community decision-making in the face of unpredictable climate and intergroup conflicts.

Historical ecologists emphasize the ability of people to act independently of external forces such as climate or environmental changes. Historical ecology studies community perceptions of the landscape (Balée 2006; Kirch and Hunt 1997; McGovern 1994; McIntosh 2005: 50). It holds that people perceive a landscape by giving it meaning through localized social practices and experience as well as spiritual value (McIntosh 2000; Knapp and Ashmore 1999: 10-13). This perception is conditioned by *social memory* that includes people's belief, worldview, and ecological knowledge. *Social memory* plays essential roles in influencing how people to adapt to their biophysical environments, and reshape the landscape to meet their social, economic, political, and ideological needs (Butzer 1982: 32; McIntosh 2005: 45-100; Tilley 1994).

The emphasis of historical ecology on the agency of individuals is vital to this thesis, in that it helps explore the behavioral and ideological motivations behind people's decision-making. Measurable aspects of social-ecological systems can be functionally and materially analyzed, but do not explain underlying 'codes' (Hodder 2007: 5-7). This thesis looks not only at external realities of the objective world but also at human perceptions of the landscape and the supernatural realm (Balée 1998; 2006; Crumley 2007; Kirch and Hunt 1997; McIntosh *et al.* 2000; Winterhalder 1994).

Historical ecology is only a research program. It is neither a theory nor a method. To put it in use in scientific research, one needs to use theoretical concepts that could "provide a framework for viewing facts selectively" (Winterhalder 1994: 17, 24). For this project, I chose *cultural niche construction theory* as a conceptual framework that includes *niche construction, social memory*, and *decision-making.*

2.2. Cultural Niche Construction Theory as a Conceptual Framework

Ecologists argue that organisms have to construct their own niches in order to survive within an ecosystem (Laland and O'Brien 2010: 303; Odling-Smee *et al.* 2003). By *niche,* they mean the role that an organism plays under specific environmental conditions and the relationship between the organism's role and characteristics of the environment that are related to it (Arnaud 2015: 547; Sutton and Anderson 2010: 46). Niche has physical and cultural aspects. A *physical niche* includes physical spaces such as the habitat and resources within it, while *cultural niche* refers to the role and activities of the species within its environments and community.

2.2.1. Niche Construction:

Ecologists coined the term *niche construction* to denote "the process whereby organisms, through their metabolism, their activities, and their choices, modify their own and/or each other's niches" (Odling-Smee *et al.* 2003: 42, 419). *Niche construction* occurs when an organism alters one or more characteristic(s) of a given environment to meet its resource demands. This alteration occurs "either by physically perturbing factors at its current location in space and time or by relocating to a different space-time address, thereby exposing itself to different factors" (Odling-Smee *et al.* 2003: 41). *Niche Construction Theory* (hereafter NCT) holds that there are complex feedback interactions between organisms and their biophysical environments. Organisms including humans do not only adapt to biophysical environments but also alter them purposely or unintentionally. This alteration disturbs, inflicts damage(s), modifies, or even optimally constructs organisms' own or other's niches (Laland and O'Brien 2010: 305, 310; Odling-Smee *et al.* 2003).

Proponents of NCT propose four categories of *niche construction*, namely *inceptive perturbation*, *inceptive relocation*, *counteractive perturbation*, and *counteractive relocation* (Odling-Smee *et al.* 2003: 44-47). Table 2.1 summarizes these four categories of niche construction:

Table 2.1: Four Categories of Niche Construction (After Odling-Smee et al. 2003: 46)

	Perturbation	**Relocation**
Inceptive	Organisms initiate a change in their particular environment by physically modifying their surroundings.	Organisms expose themselves to a new environment and modify the new place.
Counteractive	Organisms counteract a previous change in the environment by physically modifying their surroundings.	Organisms respond to a change in the environment by moving to or growing into a more suitable place.

Anthropologists and archaeologists have applied NCT to human society and coined the term *human niche construction* (Flynn *et al.* 2013; Gerbault *et al.* 2011; Kendal *et al.* 2011; Laland and O'Brien 2010; Odling-Smee *et al.* 2003; Smith 2009) and *cultural niche construction* (Boyd *et al.* 2011; Kendal 2011). Human/cultural NCT employs transdisciplinary research to explore the intricate interaction between people and their environments (Kendal 2011). The term *niche* is employed to describe the interrelationship between the community's subsistence lifeways (cultural niche) and the natural resources available to them (physical niche) such as water points, arable lands, prairies, forests, etc. (Arnaud 2015: 547; Sutton and Anderson 2010: 46).

Most of the work done so far on human/cultural NCT has focused on the biological and economic aspects of *human niche construction* (Gerbault *et al.* 2011; Laland and O'Brien 2010; Riel-Salvatore 2010; Smith 2009; Vining 2018). Cultural NCT scholars are interested in how people as organisms changed other organisms' fate through their subsistence practices. In archaeology, for instance, cultural NCT has been used to investigate processes of foraging (O'Brien and Laland 2012), domestication of plants and animals (Smith 2016; Zeder 2016), and food production (Crawford 2014). This interest in biological and economic aspects has been a sequel to the practice of proponents of NCT in ecology who treated people as biological organisms interested only in subsistence and health needs, and non-biological and non-economic aspects of a human niche such as sociopolitical and ideological contexts have been overlooked. These play an essential role in the choices and decision-making of human societies (past and present), however, and should have been considered in the study of *cultural niche construction.*

To address the underappreciation of non-economic factors in cultural NCT, this thesis considers sociopolitical dimensions of settlement decision-making. Specifically, this project analyzed whether intergroup violence influenced community decisions about where to settle. With this perspective, the term *niche* refers to the role played by archaeological communities within the sociopolitical contexts of the region. This role is defined not only by the place of the community vis-à-vis the sociopolitical contexts of the region but also by the type of institutions, technocultural materials and cultural resources available to them such as kinship, alliances, defense strategies, and warfare paraphernalia. Although this interest in sociopolitical perspectives is not new in locational analysis studies (see Allen 1996; Bond 1985; Hasenstab 1996; Jones 2010; Llobera 1996; 2001; Maschner 1996), it is novel in cultural NCT research.

Another limitation of conventional *cultural niche construction theory* addressed in this thesis is that it overlooks *counteractive relocation* in favor of the other three niche construction categories. This stems from the practice of niche construction theorists in ecology who wanted to demonstrate that in addition to the natural selection process, "niche construction provides a second evolutionary route to the dynamic match between organism and environment" (Odling-Smee *et al.* 2003: 312, 239-240). To support this perspective, proponents of NCT promoted only niche construction categories that emphasize organisms taking initiatives to modify niche(s). Inceptive and perturbatory niche construction categories are important in that they allow us to think beyond external forces such as climate and environments as the only drivers of human evolution (Laland and O'Brien 2010: 315). Let alone, they are in accord with the historical ecological concept of *human agency*. By stressing the inceptive and perturbatory nature of niche construction, the importance of *counteractive relocation* has been underappreciated. This fourth niche construction category helps to understand the causes and process of relocation of organisms to a new place. *Counteractive relocation*, therefore, offers an excellent opportunity for anthropologists and archaeologists to explore the cause and process of group mobility and migration. Both inceptive and counteractive relocations consider a community moving and settling in a new location. *Inceptive relocation* implies that the relocating community moves to a new place without knowing much about the sustainability of its resources, however, while *counteractive relocation* suggests that the relocating community has a fair judgment of the suitability of the surrounding environments before moving to the new place (Odling-Smee *et al.* 2003). This makes *counteractive relocation* an attractive concept for this study.

Using the concept of *counteractive relocation,* this thesis assumes that the occupants of Ankilivalo and Keliangebo had a fair judgment of the suitability of the landscape of MSV before they chose these sites. This judgment should be reflected in the positioning of the sites vis-à-vis the landscape, the interaction between the relocating community and the surrounding environment, and material remains left in the archaeological record (Laland and O'Brien 2010: 313; Odling-Smee *et al.* 2003).

Two concepts are relevant to consider as communities moved to new locations, namely *social memory* and *decision-making.*

2.2.2. Social Memory:

Social memory is the cultural process through which members of a society acquire knowledge and build skills from their (past and present) social environments (McIntosh 2000). The concept of *social memory* has been developed across anthropological research and is known as *social learning* (Boyd *et al.* 2011; Flynn *et al.* 2013; Kendal 2011), *indigenous knowledge* (Minar and Crown 2001; Boyd et al. 2011; Schieffelin 1990), *traditional local knowledge* (Berkes *et al.* 2000), and *traditional knowledge systems* (Sutton and Anderson 2010: 102-115). It includes people's beliefs, worldview, ecological and social knowledge (McIntosh 2000; Knapp and Ashmore 1999: 10-13).

Within a 'traditional' society, ecological knowledge mainly derives from past experiences, and information passed on from generation to generation. It can be evolutive but also cumulative (McIntosh 2000: 142). New generations receive this information from parents, peers, unrelated older individuals, and key individuals (Laland and O'Brien 2010: 308). *Social memory* helps traditional societies make informed decisions to face and survive harsh environmental stresses (Brunger 1982 in Stone 1996: 143).

Social memory, for instance, gives herders the knowledge and skills to understand local variations of climate, edaphic properties, and rainfall patterns that allow them to locate pastures and avoid loss of livestock (Fernandez-Gimmenez 2000: 1320; Krätli 2008). Eurasian nomadic pastoralists graze their camels and goats in the desert-steppe and waterless steppe pastures, but never take their cattle, yaks, and horses there, because the latter are suited to pastures in the mountain-steppe, near rivers and on mountaintops (Fernandez-Gimmenez 2000: 1320). This suggests that, thanks to social memory, nomadic pastoralists have a fair judgment of the available resources in the landscape before moving their herds. This conforms well with the concept of *counteractive relocation*. *Social memory* also motivates herders to create alliances or kinship with their neighbors in order to obtain subsidies or loans during a period of significant loss of herds afflicted by environmental stress (see Anthony 2007; Ingold 1984). Thanks to *social memory*, thus, herders could sustain their nomadic pastoral activity. In West Africa, *social memory* of climate crises encouraged Mande communities to sustain a flexible and mutualistic heterarchical society suitable for responding to the unpredictable climate instead of creating a rigid centralized or hierarchical power (McIntosh 2000: 144).

To encourage people to implement and maintain *social memory*, 'traditional' society backs it with ideology, beliefs, and rituals (Sutton and Anderson 2010: 104). These help sustain the essence of a given practice in the face of interference from social, economic, political and technological changes. Within a community without written documents, *social memory* reminds people of their history, rituals, rules, identity, ecological knowledge, and other kinds of information (Faublée 1947: 486; McIntosh 2000; Mixter and Henry 2017: 2). Dedicated professionals such as the griots of West Africa or other musicians may play an important role in keeping and transmitting *social memory* (McIntosh 2000; Jones *et al.* 1989). In southern Madagascar, for instance, Etienne de Flacourt (1661: 111) reported the role of musicians in transmitting *social memory* as follows:

> "*Le joueur d'Herravou c'est celui qui est le plus écouté, lequel ne récite que des choses serieuses et le plus souvent des fables du temps passé.*"
>
> The *Herravou* player [*Hararavo* = traditional violin] is the most respected, the one who only recites relevant things and mostly ancient fables. [My translation]

In section 2.4., I discuss the importance of *social memory* in southwest Madagascar, and how it helps us understand decision-making along the MSV. Indeed, *social memory,* either knowledge of objective matters or cognitive worldviews, is at the heart of people's decision-making in the face of climate uncertainty or intergroup conflicts (Adger *et al.* 2005; Berkes 2007: 287; Bocinsky 2014: 33; Laland and O'Brien 2010: 307; McIntosh 2000: 143; 2005: 89; Tucker *et al.* 2015). It largely conditions the 'motivations, intentions, and perceptions' behind community decisions (McIntosh 2000: 141). However, it is hard to detect *social memory* in the archaeological record, especially if it is overlooked in favor of material and functional analyses.

This is one of the reasons why this study considers ethnohistorical approaches as part of its epistemological foundations. I use ethnohistorical approaches to understand and interpret the archaeological record based on *social memory* (Whitley 2000:4). Appreciation of ethnohistorical data helps to understand cognitive aspects of the landscape and material culture, and to develop models of decision-making in the face of unpredictable climate and intergroup conflicts.

2.2.3. Decision-making

The driving forces behind social changes – from technological changes, via domestication of animals and plants, to the development of complex societies – have always been people making decisions in their daily lives (Mithen and Mithen 1990: 1). In archaeology, the decision-making of people is inferred from the contexts of their physical and social environments (Bocinsky 2014: 45; MacDonald 2009; Mithen and Mithen 1990). For instance, low curation of a tool can be explained by the abundance of raw materials available in the surrounding environment (Andrefsky 2009).

This study explores why people chose to settle at a specific part of a valley in the face of unpredictable climate and intergroup conflicts. The choice involved making a major decision. The driving forces behind the decision might be multifaceted, ranging from constraints – such as the unpredictable climate and/or intergroup conflicts – to attractive factors – such as the bountifulness of the environment and/or the defensibility of the location (Bocinsky 2014: 59).

I assume that the choice of where to settle in a valley was to some extent conditioned by the disposition of natural resources in the landscape. Especially when prolonged unpredictability of climate put stress on a community, its members may have considered finding a better solution such as relocating to a more bountiful landscape. Drawing on this, I expected that during a period of unpredictable climate and intergroup conflicts, the bountifulness of a landscape influenced the decision of communities as much as the defensibility of a location. I thus expected to see proximity of sites to permanent water sources, arable lands, prairies, and forests (Table 2.2). In the same veins, I also expected to see reflection of climate concerns in the ethnobiological remains (specifically faunal remains) recovered from sites in the area.

Nevertheless, independent of economic interests, people tend to choose a site that also meets their sociopolitical or ideological expectations (Bocinsky 2014: 36). These expectations are, to a large extent, conditioned by what the community perceives as conducive environments based on their social memory (McIntosh 2000). A river valley, for instance, might be economically conceptualized as an area of fertile land with access to water. However, not all valleys are occupied by people. Some communities preferred to avoid a valley and occupy a hazard-prone or denuded area for sociopolitical or ideological reasons (see Allen 1996; Berkes 2007: 283; Grandidier and Grandidier 1906: 299; Maschner 1996; McGovern 1994; McIntosh 2005; Sakaguchi *et al.* 2010: 1172-1173). In such a situation, sociopolitical considerations outweigh economic interests (Bocinsky 2014: 36). Accordingly, I also expected that, during a period of unpredictable climate and internecine conflicts, the defensibility of a location influenced the decision of a community as much as the bountifulness of the landscape (see Bocinsky 2014: 48). I thus expected to see a certain degree of defensibility of site locations. In addition, I expected to find weaponry or warfare paraphernalia (Laland and O'Brien 2010: 308, 314).

The following table summarizes my expected scenarios of *counteractive relocation* in the MSV during the 16th – 19th centuries CE.

Table 2.2: Models of Counteractive Relocation Expected along the Middle Sakamarekely Valley.

Scenarios	Influencing Factors	Counteractive Decisions	Expected Patterns
Scenario 1	A prolonged unpredictable climate with episodic droughts troubled communities	Communities decided to move to a location close to permanent water sources, arable lands, pastures, and forest resources	Site proximity to resourceful microenvironments
Scenario 2	Communities were concerned with intergroup conflicts	Communities decided to relocate to a more defensible location	Defensive landforms that allow site occupants to defend themselves from intruders
Scenario 3	Communities were worried about prolonged unpredictable climate and intergroup violence	Communities decided to move to a defensible location that at the same time offered access to resourceful microenvironments	Site proximity to resourceful ecozones, and defensive site

Understanding both the environmental and sociopolitical contexts of community decision-making is, thus, necessary to answer the research questions. I explore the importance of proximity to resources and/or site defensibility in community decision-making by exploring decisions that would have been made if proximity to bountiful resources and/or site defensibility were unimportant (Bocinsky 2014: 166). I did this by comparing the location of actual archaeological sites with random site locations (see Chapter 5), thereby testing the causal relationship between the decision and the bountifulness of the landscape and/or the defensibility of the site (see Maschner and Stein 1995; Jones 2010).

I combined geospatial analysis, zooarchaeology, amino acid specific nitrogen isotope analysis, pottery analysis, ethnohistory, and paleoclimatology to provide multiple lines of evidence of past decision-making. The following sections discuss the integration and application of these methods within the framework of historical ecology.

2.3. Site Location Analysis and GIS Applications

Since Kroeber (1939)'s *culture area concept* and Gordon Willey (1953)'s notion of *settlement pattern*, the spatial relationship between an archaeological site and its surrounding environments has been of interest to archaeologists.

The application of spatial analysis in anthropology is based on the structural and behavioral assumptions that "elements of social structure are present in spatial structure" (Clarke 1977: 18). That is, archaeological spatial patterning such as site location, site layout, structural and featural configurations reflect people's activities and behaviors. The spatial relationships between a site and its surrounding environments are, therefore, believed to inform us about how a community selected a location to exploit its surrounding environments at different spatial scales (Butzer 1982: 212; Clarke 1977: 18-19).

Economic-oriented theory posits that "over a span of time and experience, people move to choices and solutions which minimize costs (energy and information expenditure) and maximize profits (energy and information returns)" (Clarke 1977: 19). This *economic spatial theory* encompasses sub-theories such as Johann von Thünen (1826)'s *location theory*, Alfred Weber (1909)'s *optimal site location theory*, and Walter Christaller (1979)'s *central place theory*. These sub-theories were borrowed by archaeologists and, in other cases, tailored to develop spatial theoretical approaches such as *catchment area analysis* (Jarman *et al.* 1972; Vita-Finzi and Higgs 1970) and *settlement ecology* (Stone 1996).

These economic-oriented spatial theories were very influential in the 1960s and 1970s until it was realized in the 1980s that they overlooked the sociopolitical and ideological dynamics behind the spatial patterning of archaeological remains. The quantitative nature of the analysis was criticized as downplaying other drivers of archaeological spatial patterning (Tilley 2008; Verhagen 2017: 13-14; Wheatley 2004). With the integration and development of GIS in archaeology, archaeologists realized that, in many cases, non-economic factors such as defensibility and intervisibility influenced community decisions more than the environmental factors such as resource availability (Allen 1996; Bond 1985; Hasenstab 1996; Jones 2010; Llobera 1996; 2001; Maschner 1996).

In this thesis, my geospatial analysis uses proximity analysis and defensibility analysis not only to determine the proximity of sites to resources but also to assess the defensibility of sites (Jones 2006: 523). The development of the field ArchaeoGIS and the computational power of the GIS software today make such research possible. Methods of proximity analysis and defensibility analysis are detailed in Chapter 5.

2.4. Applying an Historical Ecological Approach in Southwest Madagascar

Despite the widespread use of niche construction theory among ecologists and archaeologists (Laland & Odling-Smee 2000), this project is the first to apply cultural NCT to any region of Madagascar to explore decision-making of communities.

The application of cultural NCT to decision-making is still developing. It is therefore useful and timely to investigate this issue at different scales and in different dimensions, including spatial, temporal, and organizational (McIntosh 2005: 56; Redman 2005: 71; Sauer 2015: 40). To do so, this study implements GIS-based methods to explore spatial settlement patterns and land use, archaeological methods to scrutinize the cumulative effects of human-environment interactions over time, and ethnohistorical approaches to analyze and interpret decision-making at an organizational scale. By integrating these three approaches analytically and theoretically, I offer a historical ecological approach to decision-making in the MSV.

I begin by documenting quantitative data such as site positioning, and the distributions and characteristics of archaeological remains (Wheatley and Gillings 2002: 159), then analyze them with geoprocessing and statistical tools to find statistical evidence of correlation, and finally interpret the patterning with ethnohistorical analogs to add sociopolitical and cognitive perspectives (Clarke 1977: 19; Jones 2006: 523; Whitley 2000:4). Historical documents contemporary with the period of study and the richness of oral traditions eased the interpretation of archaeological patterns.

According to the ethnohistorical record from the last four hundred years, communities in southwest Madagascar had a distinctive philosophical view about the world and the place of people within it. The ritual wooden post locally known as *hazomanga* has played an essential role in maintaining this worldview. It has been a central place where people and supernatural beings were believed to communicate through rituals and ceremonies. This place represents the unity of all members of a community. It is at the same time (1) a sign of a political institution based on patriarchy, and (2) a place where community members conducted ritual and ceremonial activities.

The *hazomanga* is managed by a patriarch known as *mpisoro*, who is an elder of the community and at the same time the religious leader, and sole intermediary between the group and gods and ancestors (Faublee 1948: 41). The attitudes and behaviors of an individual towards his/her social, economic, political, and ideological life have developed from his/her membership to the *hazomanga* (Faublée 1954; see also Moran 2009: 27; von Heland & Folke 2014). The *hazomanga* has been the central place where community members acquired *social memory* and learned of the complex relationship between social, natural, and supernatural beings. Other ways of sharing *social memory* include *hihitsy* (anecdotes), *tapasiry* (fables, legends, myths), and *tatara raza* (family histories) (Faublée 1947: 484).

According to ethnohistorical records in the southwest for the last 400 years, *Ndrianagnahary,* the god, created all things on earth, and made them available to people. People understand the functioning of the world by both observing the objective world and perceiving the unseen world based on social memory.

At least for the last 400 years in the southwest, like in other parts of Madagascar, space has been perceived cosmologically as rectangular (see also Kus 1990: 46; Verin and Rajaonarimanana 1991). This perception has been applied to many places such as a village, house, cattle pen, or tomb. Cardinal directions regulate the spatial arrangements of these spaces (Verin & Rajaonarimanana 1991: 55-56). Each cardinal direction has its own value (Figure 2.1): The North has been associated with power and fire. Within a traditional house, for instance, the north has been the place for the hearth; The East has been associated with sacredness. It is the direction of the sunrise, therefore symbolizes life, vitality, glory, and blessings. The *hazomanga* is located on the northeastern side of a village; The South has been associated with impurity and symbolizes emptiness and desert; Finally, the West has been associated with profanity. It is the direction of the sunset, therefore symbolizes darkness, despair, death, and bad luck.

Also, communities in the southwest for the last 400 years perceived twelve cosmological directions locally known as *vita* (Figure 2.1). They have been assigned values related to cardinal and astrological values, and regulated the spatial arrangements of a place and situated the place of people vis-à-vis the cosmological orders (see Kus 1990; Verin & Rajaonarimanana 1991: 55). The four corners of the rectangular cosmic space have been the main cosmological directions locally known as *reny vita* (mother of destiny). They include *Alahamaly* (northeast), *Asarata* (southeast), *Alimiza* (southwest), and *Alizady* (northwest). The remaining eight cosmological directions, considered as minor or *anabita* (children of destiny), have been located along the four sides of the rectangular cosmic space, in between the *reny vita* and rotating clockwise (see Figure 2.1).

Alahamaly, located at the northeast corner, was one of the foremost cosmological directions. At the intersection of power (north) and sacredness (east), *Alahamaly* symbolizes nobility and power and has been accordingly dedicated for the ancestors (Mantaux 1970: 196). In households, all sacred items used during a sacrificial ceremony such as ancestral relics, sacrificial goblets and knives have been placed at there, and only the *mpisoro* could sit there. The cattle pen, ideologically the most critical locus in a village, is placed at its northeastern edge. Cows, as premium sacrificial offerings, have been considered intermediaries between God *Ndrianagnahary* and people. The house of the *mpisoro* is located next to the cattle pen towards the west (Faublée 1954). This information helped me place one of my excavation unit at the northeast corner of Ankilivalo (Chapter 6).

Opposite *Alahamaly* is the seventh cosmological direction known as *Alimiza* (see Figure 2.1). Located at the intersection of impurity (south) and profanity (west), this cosmological direction symbolizes disgrace and filth. Within a household, the southwest corner has been considered a defiled place reserved for such purposes as storing brooms or providing space for slaves during the chiefdom periods, and it was the place of the doorway where sandals were left before entering the house (Faublée 1954: 72-73; Razafimisa 1987: 50). Within the village as a whole, it is usual to see a dumpster or garbage or latrine on the southwest edge. I refer to this information when I interpreted the placement of refuse I encountered at one of my excavation units (see Chapter 6).

The center of a cosmic space has been generally perceived as a neutral place (Kus 1990). In a village, for instance, a tamarind tree or a banian tree has been usually planted in the center. Under such a tree, people conduct different activities including daily siesta, music playing, resting, crop grinding, and so forth. This was one of the reasons my field survey targeted tamarind and banian trees to find archaeological sites (Chapter 5).

Community members believe that their lives were pre-destined by cosmic forces, and that they should live in harmony with the cosmological orders. Infringements have been believed to cause accidents and maledictions to the wrong-doer or the community (s)he belongs to.

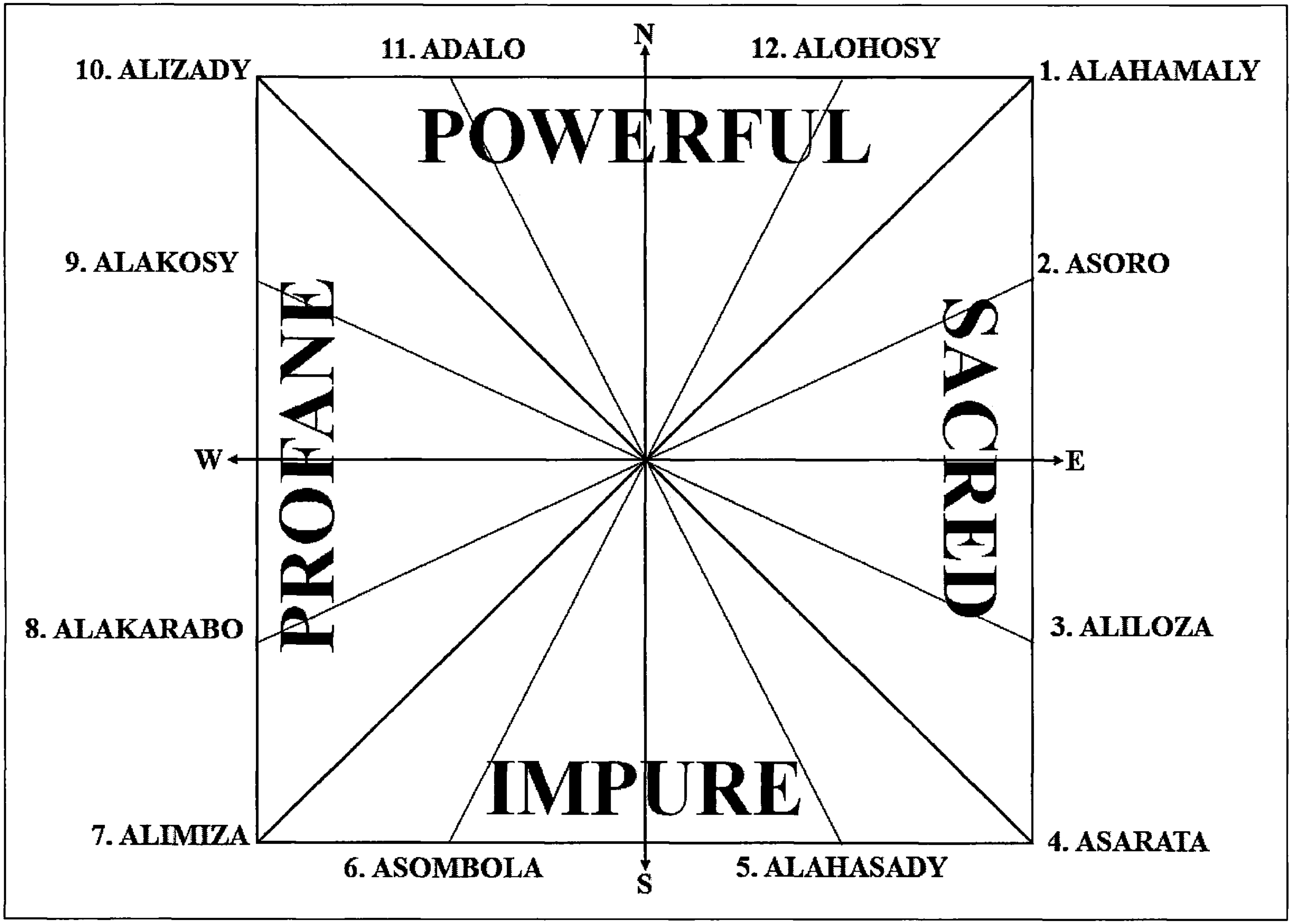

Figure 2.1: Model of Cardinal and Cosmological Orientations Recorded from Oral Traditions in the Middle Sakamarekely Valley

During the last 400 years, however, not everybody has been knowledgeable about cosmological values, and some people have not been satisfied with the destiny imposed by cosmic forces. Although people have recognized the power of destiny, they still want to manipulate the cosmic forces. Healer-diviners locally known as *ombiasy* has had the ability to do that job. An *ombiasy* has a good knowledge of divination and astrological techniques, as well as phytotherapeutic knowledge (Berthin-Irene 1994: 68; Faublee 1951: 127; Verin & Rajaonarimanana 1991: 54). People have referred to the divinatory art as a "third eye". This 'extra eye' is considered as different from the biological eye since it could see the interconnection between the social, natural, and supernatural worlds. An object, for instance, may appear harmless to the naked eye, but the divination might see it as infested with spiritual beings. The knowledge and skills of the *ombiasy* have enabled him to treat the health of his patients, and improved their economic and sociopolitical lives, and his omnipotence has been widely believed in and trusted: an *ombiasy* could see maledictions pre-determined by destiny, and soften/correct them with charms.

For the last four hundred years, community members have always consulted *an ombiasy* before making any decision or initiating any enterprise (Grandidier and Grandidier 1904: 8). For instance, it has been customary to consult an *ombiasy* before embarking on a journey in order to determine the favorable day to leave and whether the destination is in harmony with the traveler's destiny. Also, before founding a village, a patriarchal leader has consulted an *ombiasy* to see whether the proposed location is favorable for the community (see Belrose-Huyghues 1983: 143; Kus 1990: 50; Verin &

Rajaonarimanana 1991: 55). The *ombiasy* has used his divination skill to unravel the will of God *Ndrianagnahary* and the ancestors about the situation. As long as the *ombiasy* has given a green light, the group would relocate to the area even if it was hazard-prone.

Several methods of divination were practiced in Madagascar in the past (Grandidier and Grandidier 1903-1907), including *Ornithomancy* or the divination by the flight of the birds; *Extispicy*, or divination by examining the entrails of sacrificed animals; *Necromancy* or the interpretation of dreams (Malagasy people believed that the dead return to visit the living and appear to them in dreams to tell something will happen). The most popular divination method, still practiced today in the southwest is the geomancy known as *sikily*, the divinatory art *par excellence*. The Portuguese Priest Luis Mariano first reported it in 1616 as follows:

> «*Les habitants de l'Ouest ne font aucun acte important sans consulter les sortilèges qui se font de plusieurs manières sur le sable, avec des noyaux de tamarin, etc.*» (Luis Mariano in Grandidier and Grandidier 1904: 230)
>
> "The inhabitants of the West did not do anything important without consulting the divinations that are conducted in several ways on sand with tamarind grains, etc. " [My Translation]

Also, in 1651, Cauche wrote:

> «*Les Ombiassy et la plupart des maîtres des villages se servent d'une tablette sur laquelle ils étendent du sable blanc, et avec le doigt ils marquent de certaines lignes à ondes, dont ils forment certaines figures sur lesquelles ils font leur jugement* » (Cauche in Grandidier and Grandidier T.VII: 101)
>
> "The Ombiassy and most of the village masters use a tablet on which they spread white sand, and with their fingers, they mark certain wave-lines, of which they form certain figures on which they make their judgment "

Further, Estienne de Flacourt (1661) described as follows:

> «*Les Ompitsiquili, ce sont ordinairement nègres ou Anacandries qui s'en meslent, c'est ce que l'on nomme Géomance, les figures sont semblables à celles de Géomance, sinon qu'ils squillent sur une planchette couverte de sable sur laquelle ils forment leurs figures avec le doigt, en observant le jour, l'heure, le mois, la planette et signe qui domine sur l'heure en laquelle ils squillent, en quoi ils sont très bien versez : mais rarement trouvent ils la vérité de ce qu'ils cherchent et quelques uns adjoutans leur conjecture avec leur squille rencontrent parfois et se font admirer ou estimer d'un chacun. Les maladies les consultent pour leur guérison, les autres pour leurs affaires; il y en a beaucoup qui ne sortent point de chez eux sans squiller. Bref, il n'y a point de nation plus superstitieuse que celle-ci et principalement à Manghabei où ils n'entreprennent rien, ni affaires, ni achat, ni plantage, ni voyage, ni bâtiment de case, sans premièrement consulter l'oracle du squille.* » (Flacourt 1661: 173)
>
> The Ompitsiquili (*Mpisikily* = diviner) are usually Negroes or Anacandries (*Anakandria* = noble group). This is what is called Geomancy; the figures are similar to those of Geomancy, except that they predict on a small wooden board covered with sand on which they make the figures with their fingers, while observing the day, the hour, the month, the planet, and the sign that marks the hour at the time they make a prediction, at which they are very good at it. However, seldom do they find the truth of what they are looking for, and some of them using intuition to the prediction sometimes are precise and are admired or esteemed by everybody. Ill persons consult them for a cure; others for their works; many do not leave their homes without consulting them. It is especially the case in Manghabei (= Mangabe), where they do not do any business, buy, plant, build anything or travel without first consulting the divination. [My Translation].

In sum, for the last 400 years, the belief in cosmological orders played an important role in the decision-makings of communities in southwest Madagascar. Although there have been other factors – such as unpredictable climate and intergroup conflicts – influencing the decisions of people to choose where to settle, ethnohistorical records suggest that people have taken decisions primarily based on the dynamism of cosmic forces (Flacourt 1661: 173; Luis Mariano in Grandidier and Grandidier 1904: 230; Verin and Rajaonarimanana 1991: 55).

To find evidence supporting such ideological aspects of decision-making within the archaeological records is difficult. Only by discovering remains of materials associated with the belief in cosmological orders (e.g. a *hazomanga* posthole or divination paraphernalia) can we infer it. For instance, when a posthole is found located to the east of a house remains around the northeast corner of a site, it can be taken as representing the sacred wooden post *hazomanga* (Razafimisa 1987: 50). The presence of *hazomanga* at the northeast corner of a village indicates the belief in cosmological orders among the village occupants.

Finding remains of divination paraphernalia is, however, difficult since most of the items used have been of vegetal materials (grains and small wooden board) that rarely survive in archaeological records. However, it is also known that to increase his clairvoyance while reading the arrangement of the grains, an *ombiasy* puts a fragment of quartz in front of him (Verin & Rajaonarimanana 1991). I suggest a single quartz fragment, if found within an archaeological context, can be considered as evidence for the practice of the divination *sikily.* For instance, a single quartz fragment was found at the site of Rezoky (~ 160 km north of the MSV), and interpreted by Pierre Vérin (1971) as an unfinished bead. Until now, however, no finished bead made of quartz has been reported from Madagascar. This has questioned the validity of Vérin (1971)'s interpretation. Meanwhile, the above-discussed ethnohistorical records can offer better interpretation by alleging the quartz fragment from Rezoky as remains of divination paraphernalia instead of unfinished bead. Such instance demonstrates the strength of ethnohistorical approach to the interpretation of archaeological remains.

My historical ecological approach for the southwest thus considers ideological aspects of decision-makings by using ethnohistorical records (Chapter 4) to interpret the results of analyses of archaeological remains (Chapter 6) and spatial patterning (Chapter 7).

CHAPTER THREE: (PALEO)ENVIRONMENTAL SETTING OF THE SAKAMAREKELY VALLEY

This chapter describes the climates and environments of the Middle Sakamarekely Valley (MSV).

3.1. Geology and Water Sources

Millions of years ago, Madagascar was part of a Precambrian crystalline-based supercontinent called Gondwana (Collignon 1972 in Rakotomalala 2007: 18). Its crystalline base was made up of various metamorphic rocks that had undergone a physical and chemical transformation from original sedimentary rocks such as sandstones and limestone. Over this base, a series of more recent sedimentary layers were deposited from the Carboniferous geological period 345-275 million years ago to current times (Sourdat 1969). After breaking away from the supercontinent, two major sedimentary basins formed in western Madagascar: the *Mahajanga* Basin in the northwest and the *Morondava* Basin in the southwest. The *Morondava* sedimentary basin extends to the western coast of Madagascar and is the locale for this study. The sedimentary formations here are of the Karoo system, dating from the Upper Carboniferous to the Jurassic. The first series in the system is *Sakoa*. It continues to the Middle Permian age. The *Sakoa* is followed by the *Sakamena* series which extend from the Upper Permian to the Middle Triassic. Finally, there is the *Isalo* series. It extends from the Upper Triassic to the Middle Jurassic and is constituted of a group of remarkable reliefs, including a ruiniform massif in the north, and tabular massif and sandy domes in the south (Figure 3.1; Sourdat 1969: 1).

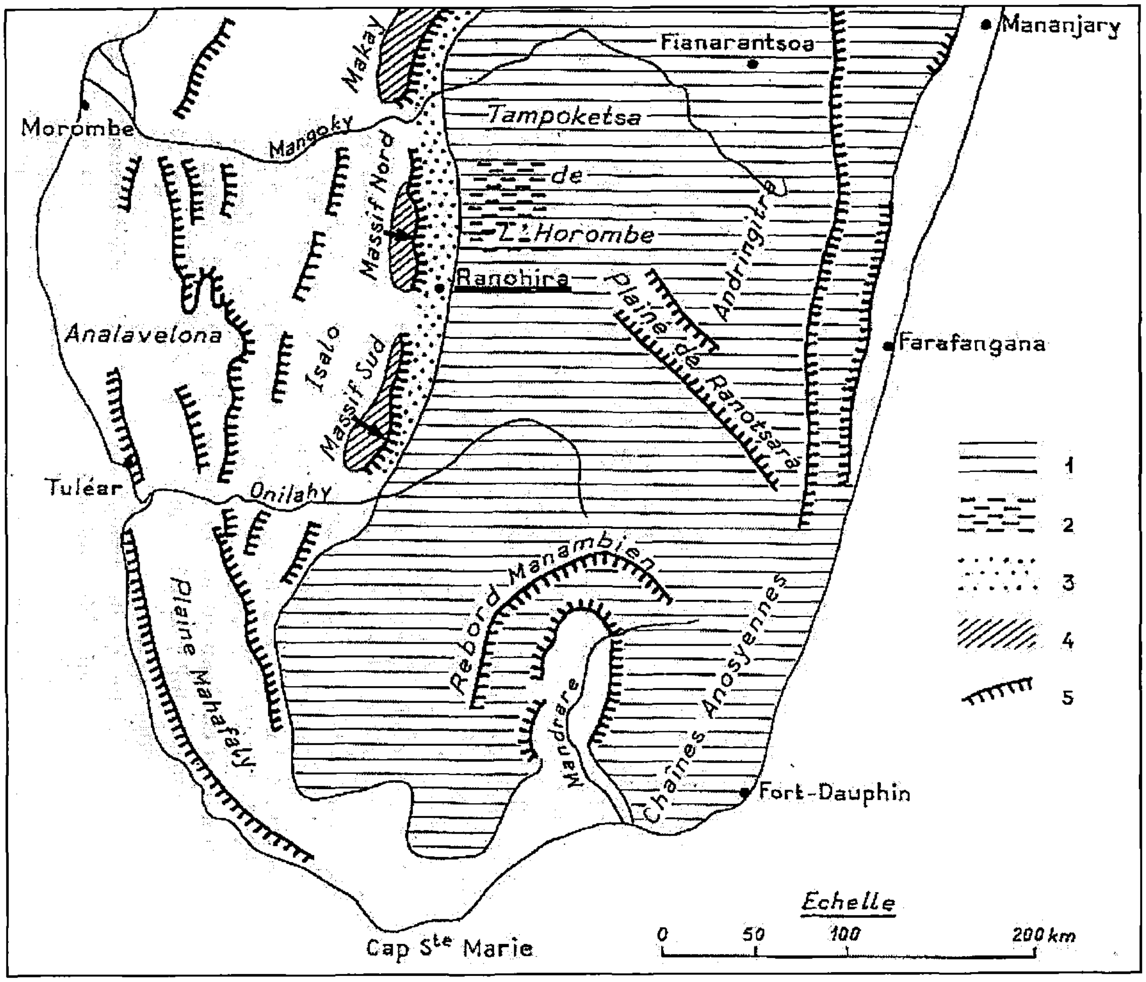

Figure 3.1: Simplified Geological Map of Southern Madagascar Showing the Southern Massif of Isalo (4), the Sakamena Depression (3), and the Horombe Plateau (After Battistini and Doumenge 1966: 68; Figure 1)

The Middle Sakamarekely Valley (MSV) lies in a depression in the Sakamena geological strata bounded by the Horombe Plateau in the East and the tabular massif of southern Isalo in the west (Battistini and Doumenge 1966: 69).

The eastern escarpments of the Isalo play an essential role in driving up air brought by the easterly trade winds and condensing clouds that produce precipitation in the area. The disposition and arrangement of the tables, buttes, and canyons in the southern Isalo enabled the formation of numerous hydrographic networks, including the Sakamarekely River, the unit of interest in this study (Petit 1996: 79; Sourdat 1969: 2;

1970: 107). From its sources, the Sakamarekely River flows torrentially along deep canyons of the southern Isalo. Immediately after emerging from the massif, it joins the central depression of the Sakamena strata and deposits alluvial soils derived from ferruginous soils that envelope the sandstone massif of Isalo (Sourdat 1969: 2). The river follows the eastern escarpment of the Isalo (Battistini and Doumenge 1966: 84, 92), and expands into an alluvial marsh along which the Bara Vinda people have established their settlements since the 19^{th} century CE (Faublée 1954). The river continues its path southwards, irrigating fields on its way toward the Onilahy River. Annual flooding of the Sakamarekely River causes damage: upstream, it erodes river banks and fields, while downstream it inundates fields with sand and obstructs irrigation canals (Plate 3.1; Faublée 1942: 157-158). These constitute yearly challenges for farmers occupying the valley.

<u>Plate 3.1</u>: Eroded Rice Field (Left), and Rice Field Covered with Sand (Right) after the Flooding of the Sakamarekely River (Credit: Le Fonds Jacques Faublée, Musée d'Ethnographie de Genève Website)

3.2. (Paleo)Climate Variability in the Southwest

Rainfall patterns conditioned rain-fed agriculture and the palatability of pastures. Farmers prefer a low but predictable rainfall regime to a heavy but unpredictable one (Usman and Reason 2004: 199), and interannual unpredictability affected the behavior of both farmers and pastoralists. The unpredictability and severity of droughts or heavy rains influence people's decision. Episodic droughts, for instance, would reduce subsistence production and encourage people to migrate to a more resilient landscape.

To understand the climate conditions under which occupants of Keliangebo and Ankilivalo lived, I used proxies from instrumental weather data for the last few decades and coral proxies for the last 400 years. From these, I estimated rainfall regimes in the MSV during the period of interest for my study (see Bocinsky 2014: 35).

It should be noted, however, that *climate proxies* are estimates. They are not an accurate measure or record of actual events (McIntosh 2005: 73). To validate the use of proxies, I crosschecked the 400 year-long coral proxies with decades-long instrument weather data, ethnohistorical records of droughts, and my own experience.

According to oral traditions, herders in the southwest ritually slaughtered a sheep in every livestock pen during a prolonged drought to implore God *Ndrianagnahary* for rain, and also sowed crops during prolonged droughts – a practice locally known as *manao katray* (hitting a hard and dry ground) – for the same reason. These practices reflect the struggle of communities in the southwest facing droughts in the past. But the first actual date of drought/famine remembered in the southwest today is1928. This was reportedly caused by low rainfall and the introduction of cochineal insects that ate/destroyed the prickly pears all over the region (Kaufmann 2001). The next recorded droughts were in 1931, 1943-1945, 1950, 1960, 1970-1971, 1982-1983, 1986-1987, 1991-1992, 2003, 2006, 2009, 2015-2016 (Interview with Mbaiaho, 75 years old elder from Amparimaiky, Fieldwork 2016).

I personally witnessed three droughts prior to 2000 – 1983-1984, 1986-1987, and 1991-1992. Although the dates differ slightly, the occurrence of climatic events (wet or dry years) in the instrument weather data correlates with those of coral proxies and the droughts I remember (Figure 3.2). This consistency validated the use of instrument weather and coral proxies. Besides, the temporal resolution (monthly to bimonthly) of the climate proxies are higher than the chronological resolution (centennial) of the archaeological dates, suggesting the adequacy of the use of these proxies to interpret the archaeological records.

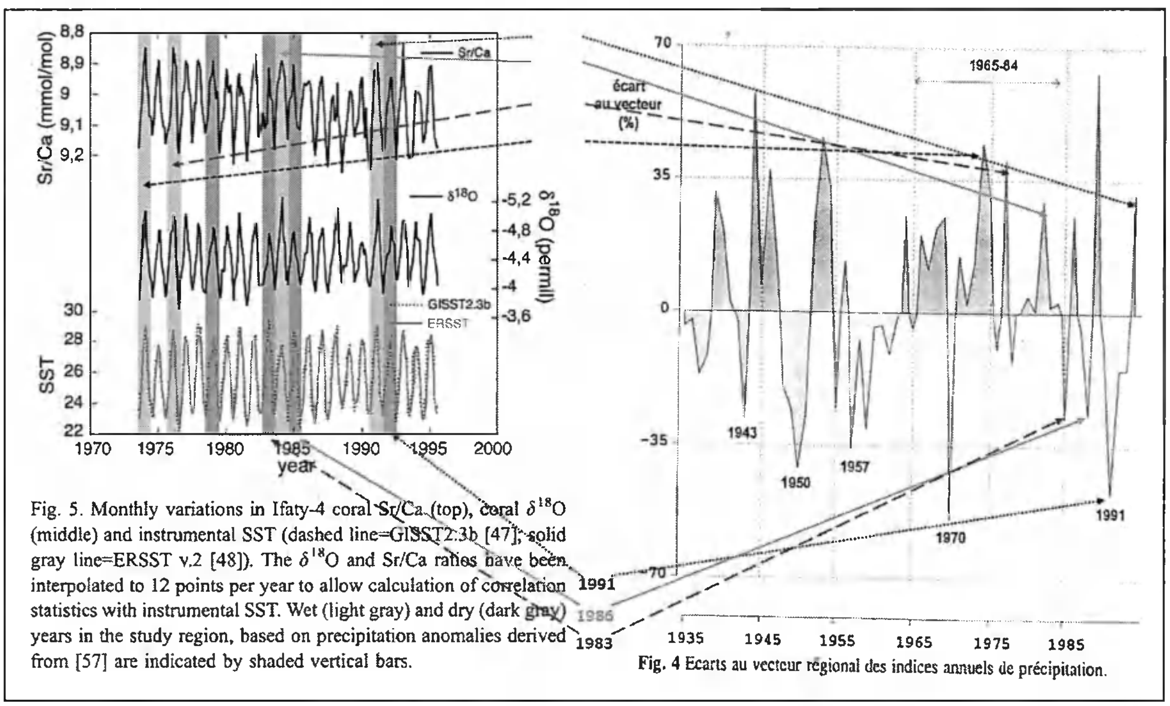

Figure 3.2: Coral Proxies compared with Weather Data (Source: Adapted from Zinke et al. 2004, and Ferry et al. 1998: 94)

3.2.1. Contemporary Climate Variability (Instrument Weather Data)

Easterly trade winds condition the weather and distribution of rainfall in southern Madagascar (Sourdat 1977, Battistini and Hoerner 1986). These moisture-laden winds bring heavy rainfall along the east coast (Randriamahefasoa & Reason 2017: 421). High mountains in the south-center of the island subsequently constitute an obstruction, and winds take the form of a *foehn* as they blow on west in the lee side of the mountains, gradually losing moisture and reducing rainfall amounts in the southwest to 300-1000mm per year (Figure 3.3; Ferry *et al.* 1998: 89; Randriamahefasoa & Reason 2017: 421).

The histograms in Figure 3.3 show not only the seasonal contrast but also the high variability of annual rainfall in the southwest. The isohyet map shows annual precipitation gradually increasing from the coast (Tulear City = 397 mm, Morombe = 491 mm) towards the interior (Ihosy = 802 mm, Ranohira = 976 mm) (Ferry *et al.* 1998: 92).

Ferry *et al.* (1998) singled out 1943, 1950, 1957, 1970, and 1991 as the harshest years of drought they recorded in the southwest (Figure 3.4). The return intervals between these 'mega-droughts' are inconsistent, testifying to the extreme unpredictability and corollary frustration that farmers and herders must have faced.

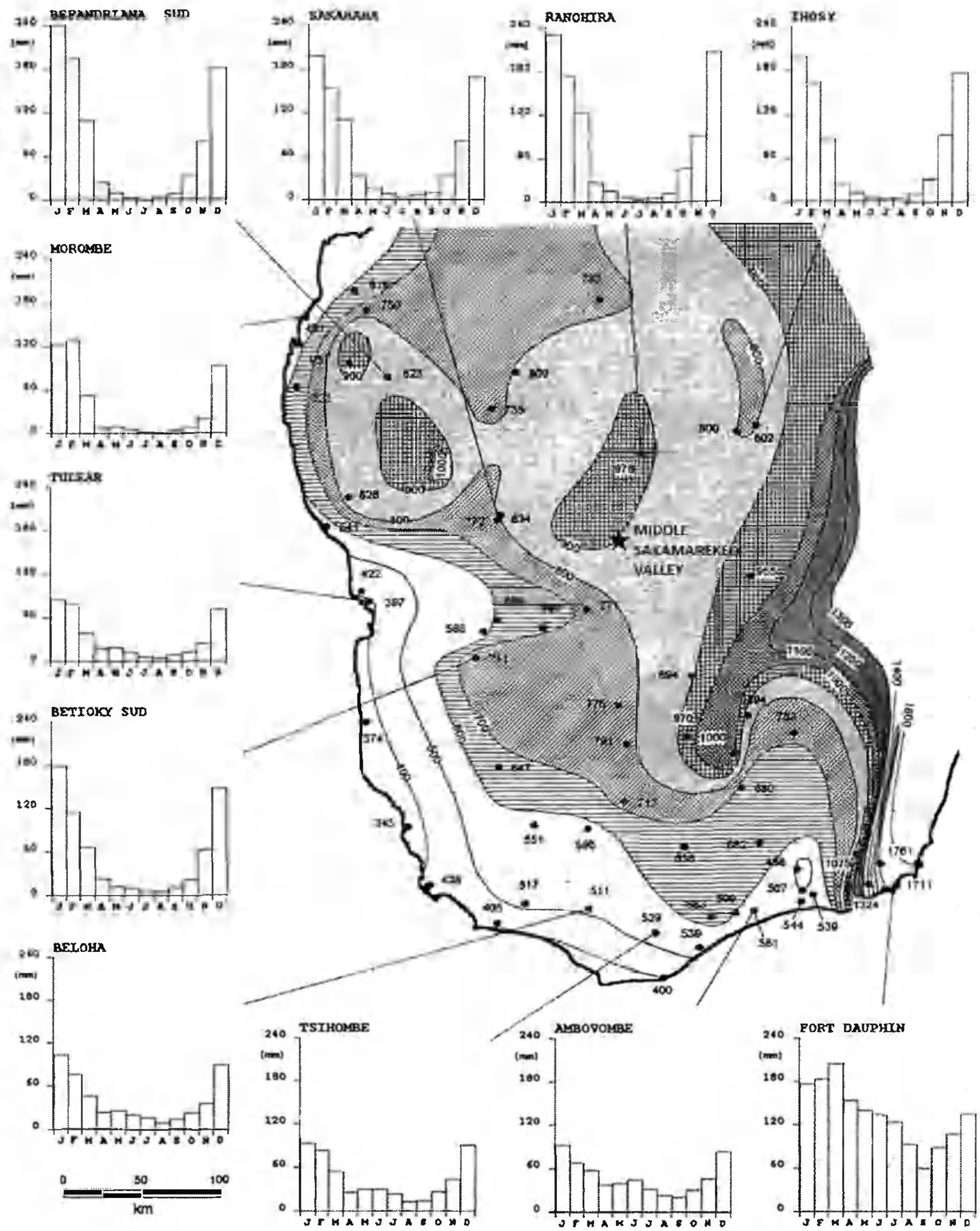

Figure 3.3: Annual Mean of Isohyets (1951-1980) and Monthly Rainfall (1935-1994) in Southwest Madagascar (After Ferry et al. 1998: 91).

The isohyet map (Figure 3.3) shows that around the MSV, rainfall can reach 800-900 mm per annum. The average mean daytime temperature during the year in the MSV is 25.1°C, with a maximum of 35.7°C in December and a minimum of 11.3°C in July

(Table 3.1). There are four distinct seasons. The first, locally known as *Lohatao,* (October-November) coincides with the first rainfall; the second (December-March) is a wet and hot season known as *Asara*; the third (April-July), *Asotry,* is dry and cold; and the fourth (August-September), *Afaosa,* is a dry and hot.

Table 3.1: Average Temperature in °C and Seasons in the Middle Sakamarekely Valley (Adapted from www.climate-data.org)

	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Avg. Temp. (°C)	26.3	27.6	27.9	27.6	27.4	27.5	25.9	24	21.8	20.4	21.4	23.4
Max. Temp. (°C)	35.2	35.1	35.7	34.2	34.1	34.9	33.8	33.8	31.2	29.5	30.8	33
Min. Temp. (°C)	16.5	19.1	20.2	21	20.7	20.1	18.1	14.2	12.5	11.3	12	13.8
Season	**LOHATAO**		**ASARA**				**ASOTRY**				**AFAOSA**	
Charac.	***Wet&Hot***		***Wet&Hot***				***Dry&Cold***				***Dry&Hot***	

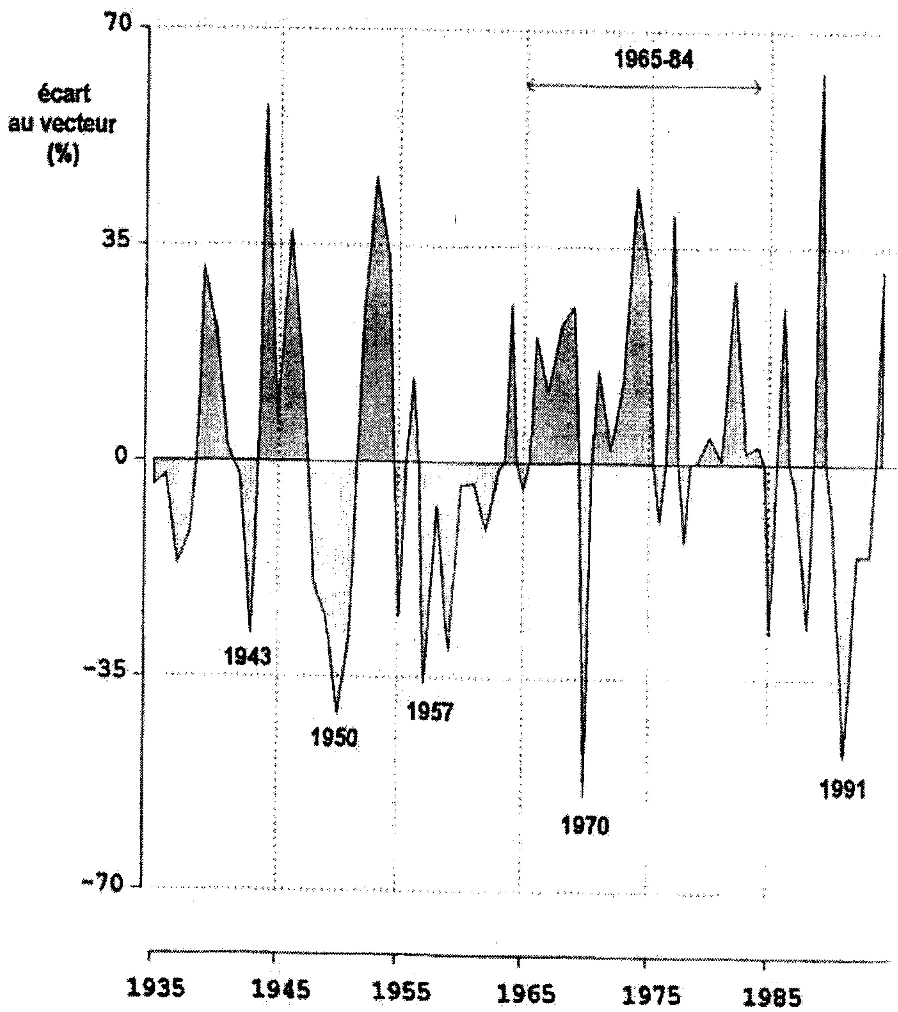

Figure 3.4: Annual Mean Rainfall in the Southwest (After Ferry et al. 1998: 94)

I used climatic data from the weather stations of Ranohira (~ 80 km from the MSV) and Toliara (~ 150 km from the MSV) to examine monthly and interannual variability in the frequencies of wet days and days of heavy rain (Randriamahefa & Reason 2017: 423). These variables differ from the total rainfall per season, which might provide a misleading assessment of the impact of climate unpredictability on farming and herding activities. The total number of wet and dry days affect these activities and decision-making directly (Moron *et al.* 2007: 5244-5245; Randriamahefa & Reason 2017: 424; Usman and Reason 2004: 199).

Randriamahefasoa & Reason (2017) observed that the two stations of Ranohira and Toliara record heavy rainfall during the summer, starting in December and ending in March (Figure 3.5). They accordingly targeted four months (December, January, February, and March) to investigate the monthly distribution of wet days and heavy rain days (Figure 3.6). They found that at both stations, "the number of wet days increases significantly in either November or December with peak values in January. During February, there is a small decrease in wet day frequency followed by a sizeable decline in March, the last summer month. From April to October, there are rather few wet days on average" (Randriamahefasoa & Reason 2017: 426-427).

Comparing the number of wet days with the number of heavy rainfall days per summer season at each station, Randriamahefasoa and Reason (2017: 427) found that "seasons with high numbers of wet days do not necessarily have high numbers of heavy rain days and vice versa" (see Figure 3.6).

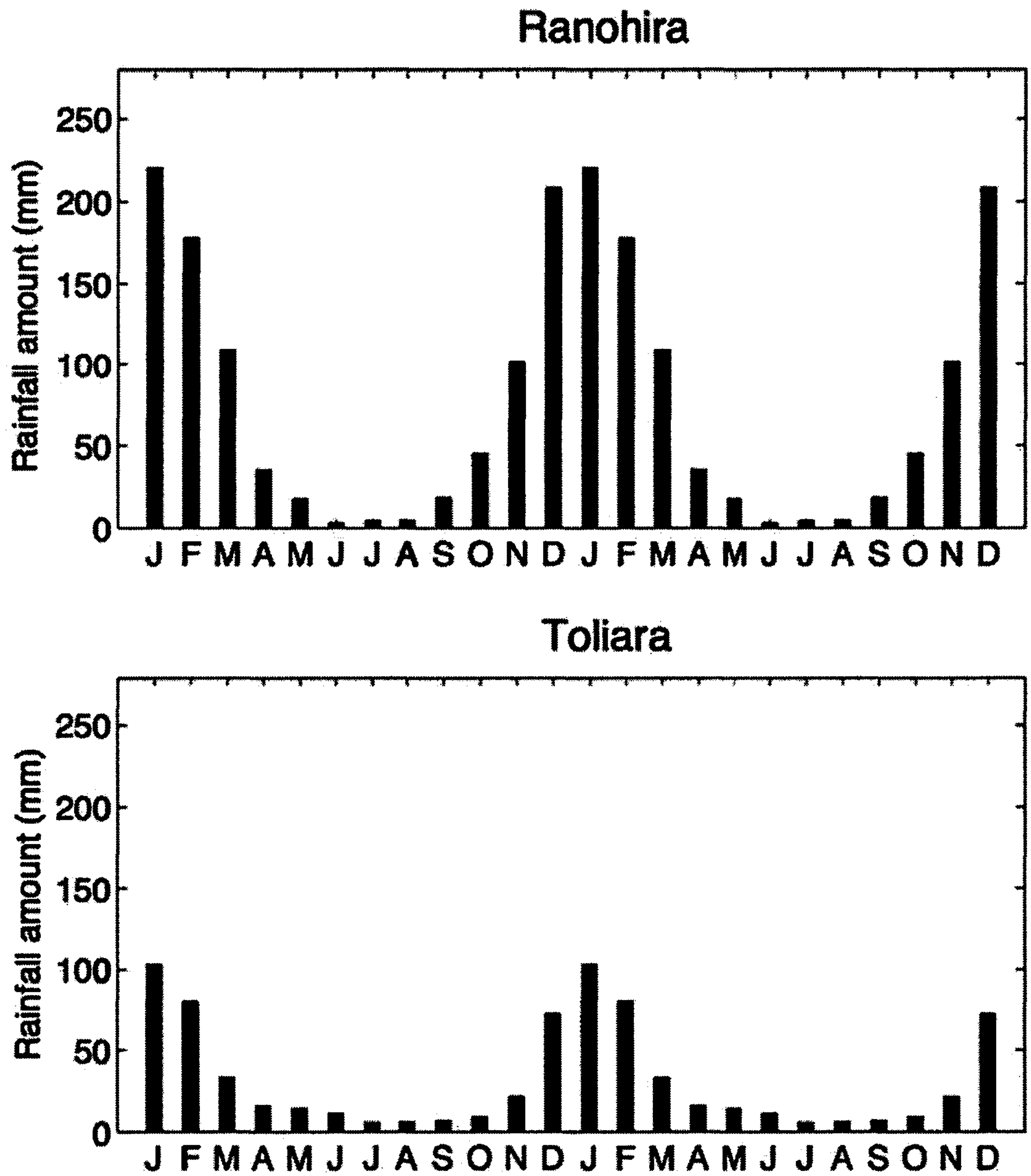

Figure 3.5: Annual Cycle of Mean Monthly Rainfall Amount (mm) Computed for 1971-2000 (After Randriamahefasoa & Reason 2017: 423)

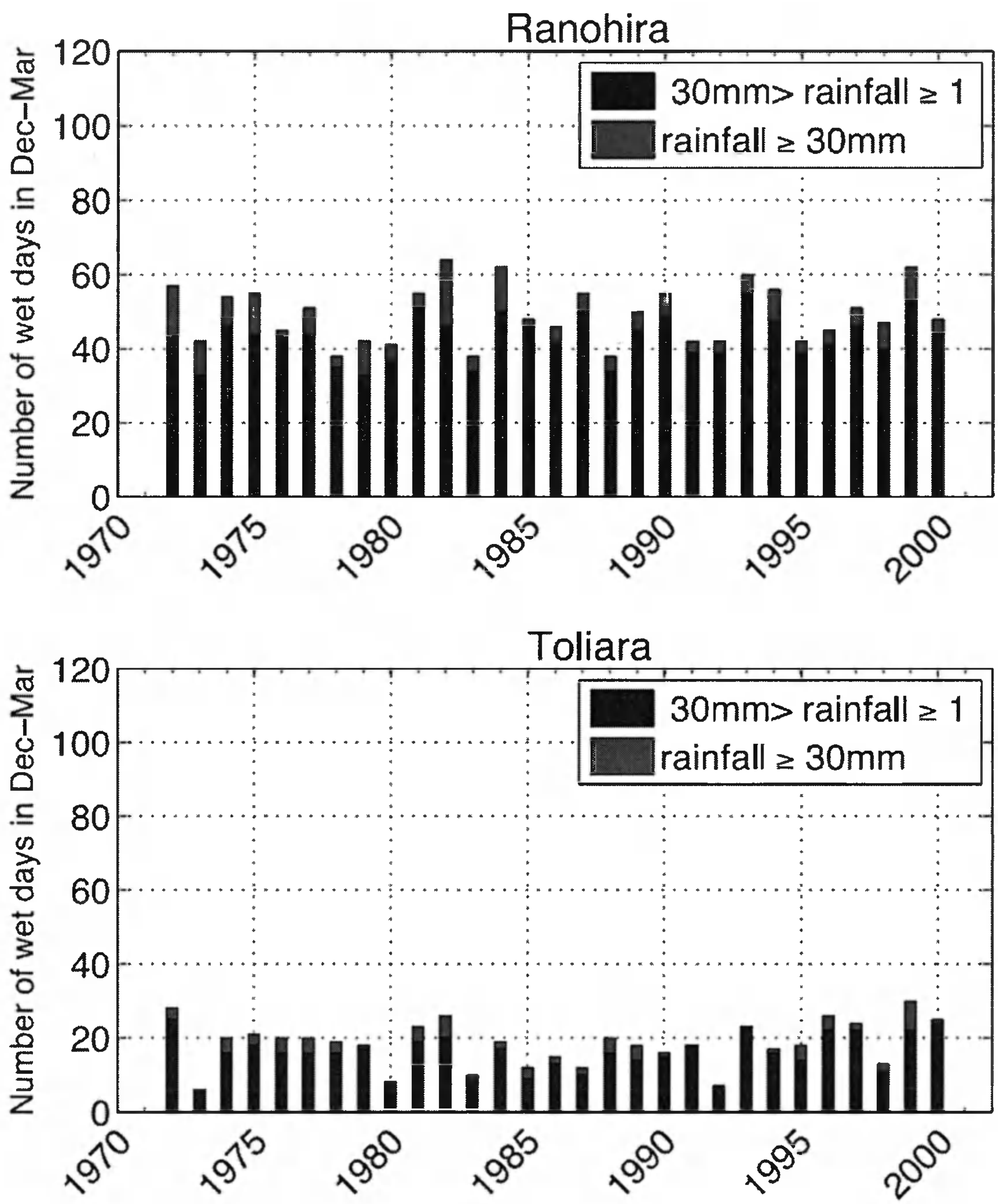

Figure 3.6: Number of Wet Days per Summer Season (Blue) or Received Heavy Rainfall (Red) (After Randriamahefa and Reason 2017: 429)

Randriamahefa and Reason (2017) computed the likelihood of 'exceedance' of rainfall amounts for each summer month from 1971–2000 at each station. They produced a probability of rainfall amounts for December, January, February, and March at 25, 50, and 75% confidence (Table 3.2). For instance, in January of any year Ranohira has a 75 % probability of receiving 83mm of rain, a 50 % probability of 207 mm, and a 25 % probability of 295 mm. The return periods of these rainfall amounts were calculated as a fraction of the corresponding probability of exceedance. That is, the return period for 83mm rainfall at Ranohira in January is 1/0.75 (1.3 years); the probability of 207 mm rainfall reoccuring in January at Ranohira is within two years (1/0.5), and for 295 mm it is within four years (1/0.25). These findings confirm and extend the characterization of the southwest as an exceedingly unpredictable environment.

Table 3.2: Monthly Rainfall Depth Expectations for December, January, February, and March for each Station (After Randriamahefa and Reason 2017: 428)

Station	**Probability of Exceedance (%)**	**Dec**	**Jan**	**Feb**	**Mar**
Ranohira	75	86	83	120	65
	50	190	207	170	100
	25	270	295	228	137
Toliara	75	14	32	26	0
	50	53	71	48	28
	25	117	125	113	49

3.2.2. Climate Variability for the Last Four Centuries (Coral Proxies)

As corals grow, their skeletons continuously record information about the conditions (temperature and composition) of the seawater they live in, including oxygen isotopes (δ18O), ratios between strontium and calcium (Sr/Ca), uranium and calcium (U/Ca), magnesium and calcium (Mg/Ca), and barium and calcium (Ba/Ca) (Cobb et al., 2008; Grottoli and Eakin 2007: 68). This information reflects conditions prevailing in the upper layer of the ocean including Sea Surface Temperature (SST), Sea Surface Salinity (SSS), precipitation, oxygen isotope ($\delta^{18}O$ or the ratio between ^{18}O and ^{16}O) and so forth (Grottoli and Eakin 2007). For instance, the $\delta^{18}O$ of seawater reflects the ratio between evaporation and precipitation in the region (Juillet-Leclerc *et al.* 1997). A rise in SST provokes evaporation that decreases the ^{18}O and increases the ^{16}O recorded in the coral skeleton (Kim and O'Neil 1997; Nicolas 2012: 1). Analyzing coral skeletal isotopes, traces, and minor elements over times makes it possible to reconstruct an approximation of the variability of past climates (Grottoli and Eakin 2007: 68).

In the tropics and subtropics, coral paleoclimatic data are generally used to reconstruct climate records not covered by instrument weather data (Nicolas 2012: 2). In the western Indian Ocean, this technique was successfully used to supplement the limited data obtained from instrument stations and satellites (Zinke *et al.* 2004).

To reconstruct the paleoclimatic condition of the MSV, I used a publicly available record of coral proxies from the reef at Ifaty (about 160 km west of the MSV) covering a bimonthly sequence from 1650 to 2000 CE (Zinke *et al.* 2004). The correlation between climatic events at the meteorological stations of Toliara (10 km from Ifaty) and Ranohira (80km from the MSV) makes it reasonable to use the Ifaty coral proxies as a reference to paleoclimatic events along the MSV. Although estimated dates at the two locations are slightly different, the frequency of events is similar across the southwest (Ferry *et al.* 1998; Randriamahefasoa & Reason 2017). Coral proxies recorded anomalies of lower precipitation in the years of 1978, 1983, 1985, 1987, 1990, and 1992, and higher precipitation in 1974–1976, 1984, 1988, and 1991 (Zinke *et al.* 2004: 184). These anomalies correlate broadly with the occurrence of droughts in instrument records across the southwest. Likewise, the occurrences of higher precipitation anomalies recorded in coral proxies correlate with those from instrument data across the southwest (see Figure 3.2).

The period covered in this study (16^{th} – 19^{th} centuries CE) coincided with the Late Maunder Minimum of the mid-17^{th} – early 18^{th} centuries CE, the coldest part of the Little Ice Age of 1550-1840 (see Mann et al. 2009; McIntosh 2000: 156; Zinke *et al.* 2004: 177-178). This event was recorded in the Ifaty coral proxies (Zinke *et al.* 2004: 182), and should be considered in the past climatic condition of the MSV.

Zinke *et al.* (2004) investigated past SST variability on seasonal to multidecadal scales by recording variation in coral oxygen isotopes ($\delta^{18}O$). They found significant shifts between positive and negative isotope values. The period between 1675–1760 (Late 17^{th} – mid-18^{th} centuries CE) – including the Late Maunder Minimum (1675–1710) – was the coldest period in the southwest. Another cold period of interest was in the mid-19^{th} century CE (1825-1850) (Zinke *et al.* 2004: 182). The warmest decades during my study period were between 1880 and 1900 CE (Zinke *et al.* 2004: 177). Other warm periods of interest were the mid-17^{th} (1650– 1675), late 18^{th} (1750–1800), and most parts of the 19^{th}century CE.

Zinke and colleagues (2004: 180-183) validated the variability of SST obtained from their coral oxygen isotope data by calibrating them with Sr/Ca ratios and instrumental records of SST and rainfall. The results demonstrated pronounced interannual variability (Figure 3.7).

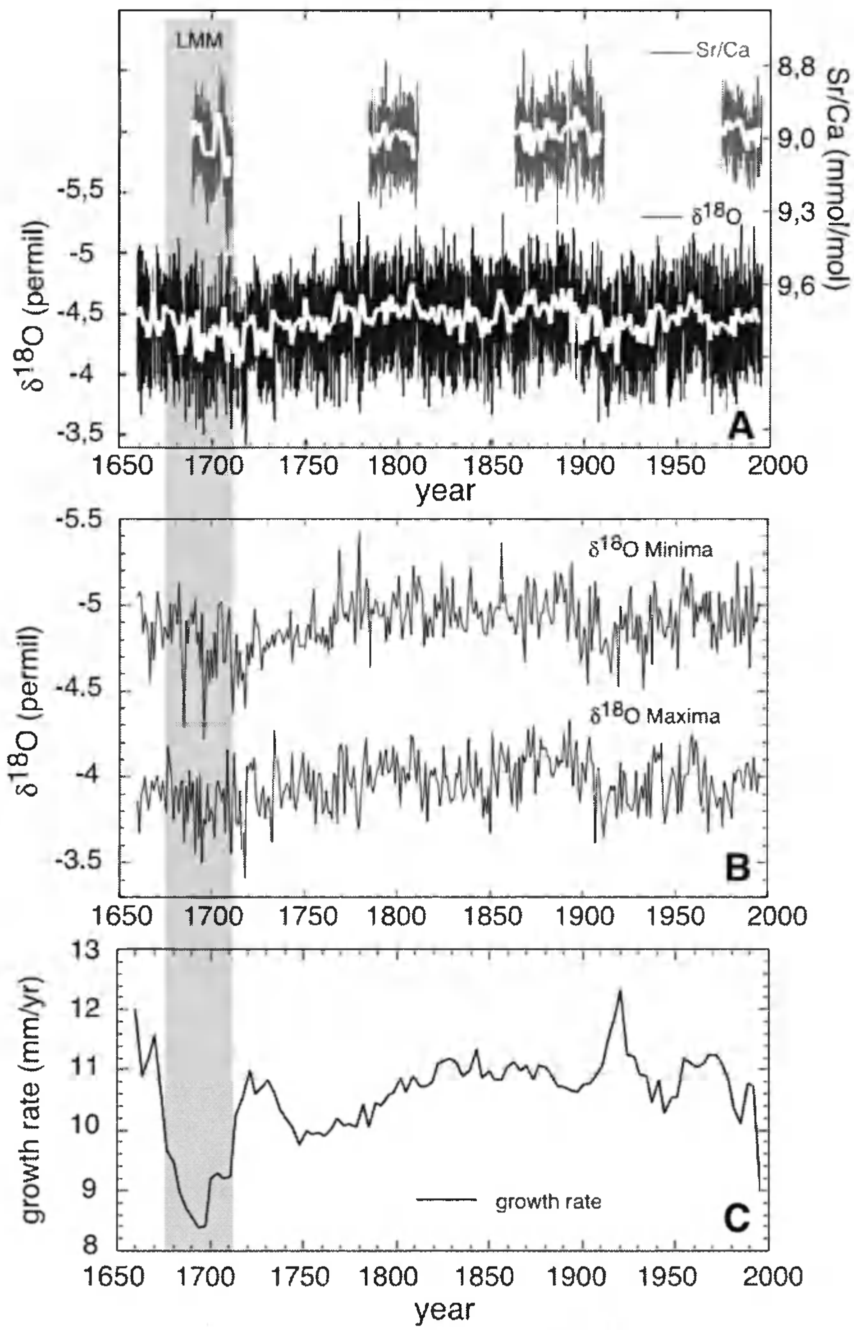

Fig. 4. (A) Ifaty-4 coral Sr/Ca (top) and $\delta^{18}O$ (bottom) bimonthly time series with annual means superimposed (solid white line), (B) coral $\delta^{18}O$ minima (January/February) and maxima (July/August), (C) annual coral growth rate calculated between the coral $\delta^{18}O$ maxima. The Late Maunder Minimum (LMM) is indicated by a shaded vertical bar.

Figure 3.7: Four Decades of Coral Proxies in Southwest Madagascar (After Zinke et al. 2004: 182, Fig.4)

3.3. Microenvironments and their Resources

A microenvironment or an *ecological zone* is a unit of landscape with distinct environmental conditions accommodating a distinct assemblage of species. At first, I thought people in the MSV divided the landscape into three ecological zones - the valley, the Horombe Plateau, and the Isalo Massif. However, interviews with current occupants of the MSV showed that they define ecological zones differently - as prairies (Horombe grassland, Isalo grassland, and to some extent the scrubland, and fields), potentially arable lands (reeds, *baiboho,* and *tevy*), and forests (deciduous forests and Tapia forests).

3.3.1. Prairies

Depending on plant formation and the period of exploitation, locals for the last few decades recognize four types of grazing areas in the study area, the Horombe grassland, Isalo grassland, gallery forests and scrubland, and fields along the Sakamarekely river bank. The presence of numerous water points and different pasturelands are assets for cattle herding.

The Horombe Plateau is composed of laterite soils covered mainly by open grasslands that rarely exceed 80 - 100 cm in height (Morat 1973 and Koechlin et al. 1974). Some trees (mostly of *sakoa* or *Sclerocarya caffra*) are found, reaching up to 10 m tall and intercalated by grasses.

The following table details various fodders exploited by herders in the Horombe Plateau (Table 3.3):

Table 3.3: Graminaceous Fodders in the Horombe Plateau

#	Local Names	Scientific Names
1	Ahibe	*Panicum maximum*
2	Ahidambo	*Heteropogon contortus*
3	Ahidravala	*Aristida rufescens*
4	Ahinombilahy	*Chrysopogon serrulatus*
5	Ahitronga	*Echinocloa colonum*
6	Akatafoty	*Pennisetum sp*
7	Bakaka	*Sorghom verticilliflorum*
8	Kidresy	*Cynodon dactylon*

The graminaceous species *Heteropogon contortus,* locally known as *Ahidambo,* constitutes the main fodder on the Horombe Plateau. Livestock do not consume all that is available (Rakotomanana 2002: 14). This leaves large areas of under-exploited pastures at the end of the rainy season. The leftovers become dry and hardened, therefore disagreeable to animals, and prevent them from accessing the more appetizing (fresh and tender) regrowth in the following year. It is preferable thus to remove these tufts so that green regrowth reappear. This is the reason why herders deliberately burn grasslands to improve the quality of fodder (Ranaivoarivelo and Milleville, 2001). A grassland fired at the end of the dry season (from September) offers good quality fodder after the rains (Rakotoarimanana, 2002, Ranaivoarivelo, 2002).

In the Horombe, herders let animals roam and only check on them periodically. This practice is conducive for herds with a headcount of more than 50 animals. The intervention of herders is minimal. Cattle organize themselves in groups of 4 to 8 individuals, while goats or sheep form a single flock, regardless of numbers. Each group of cattle has a common area of grazing and a more or less fixed place to spend the night, which makes it easy to find and control them.

There is usually a common water point for all groups in the herd, and each goes to this point every day to drink. This is where the keeper verifies the headcount and condition of animals. The verification is conducted every 2–3 days from noon to sunset whenever animals come and drink. If animals are absent, the keeper waits until the next day to make sure they are in the vicinity. However, if they still do not appear, he has to search for them, first by visiting the usual places, then by following their tracks until he finds them.

At the end of the rainy season, when herds begin to graze less on *Heteropogon contortus*, herders in search of alternative fodder drive livestock to the valleys to browse on trees and scrubs there.

In the southern Isalo, tables constitute a series of aligned buttes (Sourdat 1970: 107). Their tops are flat and covered with tropical ferruginous soils formed through the weathering of sandstone (Lavelle and Spain 2001: 190-191; Petit 1996: 69, 79; Sourdat 1970: 106). These soils are covered with grassland where occupants of the MSV graze their herds (Sourdat 1969: 3; 1970: 107). Table 3.4 lists graminaceous species exploited in the Isalo grassland:

Table 3.4: Graminaceous Fodders in the Isalo Massif.

Local Names	**Scientific Names**
Ahibe	*Panicum maximum*
Ahidambo	*Heteropogon contortus*
Bakaka	*Sorghom verticilliflorum*
Kidresy	*Cynodon dactylon*

For herders, the Isalo grassland differs from the Horombe in that it hosts most ancestral burials and ritual places. Customary law permits only locals (*tompon-tany*) to pasture their herds in the Isalo, for fear that a stranger will jeopardize the sacredness of the area. At least since the early 1900s, Bara-Vinda people bring their herds to the Isalo, but never establish a permanent habitation there (Faublée 1941: 117).

In addition, the Isalo grassland is reserved for herds of no more than 50 in size, and at night cattle are kept in a pen near a village in the MSV. In the morning, at sunrise, a keeper takes the herd out to graze. Around noon, he brings them to a water point to drink, and at the end of the day he takes them back near the village and locks them up in a pen overnight. This is quite different from the free herding practices on the Horombe Plateau.

Meanwhile, due to water scarcity in both the Isalo and the Horombe during the dry season, herders bring their livestock back into the valley and keep them there from May to November. In the valley, herds find fodder in the gallery forests and scrublands. This vegetation is more of a temporary refuge than an actual pasture (Rakotomanana 2002: 14). Tables 3.5 and 3.6 list species exploited by herders in the gallery forests and scrublands:

Table 3.5: Ligneous Fodders in the Gallery Forests and Scrubland

#	**Local Names**	**Scientific Names**
1	Avoha	*Dichrostachys humertii*
2	Fandrian-dambo	*Physena madagascariensis*
3	Hazon-ta	*Rigozum madagascariensis*
4	Katrafay	*Cedrelopsis grevei*
5	Kotipoky	*Grewia grevei*
6	Kily	*Tamarindus indica*
7	Mantsaky	*Enterospermum pruinosum*
8	Sasavy	*Salvadora augustifolia*
9	Tratsiotsy	*Acacia augustifolia*
10	Vontaky	*Pachypodium geayi*
11	Za	*Andasonia za*

Table 3.6: Graminaceous Fodders in the Gallery Forests and Scrubland

#	**Local Names**	**Scientific Names**
1	Ahidravala	*Aristida rufescens*
2	Akatafoty	*Pennisetum sp*
3	Ahinombilahy	*Chrysopogon serrulatus*
4	Kidresy	*Cynodon dactylon*

During the lean season of *Afaosa,* the tree *Tamarindus indica* (Kily) in the gallery forest offers nourishment to herds, since its tender leaves are available during this hot and dry season. Herders also feed their animals with reeds at this time, and may cut down a baobab tree (*Andasonia za)* or *Pachypodium geayi,* and scrape out the moist interior of the trunk as food.

At the end of the dry season and beginning of the rainy season, fields are left uncultivated and are taken over by graminaceous species. These grasses serve as pasture for herds kept in the valley during this period. Herders also give crop residues such as corn stalks, rice straw and cowpea fodder to their cattle. Table 3.7 lists species exploited in fields:

Table 3.7: Fodders at Farming Field

#	**Local Names**	**Scientific Names**
1	Ahibe	*Panicum maximum*
2	Ahitronga	*Echinocloa colonum*
3	Angama	*Tridax procumbans*
4	Bakaka	*Sorghom verticilliflorum*
5	Bea	*Commicarpus commersonii*
6	Beamena	*Boherhavia diffusa*
7	Kidresy	*Cynodon dactylon*
8	Moita	*Cyperus articulatus*

3.3.2. Forests

Some trees such as *kily* are considered sacred and haunted by spirits, and people always hesitate to enter a forest that has *kily* for fear that spirits living there will harm them. Forests in the study area accommodate a wide range of wild plant and animal species exploited by the occupants of the MSV, although they constitute a minimal part of people's subsistence today.

In southern Isalo, the rocky residual reliefs and thalwegs are covered with *Tapia* forests (*Uapaca bojeri*) and galleries of pandanus (Sourdat 1969: 3; 1970: 107). *Tapia* forests are dominated by sclerophyllous trees with a low continuous canopy (Rabehevitra & Rakotoarisoa 2007: 38). They accommodate a range of plant and animal species that local people exploit (Plate 3.2, Table 3.8).

Table 3.8: Lists of Natural Resources Exploited from the Tapia Forests

Types	Local Names	Scientific Names	Uses
Insects	Landy (Silkworms)	*Bombyx mori*	Produce cocoons for silk fabrics
	Sy	-	Produce food
	Tantely (Honey Bees)	*Apis mellifera*	Produce food
Birds	Akanga (Guinea fowl)	*Numida meleagris*	Food
	Aliotsy	*Coua coquereli*	Food
	Kibo (Quail)	*Coturnix coturnix*	Food
	Sarivaza (Parrot)	*Coracopsis vaza*	Commensal
	Tsakodara	*Upupa marginata*	Food
Mammals	Maky	*Lemur catta*	-
	Sora (hedgehogs)	*Hemicentetes semispinosus*	Food
	Tandraky (Tenrecs)	*Tenrec ecaudatus*	Food
Fruits	Angeriboky	*Asparagus schumanianus*	Food
	Kilambolambo	-	Food
	Kily	*Tamarindus Indica*	Food
	Lamoty	*Flacourtia ramountchi*	Food
	Mokoty (Palm fruit)	-	Food
	Rotsy	*Eugenia sp.*	Food
	Sely	*Grewia sp.*	Food
	Tapia	*Uapaca bojeri*	
	Tsoha (lemon)	*Citrus limon*	Food
Tubers	Babo	*Dioscorea bemandry*	Food
	Fangitsy	*Dolichos fangitsa*	Food
	Kenjiky	*Dioscorea fandra*	Food
	Ovy	*Dioscorea alatipes*	Food
	Sosa	*Dioscorea soso*	Food
Vegetables	Boreoky	-	Food
	Tsiparahy	-	Food
Medicinal plants	Beholitsy	*Hymenodictyon decaryi*	Medicinal
	Lengomantsy	*Stylosanthes sp.*	Medicinal
	Lombiry	*Cryptostegia madagascariensis*	Medicinal
	Vahenamalo	*Vanilla decaryana*	Medicinal
	Vahombe (Aloe)	*Aloe vaombe*	Medicinal
	Vahontsoy	*Aloe divaricata*	Medicinal
	Vendrangy	*Pandanus sp.*	Medicinal
	Vontaky	*Pachypodium lamerei*	Medicinal

Plate 3.2: A Man Digging the Tuber 'Kenjiky' (Left) and Cattle Pen (Right) in the Isalo (Credit: Le Fonds Jacques Faublée, Musée d'Ethnographie de Genève Website)

There are two types of deciduous forest in the study area: gallery forest, and low dry deciduous forest. Gallery forests are riparian habitats dominated by tall trees (up to 20m) with a high canopy, while the low deciduous forests are composed of short trees mixed with shrubs (Smith 2007: 40). These forests accommodate a broad array of plant and animal species exploited by local people for different purposes (Table 3.9).

Table 3.9: Lists of Natural Resources Exploited from the Dry Deciduous Forests

Types	Local Names	Scientific Names	Uses
Insects	Sy	-	Produce food
	Tantely (Honey Bees)	*Apis mellifera*	Produce food
Birds	Akanga (Guinea fowl)	*Numida meleagris*	Food
	Aliotsy	*Coua coquereli*	Food
	Kibo (Quail)	*Coturnix coturnix*	Food
	Ongongo (wild goose)	*Sarcidiornis africana*	Food
	Vaza (Parrot)	*Coracopsis vaza*	Commensal
	Tsakodara	*Upupa marginata*	Food
	Vivy (Teal)	*Tachybaptus pelzelnii*	Food
Mammals	Sora (hedgehogs)	*Hemicentetes semispinosus*	Food
	Tandraky (Tenrecs)	*Tenrec ecaudatus*	Food
Fruits	Angeriboky	*Asparagus schumanianus*	Food
	Kilambolambo	-	Food
	Kily	*Tamarindus Indica*	Food
	Lamoty	*Flacourtia ramountchi*	Food
	Mokoty (Palm fruit)	-	Food
	Rotsy	*Eugenia sp.*	Food
	Sakoa	*Scelrocarya caffra*	Food
	Sakoandalitsy	*Poupartia sp.*	Food
	Sasavy	*Salvadora angustifolia*	Food
	Savoa	*Jatropha curcas*	Food
	Sely	*Grewia sp.*	Food
	Tsoha (lemon)	*Citrus limon*	Food
	Za (baobab fruit)	*Andasonia za*	Food
Tubers	Angily	*Dioscorea ovinala*	Food
	Ataly	*Dioscorea antaly*	Food
	Babo	*Dioscorea bemandry*	Food
	Fangitsy	*Dolichos fangitsa*	Food
	Gago	*Dioscorea sp.*	Food
	Katro	*Dioscorea hombuka*	Food
	Kenjiky	*Dioscorea fandra*	Food

	Nako	*Dioscorea nako*	Food
	Ovy	*Dioscorea alatipes*	Food
	Sosa	*Dioscorea soso*	Food
	Tavovola	-	Food
	Valay	-	Food
	Veoveo	*Dioscorea sansibarensis*	Food
Vegetables	Agnamamy	*Solanum nigrum*	Food
	Bikobiko	-	Food
	Boreoky	-	Food
	Lalanda	*Ipomoea pes-caprae*	Food
	Melo	*Solanum nigrum*	Food
	Melomboay	-	Food
	Tombombositsy	-	Food
	Tsibogoda	-	Food
	Tsiboraky	-	Food
	Tsiparahy	-	Food
Medicinal Plants	Andapary	*Grewia andraparo*	Medicinal
	Andranahaky	-	Medicinal
	Angalora	*Secamonopsis madagascariensis*	Medicinal
	Beholitsy	*Hymenodictyon decaryi*	Medicinal
	Daro Sengatsy	*Commiphora simplicifolia*	Medicinal
	Darosike	*Commiphora mahafaliensis*	Medicinal
	Farehitsy	*Uncarina leandri*	Medicinal
	Fengoky	*Senna leandri*	Medicinal
	Fihamy	*Ficus grevei*	Medicinal
	Filofilo	*Azima tetracantha*	Medicinal
	Halimboro	*Albizia balabaka*	Medicinal
	Handy	*Neobeguea mahafaliensis*	Medicinal
	Haronga	*Haronga madagascariensis*	Medicinal
	Hazomalagny	*Moringa drouhardii*	Medicinal
	Hazomby	*Croton sp.*	Medicinal
	Hazomena	*Securinega capuronni*	Medicinal
	Jabihy	*Operculicarya decaryi*	Medicinal
	Katrafay	*Cedrelopsis grevei*	Medicinal
	Kinagna	*Ricinus communis*	Medicinal
	Lalanda	*Ipomoea pes-caprae*	Medicinal
	Lengomantsy	*Stylosanthes sp.*	Medicinal
	Lombiry	*Cryptostegia madagascariensis*	Medicinal
	Mongy	*Kalanchoe beharensis*	Medicinal
	Relefo	*Strychnos sp. (madagascarensis or decussata)*	Medicinal
	Sagnira	*Cryptocaria sp.*	Medicinal

	Somontsoy	*Fernandoa madagascariensis*	Medicinal
	Tapisaky	*Xerosicyos danguyi*	Medicinal
	Taritariky	*Ipomoea sp.*	Medicinal
	Tsingarifary	*Senna leandri*	Medicinal
	Vahenamalo	*Vanilla decaryana*	Medicinal
	Vahombe (Aloe)	*Aloe vaombe*	Medicinal
	Vahontsoy (Aloe)	*Aloe divaricate*	Medicinal
Construction Woods	Bararata	*Phragmites mauritianus*	Construction
	Magnary	*Dalbergia trichocarpa*	Construction
	Vaovy	*Tetrapterocarpon geayi*	Construction
	Vondro	*Typha augustifolia*	Construction
Ritual Use	Mendoravy	*Albizia tulearensis*	Coffin
Miscellaneous Use	Kompitsy	*Pentopetia grevei*	Glue
	Monongo	*Zanthoxylum decaryi*	Transportation paraphernalia
	Ropitiky	*Acacia pervillei*	Fence
	Roy	*Acacia farnesiana*	Fence

Local people rarely hunt. They mostly obtain the meat of wild animals when defending their fields against scavengers such as wild boar and guinea fowl, trapping or shooting them with a sling or spear (Plate 3.3). Cattle keepers might also set out traps in the forest for wild boars, and sometimes use their dogs to sniff out tenrecs (Faublée 1942: 176).

On the other hand, women habitually forage for wild vegetables in the forests and fields. Collecting wild fruit is a pastime rather than a subsistence activity, however - except when food is scarce.

Plate 3.3: A Big Hole with Wooden Stakes Inside Used as Trap for Wild Boar at a Maize Field (Left), and Mandibles of Wild Boars Exhibited as Trophies (Right) (Credit: Le Fonds Jacques Faublée, Musée d'Ethnographie de Genève Website)

The Sakamarekely river produces a few « river foods » such as eels *(fady* for some people) and shrimp, available at the beginning of the rainy season. Valley occupants go down to the Onilahy river (7 km away as the crow flies) to fish for other kinds of 'river food' (Faublée 1942: 176). At the beginning of the rainy season, a variety of fish species - *bevava, amalo, toho, maraky, gogo, lera, jopo, marotola, rety, driatsy* – are to be found in the Onilahy. People use a thin bamboo (*bararata*), aloe string (*hoto)* and hook baited with an earthworm to catch them. All these materials are available in the area (Faublée 1942: 177).

3.3.3. Arable Lands

This section considers only areas under regular cultivation, including fields in the MSV and on the Horombe Plateau. Chapter 5 assesses potentially arable lands in the study area.

Sakamarekely is a year-round river, which makes it favorable for humans and animals to settle along its banks. The river only has banks downstream from the MSV to the confluence of Sakamarekely and Onilahy rivers. These are composed of alluvial soils where gallery forests grow. Alluvial marshes are covered with reeds *bararata* (*Phragmites communis/mauritianus*), which people clear to open up fields. They produce rice twice a year on these soils: the first season *vary aloha* (first rice) from November-December and the second season *vary afara* in June (Faublée 1942: 161, 162, 168). They also cultivate taro, bananas, sugarcane, manioc and beans. Flooding of the Sakamarekely during the rainy season leaves sandbanks along the valley. They remain moist during the dry season, and people sow sweet potatoes on these soils (Plate 3.4).

<u>Plate 3.4:</u> Temporary Field of Sweet Potatoes in the River Bed (Credit : Le Fonds Jacques Faublée, Musée d'Ethnographie de Genève Website)

On the Horombe Plateau, apart from the Imaloto River, there are only seasonal streams that are dry during eight months of the year. In the rainy season, rice can be cultivated on the Plateau in the rainy season, but there is only one harvest a year. When water is insufficient water, people make small dikes on slopes to retain it (Faublée 1942: 162).

The ferrallitic soils of the Horombe support manioc and peanut cultivation (Plate 3.5), while sandy areas in seasonal streams can be planted with sweet potatoes and sometimes manioc (Faublée 1942: 165, 166). Manioc is an increasingly important crop on the Horombe plateau (Faublée 1942: 162). It does not require nearly as much water as rice. People look for soils that are neither dry nor too damp, recognizable by the presence of greener grasses. Although manioc grows at any time during the year, Bara-Vinda people plant it especially in the austral spring (from September to December), before the first rains (Faublée 1942: 166).

Historically, people also practiced shifting agriculture locally known as *tevy* in gallery forests or on hillsides to cultivate maize, squash, calabash or watermelon (Plate 3.6; Faublee 1942: 175). Current occupants of the MSV rarely practice *tevy,* and are focused rather on irrigated rice cultivation.

Plate 3.5: A Man Weeding a Peanut Field (Left) and Field of Sweet Potatoes (Right) in the Baiboho of the Horombe Plateau (Credit: Le Fonds Jacques Faublée, Musée d'Ethnographie de Genève Website)

<u>Plate 3.6:</u> Swidden Maize Field and a Man Chasing Parrots with Sling Shot (Left), and A Man Preparing Harvested Corn at a Swidden Maize Field (Right) (Credit: Le Fonds Jacques Faublée, Musée d'Ethnographie de Genève Website).

CHAPTER FOUR: HISTORICAL AND CULTURAL SETTINGS OF THE MIDDLE SAKAMAREKELY VALLEY

This chapter reviews the historical and cultural backgrounds of the study area. It aims to reconstruct the sociopolitical and economic life of people living in the southwest during the period under study, in order to understand how this may have influenced their decision-making. It should be noted, however, that the cultural history of southwest Madagascar is still based on limited historical documents, oral traditions, and archaeology.

4.1. Historical Documents

Mention of Madagascar in historical documents dates back to the early first millennium CE. The Greek geographer Claudius Ptolemy (100 – 170 CE) alluded to the island of Madagascar under the name *Menuthias* on a map, and briefly identified the island in his book *Geography* as follows:

> *"Huic (sc.: Praso promontorio, hod. Mosambique) adjacet ab aestivo ortu insula, nomine Menuthias, cujus positio 85. Austral 12.0"* (Ptolemy Book 4, Chap 9 cited in Grandidier and Grandidier 1903: 428)
>
> Next to the Prasum promontory, today Mozambique, lies the island called *Menuthias*, the longitude of which is 85° and the southern latitude 12°0'. [My Translation]

Arab travelers and geographers such as Al Massudi, Al Idrissi and Yaquout also referred to Madagascar as *Djafuna*, *Chezbezat*, and *Djezirat al Komr* (Grandidier and Grandidier 1903: ix-x). However, they did not give any information about specific regions and none of these ancient authors, be they Greek or Arab, ever actually saw Madagascar. Their accounts and maps are based on what they heard from others, who themselves never visited the island, and their reliability is highly questionable. There are other islands in the southwestern Indian Ocean (Kilwa, Zanzibar, Comoros, etc.) to which they might have been alluding.

Only in the early 16th century CE, when Portuguese explorers discovered the island they named '*San Lourenço*', do fairly detailed references to some regions begin. Between 1903 and 1907, Alfred Grandidier and Guillaume Grandidier compiled some of these documents and reports in five volumes titled *Collections des ouvrages anciens concernant Madagascar*. According to these documents, the southwest and interior of Madagascar were populated by circumcised black 'pagans' who went half naked (Gaspar Correa, Duarte Barbosa, Ed. Lopez, De Constantin, and Purchas cited in Grandidier and Grandidier 1903: 4, 11, 54, 147, 167, 193, 255, 439; 1904: 6), while port towns were occupied by Moors or Muslims (*ibid*: 11, 52, 54, 99, 152, 440). Kent (1970: 178-180) and Kottak (1980: 50-51) argued that these ports formed city-states connected to the Swahili and Arab worlds through trade.

Historic documents also reported that there were many rulers and chiefs in different regions of Madagascar, who were constantly at war with each other (Duarte Barbosa, Diogo do Couto, Ed. Lopez, André Thevet cited in Grandidier and Grandidier 1903: 54, 89, 99, 147, 152). They used spears (with iron or animal bone points), shields, and bows-and-arrows as weapons (De Constantin, Diogo do Couto, Ed. Lopez, André Thevet, François Martin de Vitré cited in Grandidier and Grandidier 1903: 11, 54, 89, 101, 147, 152, 194, 255, 282, 284). Some early maps of Madagascar depicted Malagasy warriors holding these weapons (see Figure 4.1, and Guillaume le Testu 1555 reproduced in Grandidier and Grandidier 1903: 79, 88). These warriors were agile and skilled at using their weapons (Duarte Barbosa cited in Grandidier and Grandidier 1903: 54).

Coastal people fished with canoes and nets or harpoons (Duarte Barbosa, André Thevet cited in Grandidier and Grandidier 1903: 54, 147), while people in the rest of the country herded livestock, hunted wild small game, and collected wild plant products (*ibid:* 442). The country had abundant zebu, sheep, goat, rice, millet, yams and tubers, oranges, lemons, bananas, ginger and saffron, and even corn and manioc (Diogo do Couto, De Bry, André Thevet, and De Constantin cited in Grandidier and Grandidier 1903:101, 145, 147, 195; 1904: 12). Some wealthy people wore copper tin and silver jewelry on their arms, and wooden pieces in their ear lobes (Duarte Barbosa, Diogo do Couto, and De Constantin cited in Grandidier and Grandidier 1903:11, 54, 101, 194). People valued copper more than silver (*ibid*: 459), and were reluctant to trade with foreigners (Jehan Allofonsce and Raulin Secalart, and André Thevet cited in Grandidier and Grandidier 1903: 92, 147).

In the southwest, people lived in patriarchal societies. They were not sedentary, moving with their cattle and sheep from place to place following seasons and the availability of pastures (De Bry, De Constantin, and François Martin de Vitré cited in Grandidier and Grandidier 1903: 145, 197, 284). They supplemented herding activity with hunting small game, collecting wild plants, and fishing for those living along the coast (De Constantin cited in Grandidier and Grandidier 1903: 194). Cultivation was supplemental (*ibid*: 194). Their food came from tamarind fruits, pumpkin, calabash, tubers, beans, honey, wild animals and birds, and sometimes the meat of livestock (De Bry, and De Constantin cited in Grandidier and Grandidier 1903: 146, 196). Women wove cotton fabrics (De Constantin, and François Martin de Vitré cited in Grandidier and Grandidier 1903:196, 284). Their huts were made of vegetal materials (De Bry, De

Constantin, and François Martin de Vitré cited in Grandidier and Grandidier 1903: 146, 194, 284).

Figure 4.1: Malagasy People around the Onilahy Embouchure (Southwest Madagascar) in 1595 CE (After 'Histoire de la Navigation Hollandaise aux Indes Orientales en 1595' p.6 reproduced in Grandidier and Grandidier 1903: 174)

These observations were likely made during a dry period for the following reasons. According to oral traditions, people in the southwest relied on tamarind fruits and other wild plants and animals only during lean seasons and famines. Proximity to waterpoints, forest resources and prairies are essential, and influenced decision-making during these periods of scarcity. Proximity to arable lands may have been less important in the absence of extensive cultivation of the land.

Grandidier and Grandidier (1903: vii) did not give much credit to the 16th century CE Portuguese historic documents on the following grounds:

> *"Par le simple examen des anciennes cartes que nous publions dans ce premier volume, et dont l'une remonte à 1492, on constate combien elles sont fantaisistes et erronées, ayant été tracées par leurs auteurs après de hâtives et très rudimentaires investigations. Les navigateurs qui ont débarqué à Madagascar au 16ᵉ siècle sont restés sur la côte ou ne se sont que fort peu avancés dans l'intérieur de l'île; c'est seulement aux 17ᵉ et 18ᵉ siècles, avec Flacourt, que commencent les explorations proprement dites dans l'intérieur et l'étude détaillée du pays."*
>
> With the simple examination of ancient maps that we publish in this first volume, one of which dates back to 1492, it is evident how imaginary and erroneous they were, having been drawn after quick and very rudimentary inquiries. Navigators who landed in Madagascar in the sixteenth century remained on the coast, or made but little progress into the interior of the island; It was only in the seventeenth and eighteenth centuries, with Flacourt, that explorations in the interior and detailed study of the country began. [My Translation]

We owe a debt to Etienne de Flacourt (1607-1660) for compiling information about several regions – including the Southwest - during the second half of the 17^{th} century CE. A map he produced in 1656 (Figure 4.2) shows the Middle Sakamarekely Valley – my study area - located within a territory referred to as the "*Pays des Pierres*" [litt. Land of stones], a region covering the northern bank of the upper Onilahy River. In the map, *Pays des Pierres* was bordered to the north by the "*Ontaisotrouha Anthropofages*" mountains, to the west by the "*Pays des Soies*" [litt. Land of silks] of the "*Pays des ZafeAnrenavoule*" [along the *Ongh-Lahe Massei* (Taheza River)], to the south by the *Ongh-Lahe* River, and to the east by the "*Alfissach*" [Ala-Fisakàna or Alam-pisàka] the land of "*Peuple Larron*" (litt. bandit people).

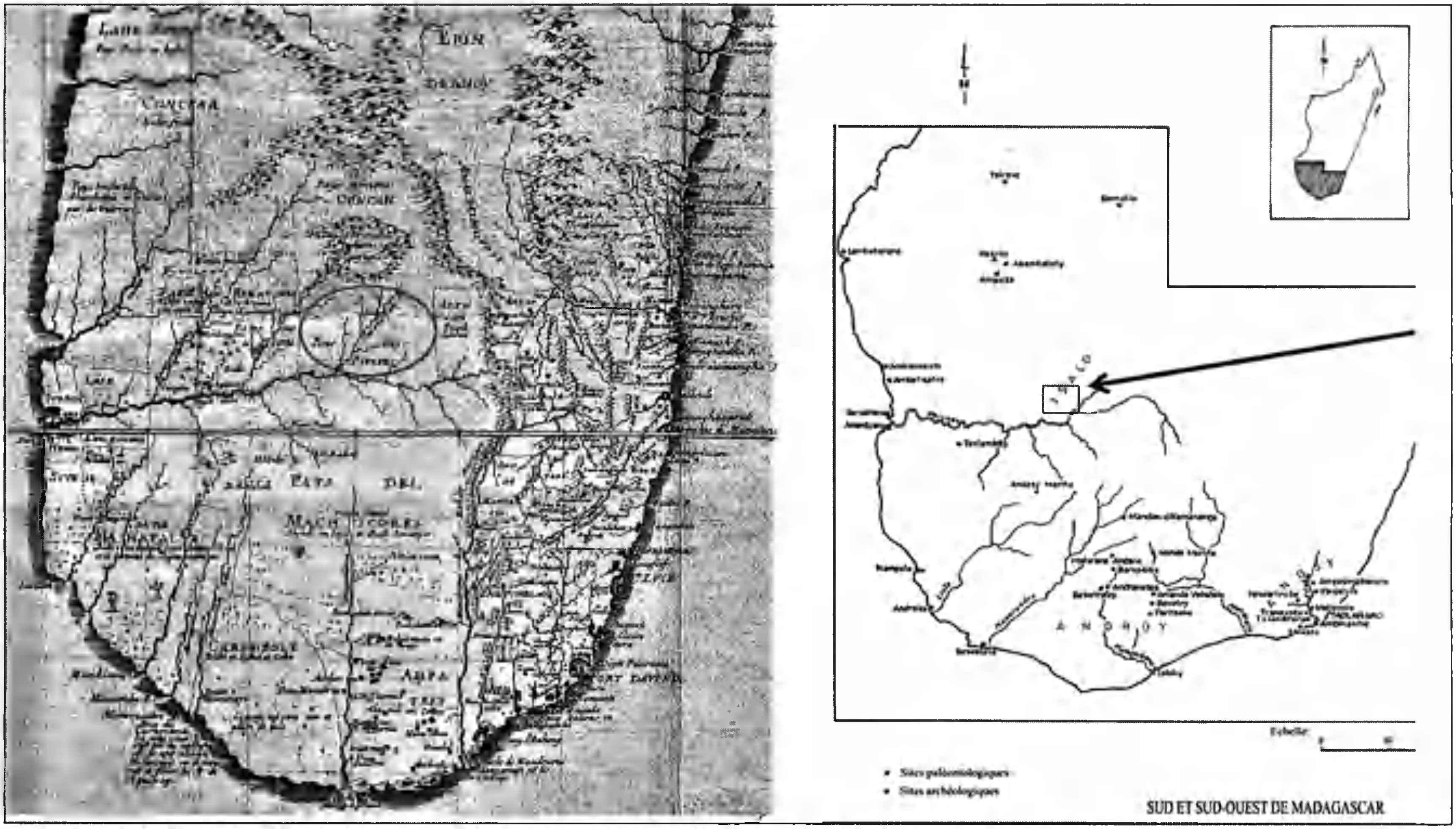

Figure 4.2: Etienne de Flacourt's Map of Madagascar in 1656 Showing the Study Area as 'Pays des Pierres' Compared with Map of the Distribution of Archaeological Sites in the Southwest (After Flacourt 1661; and Radimilahy 2011: 826)

Although the upper Onilahy region was among the potential food suppliers of the French colony in Fort-Dauphin during the 17th century CE, Flacourt provided little information about this *Pays de Pierres*. He did not in fact travel to the area as the Grandidiers suggested (Grandidier and Grandidier 1903: vii) but simply learned about it secondhand from reports. The name *Pays des Pierres* he gave the area might have come from scanty information given by Claude Le Roy who led an expedition against the Andrevola group in the Onilahy Valley in 1650 under the aegis of local chiefs (Flacourt 1661: 290):

> *"Le sieur Le Roy avec vingt-deux Français à l'issue des Ampatres, fut à la guerre contre les Zafean Renavoule vers la rivière d'Yonghlahe pour Dian Raval, où il gagna deux mille bœufs et vaches, beaucoup de marchandises, et entre autres, en leur chemin trouvèrent grande quantité de pierreries dans le pays où ils passèrent."*
>
> Sir Le Roy, leaving the *Ampatres* [Ampatra = eastern Androy] in company with twenty-two Frenchman, went to war with the *Zafean Renavoule* [Andrevola] around the *Yonghlahe* [Onilahy] River for *Dian Raval* [Andriandravala] where he obtained two thousand oxen and cows, and many trade goods, and they found large quantities of precious stones among other things in the land through which they traveled. [My Translation]

This land was most probably the *Pays des Pierres*, for Flacourt reported as follows:

> *« Dans la rivière d'Yonghe-lahe, du côté du nord, descendent outre plusieurs ruisseaux, trois rivières, à savoir le Ranoumainthi, l'Yonghe-lahe Massei et le Sacamassei ou Sacamarei, dans lesquelles et aux environs, se trouvent quantité de pierres, comme des topazes, aigue-marines, émeraudes, rubis et saphirs, et quantité de cristaux très durs et excellents"* (Flacourt 1661 : 44)
>
> Along the Yonghe-lahe [Onilahy] river, on its northern bank, flow several streams and three rivers, namely the Ranoumainthi [Ranomainty = Sakondry], the Yonghe-lahe Massei [Onilahy Masay = Taheza] and the Sacamassei or Sacamarei [Sakamare], where one can find stones, such as topazes, aquamarines, emeralds, rubies and sapphires, and a good amount of very hard and excellent crystals. [My Translation]

These areas still produce precious stones today, and they were all located within the so-called *Grand Pays Machicores* (Masikoro Great Land), as Flacourt (1661) suggested:

> *« Reste maintenant à parler du grand pays Machicores, qui s'étend depuis la terre d'Yvouronhehoc, jusqu'a Carcanossi, et est bordé de la rivière de Mandrerei du côté de l'est, et de l'est-sud-est ; du sud du pays des Ampatres et Mahafalles, de l'ouest, du pays de Houlouve, et Yvouronhehoc ; de l'est, du pays des Manamboulles et Alfissach, et du nord, du pays de Concha."* (pp.43)
>
> It remains now to speak of the *Machicores* [Masikoro] great land, which stretches from the land of *Yvouronhehoc* [Ivoroneoke] to *Carcanossi* [Harakanosy = Anosy], and is bordered by the *Mandrerei* [Mandrare] river on the eastern and eastern-southeast sides; in the south by the *Ampatres* [Ampatra = Eastern Androy] and *Mahafalles* [Mahafale] lands, in the west, by the land of *Houlouve* [Ilovo], and *Yvouronhehoc* [Ivoroneoke], in the east, by the lands of the *Manamboulles* [Manambolo] and *Alfissach* [Ala-Fisakàna or Alam-pisàka], and in the north, by the *Concha* [Ikonka] land. [My Translation]

The *Grand Pays Machicores* was an important polity that unified a vast area in the southwest around the end of the 16th century CE or beginning of the 17th century CE. Etienne de Flacourt (1661) reported that it was ruled by Andriambaloale, and that this was a peaceful period. He reported the fall of Andriambaloale and fragmentation of the *Grand Pays Machicores* territory as follows:

> *"Tout ce pays des Machicores est ruiné par des guerres, et autrefois le Grand qui s'appelait Dian Baloualen, c'est-à-dire, maître de cent mille parcs, était le maître de tous ces pays des Machicores, Concha, Manamboule, Alfissach et Mahafalles, ainsi que les habitants le confessant encore. Tous vivaient en grande paix, et les environs étaient très florissants. Mais ses enfants après sa mort, se sont tellement fait la guerre qu'ils se sont tous ruinés, et chacun a tiré de son côté tellement que Dian Manhelle et les Zaffenrenavoulle s'en sont enrichis et les autres, se sont à présent ruinés, comme Dian Sorats, Dian Rahotty, Dian Mananghe et quelques autres, qui au lieu de se maintenir les uns et les autres, se sont ruinés, massacrés et tués, jusqu'aux enfants, coupés par pièces, ainsi qu'ils ont coutume de faire en guerre."* (Flacourt 1661: 44)
>
> The whole *Machicores* [Masikoro] land is ruined by wars, and formerly a Chief named *Dian Baloualen* [Andriambaloale], that is to say master of a hundred thousand livestock parks (believe that is a better translation of 'parcs' in this

> context) [the exact translation is 'master of the eighty thousand'], was the master of all the lands of the *Machicores* [Masikoro], *Concha* [Ikonka], *Manamboule* [Manambolo], *Alfissach* [Ala-Fisakàna or Alam-pisàka] and *Mahafalles* [Mahafale], for the inhabitants still say so. They all lived in great peace, and the lands were very prosperous. But his children, after his death, were so intent on fighting each other that they were all ruined. His children were so divided that *Dian Manhelle* [Andriamagnely] and the *Zaffenrenavoulle* [Zafindrenivola or simply Andrevola] enriched themselves while the others were all ruined, including *Dian Sorats* [Andriantsoratsy], *Dian Rahotty* [Andriandraòty or Andriandràotsy], *Dian Mananghe* [Andriamananga], and few others who, instead of helping each other, ruined themselves and massacred each other, even cutting children to pieces as they are accustomed to do in war. [My Translation]

Andriambaloale's sons emerged as warring chiefs in the southwest during the 17th century CE (Fagereng 1971: 8). In historical documents, European travelers reported intergroup conflicts in the region during this period (Grandidier and Grandidier 1903). During the second half of the 17th century, a group who identified themselves as Zafindravola [litt. descendants of *Ravola*] occupied the area around the MSV. A map by Sanson-le-Fils (1667) – a decade after Flacourt's map – identified the earlier *Pays des Pierres* area as *Zaffe Anravoule* [Zafindravola] (Figure 4.3). It should be noted that this new name is different from *Zaffe Anrenavoule* (Zafindrenivola or simply Andrevola) who, according to the map, occupied the adjacent lands stretching from the *Ranoumainthi* River (Sakondry River) via the *Ongh-Lahe Massei* River (Taheza River) to the upper *Ranoumena River* (Fiherena River) (see Figure 4.3).

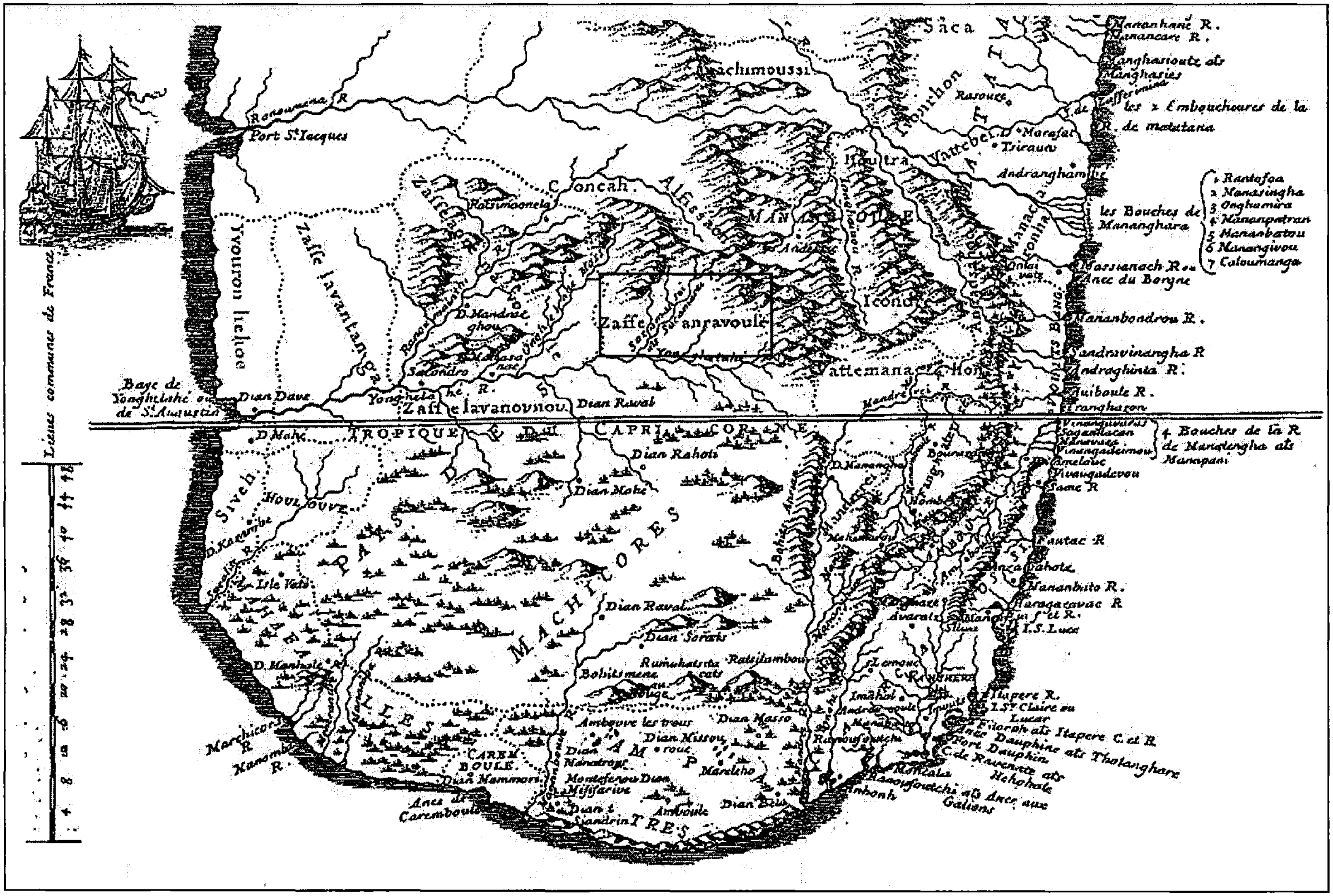

Figure 4.3: Map of Southwest Madagascar after Sanson-le-Fils (1667) Showing the Study Area as 'Zaffe Anravoule' (i.e. Zafindravola).

The Norwegian historian Edvin Fagereng (1971: 8) argued that the Zafindravola group was the same as Flacourt's *Machicores* group. I find his argument unconvincing. Fagereng (1971) posited that Andriambaloale was the founder of the Zafindravola group, and that Andriamandreandagnitse was his elder son and successor. This latter fathered Andriandravala, for whom Sir Le Roy and his twenty-two Frenchmen worked (Flacourt 1661: 45). In both the Flacourt (1656) and Sason-le-Fils (1667) maps, however, the name *Dian Raval* [Andriandravala] appears in two separate places: one along an unnamed southern tributary of the Onilahy river that could have been the Savazy River, and another in the upper Manambovo (see Figure 4.1 and Figure 4.2). Flacourt (1661: 45) also stated that *Dian Raval* [Andriandravala], son of Andriamandreandagnitse, died in an ambush prepared by his cousin *Dian Mahe* [Andriamahy] in 1653. Since the names of *Dian Mahe* [Andriamahy] and *Dian Raval* [Andriandravala] are placed along the same southern tributary of Onilahy, it is reasonable to presume they were occupying that area, which is far away from the *Zaffeanravoule* territory in the Sason-le-Fils (1667) map. The *Zaffe Anravoule* territory and the *Pays des Machicores* (which *Dian Raval* and *Dian Mahe* occupied) were contemporaneous and clearly separated by the Onilahy River during Andriandravala's time, hence could not be the one and the same as Fagereng (1971: 10) suggested. The Zafindravola polity likely emerged around the MSV in the second half of the 17th century CE, and may have been associated with the occupants of archaeological sites found in the area of the same period. It seems highly likely that the emergence of this polity and ongoing intergroup conflicts influenced sociopolitical decision-making of the occupants of Keliangebo during the 16th - 17th centuries CE. My spatial analysis of site defensibility in Chapter 7 explores this question.

Based on historical documents, the Southwest experienced major political, economic, and social changes in the 17th century CE: there was a shift from herder-forager semi-horticultural communities to raiding polities. This change contributed to the fragmentation of ancient polities and formation of new sociopolitical organizations (Kottak 1980: 52). Due to increasing internecine conflicts and trade with foreigners, local rulers started to use blunderbuss (*basy*) and muskets in addition to spears and bows-and-arrows (Paulo da Costa, Pedro Freire and Luis Mariano quoted in Grandidier and Grandidier 1904: 9; Kottak 1980: 51). The previously monogamic society of the southwest observed in the 16th century CE (Purchas cited in Grandidier and Grandidier 1903: 497) started to disappear, and polygamy became the standard among the royal family and their servants (Firinga 1971: 93; Paulo da Costa and colleagues, Luis Mariano, and Mandelslo cited in Grandidider and Grandiddier 1904: 7, 212, 217, 222, 489). The Portuguese Father Luis Mariano in Grandidier and Grandidider (1904: 226) thought that natives learned the institution of polygamy from the Moors/Muslims. But Firinga (1971: 91, 93) argued that this institution developed locally as a means to expand territory by creating more alliances with neighboring groups.

I also observed from the historic documents that the sea level have been higher in the 17th century CE, for most reports of this period mentioned only one islet at the entry of St Augustine Bay (Paulo da Costa, Pedro Freire and Luis Mariano cited in Grandidier and Grandidier 1904: 29), while Portuguese and Dutch documents in the previous century reported a second (De Constantin, and Purchas cited in Grandiddier and Grandidier 1903: 178, 402-403). It should be noted, however, that the French General Augustin de Beaulieu still reported having seen two in the Bay in 1620 (Grandidier and Grandidier

1904: 335). Although Zinke and colleagues' (2004) coral proxies did not cover the period before 1659 to provide an independent assessment of climate during this period, I can consider the effect of rising temperatures associated with the period between the Spörer Minimum and the Maunder Minimum at the beginning of the 17th century CE (Figure 4.4).

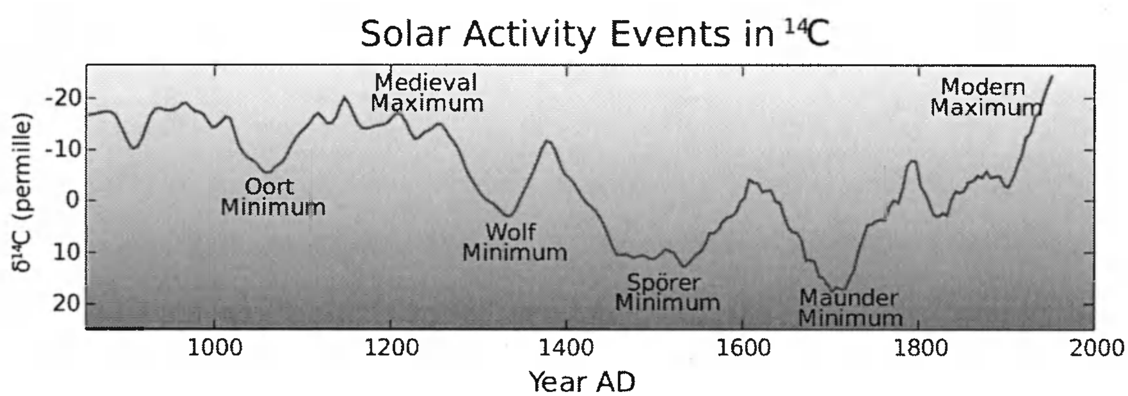

Figure 4.4: Changes in the $\delta^{14}C$ Caused by the Changes in Solar Activity (Source: Leland McInes, Wikipedia)

Today, there is only one island (Nosy-Ve) in the St Augustine Bay. With a rise in sea level would have come more humid conditions and higher rainfall, favorable shifts in the arid southwest. Historical documents reported the richness of the country in terms of vegetation and wild animals. Flacourt (1661: 44), however, reported that people suffered from prolonged famines during the 17th century CE, because of the intergroup conflicts:

> *"Maintenant, dans tout ce pays, il ne se fait aucune culture de la terre, et les habitants y vivent de racines et de bœufs sauvages, et se tiennent cachés dans les bois, à cause des guerres."*
>
> Today, in all this country, there is absolutely no cultivation, people survive on roots and the meat of wild cattle, and hide in the woods because of the warfare. [My Translation]

This suggests that during a period of intergroup conflicts, the defensibility of a site was not the only consideration in site selection by a community. Proximity to water, forests and prairies were also important, since people did not cultivate the land and relied rather on their livestock and wild resources. Flacourt also reported that during this period, "people were hiding in the woods", suggesting that we can expect to find archaeological sites temporarily occupied in the forest.

The situation persisted into the 18th century CE, according to Robert Drury. He described the southwest as a land endowed with many resources (cited in Grandidier and Grandidier 1906: 299), but jeopardized by local chiefs who continually engaged in internecine conflicts that reduced their inhabitants to famine. Intergroup violence was likely amplified by the slave trade and increasing use of firearms in the region (Kottak 1980: 52, 61). Drury explained that people were constrained to live behind fortified walls and close to each other, in order to respond quickly to any call. Consequently, the most beautiful and fertile parts of the countryside were deserted (Drury cited in Grandidier and Grandidier 1906: 299), reinforcing the idea that proximity to arable lands did not influence economic decision-making at this time.

From Drury's narratives we learn that, due to the violence during the 18th century CE, good lookout points were important to communities when choosing where to settle. We can also expect to see defensive structures such as fortified walls or ditches in archaeological settlements.

Robert Drury did not provide specific information about the upper Onilahy. We only learn from oral traditions collected by Edvin Fagereng (1971: 75) that during Drury's time, Andriamagnely, the founder of the Bara Zafimagnely polity, started a war against the Zafindravola and Tsienimbalala in the region east of the upper Onilahy. One of his three sons, Ratsimivé, was the forefather of the Bara Zafimagnely Vinda group that occupies the Middle Sakamarekely Valley today. After he was assassinated by his nephew Ramitongoa, Ratsimivé's descendants fled westward and founded the Bara Zafimagnely Vinda polity around the Middle Sakamarekely Valley (Fagereng 1971: 85). This westward movement occurred before the advent of their king Ratsileondrafy, who ruled between 1804 and 1817 (Kent 1970: 155). The Bara Zafimagnely Vinda arriving in the upper Onilahy likely chased the Zafindravola group out of the region, if they were still occupying it at all, and may have influenced sociopolitical decisions of the community occupying Ankilivalo during the late 17^{th} – 19^{th} centuries CE. The spatial analysis in Chapter 7 will address this question.

4.2. Oral Traditions

Although oral traditions cannot be taken as reliable historical references, their descriptions may provide useful clues to the social, economic, political character of communities in the past. For example, while oral traditions may not provide a reliable chronology of when an individual ruler reigned, they often tell us something about the institution (chiefdom or kingdom) and can be helpful in interpreting finds in an archaeological site.

Oral traditions in the Middle Sakamarekely Valley are mainly family histories (*tatara raza*) and myths (*tafasiry*). Family history collected among the royal Bara Zafimagnely Vinda group goes back only to the late 18^{th} century CE (Faublée 1947; Interviews in 2014-2016) but myths, though chronologically fuzzy, seem to trace back history to the 16th century CE or earlier. The maintenance of these myths demonstrates their social importance.

According to Bara Vinda myths, the Middle Sakamarekely Valley experienced two major historical periods, namely *fahaky Kimosy* (*Kimosy* period) and *fahaky mpanjaka* (period of rulers) (Faublée 1947; Interviews with Mbaiaho and Avimana 2016).

4.2.1. Fahaky Kimosy Period:

According to oral traditions, the early population of the Middle Sakamarekely Valley was the *Kimosy* (Faublée 1947: 207-210), a semi-mythical group first reported by Etienne de Flacourt in the mid-17th century CE. In his map and manuscripts Flacourt placed *Anachimovssi* (Anakimosy = Kimosy Land) northeast of the Sakamarekely Valley, however, (Flacourt 1661: 14; Rakotoarisoa 1998: 76-78), suggesting that *Kimosy* people did not occupy the Middle Sakamarekely Valley in mid-17th century CE. Meanwhile, according to Bara Vinda myths, Kimosy people were not semi-mythical beings but real people who occupied the Middle Sakamarekely Valley and the Isalo Massifs (Faublée 1947: 209-210). They are thought to have drawn paintings on cave walls as part of their divination skills. If so, the Kimosy group had a pastoral lifeway, since most of the figures in the Isalo cave paintings I discovered in my survey (Chapter 6) depict zebus (Plate 4.1). Alternatively, they were painting feral cattle spotted in the forest. Allibert (2007: 459) argued that the semi-mythical traits attributed to the Kimosy stemmed from the Zafiraminia royal group myth that portrayed any other indigenous people as savages.

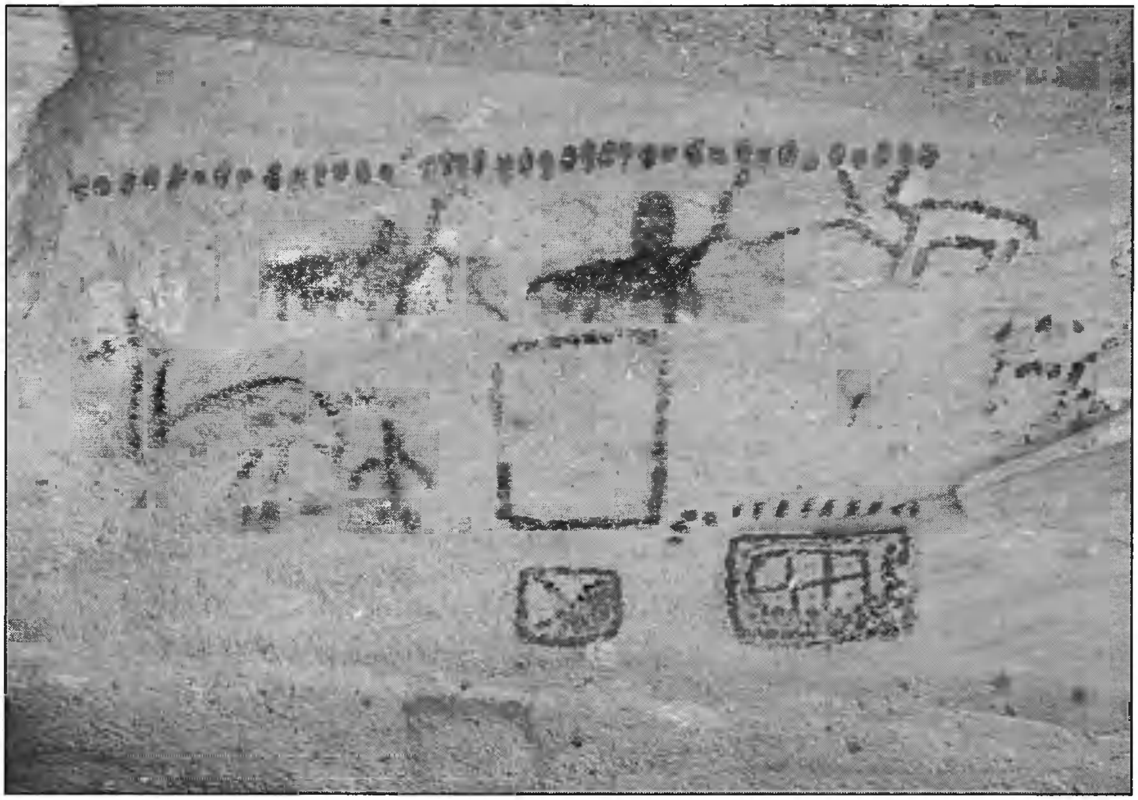

Plate 4.1: Cattle Depicted in Rock Paintings from Isalo

4.2.2. Fahaky Mpanjaka Period:

Oral traditions are not clear about whether the *fahaky mpanjaka* period evokes only the time of the Bara Vinda Zafimagnely polity (from late 18th century CE to early 20th century CE) or includes other polities before them. My informants were not aware of the presence of the Zafindravola group occupying the area before their ancestors. However, the information I collected gives some idea of how communities organized their sociopolitical worlds during the *fahaky mpanjaka* period and this, in turn, hints at ways in which climate variability and intergroup conflicts may have influenced decision-making.

Bara Vinda myths emphasize that God *Ndrianagnahary* created the world and instituted royalty and social hierarchy (Faublée 1947: 488). God gave the power to the first ruler called *mpanjaka* (ruler) in a fair way (Faublée 1947: 203-207). In one myth about the emergence of *mpanjaka*, God instructed his servants to tell the *mpanjaka*-to-be the following:

> *"Italilionareo gny ragniso, ampamboleonareo ambohis'egny iy. Aoregno egny ndre voly ino fa ho lò tany toy, hailiko agny rano toy."* (Faublée 1947: 206).
>
> Tell my friend to plant on the mountain. Tell him to plant all the crops there, for this earth [lowland] will be flooded, I will pour this water there. [My Translation]

Thanks to this, "God's friend" foresaw the flood and survived the subsequent crop failures in his terraced field, unlike other people who cultivated the lowlands. Subsequently, all deprived and starving people came to him and asked for food in exchange for their allegiance.

This particular Bara Vinda myth suggests that floods and famine brought the ruler to power, and commoners were not coerced into offering their allegiance. Unpredictable flooding followed by crop failures and famines influenced not only economic but also sociopolitical arrangements. The myth also tells us that the ancestral Bara Vinda had agriculture and depended on rainfall to water their crops, indicating the importance of both proximity to arable lands and unpredictable rainfall in economic decisions. The variable climate also affected sociopolitical decisions, since it indirectly led victims of climate stress to declare allegiance to the ascending ruler, allowing the formation of a new polity(?) and possibly larger habitations.

Bara Vinda oral traditions also shed light on the social structure of the community during the *fahaky mpanjaka* period: the ruler *mpanjaka* was the supreme power and judge of disputes within the community (Faublée 1947: 484). He was advised by a diviner-healer known as *ombiasy* (Faublée 1947: 482) A *mpanjaka* had servants called *mahombe,* who ensured his security and assisted in executing his orders. The royal house was also served by slaves called *ondevo*, who were treated as part of the family. Unlike hierarchical communities in southeast Madagascar, the elite family in the southwest ate animals slaughtered by *ondevo* (Faublée 1947; Grandidier and Grandidier 1906), although it was a profanation for a royal family member to have an intimate relationship with a slave (Faublée 1947: 485). When a *mpanjaka* died, a royal caretaker called *andrahofiky* took care of the body. Although a *mpanjaka* ruled over people occupying his domain, he could not coerce them to stay if they wanted to leave. An individual or group might leave and seek refuge under another *mpanjaka*, if their ruler was too demanding or cruel (Faublée 1947: 210; 482). There are many instances in oral traditions that show a *mpanjaka* making decisions carefully for fear that people would leave his fief (Faublée 1947: 488; see also Grandidier and Grandidier 1906). Figure 4.5 is a sketch of social organization during the *fahaky mpanjaka* period according to oral traditions:

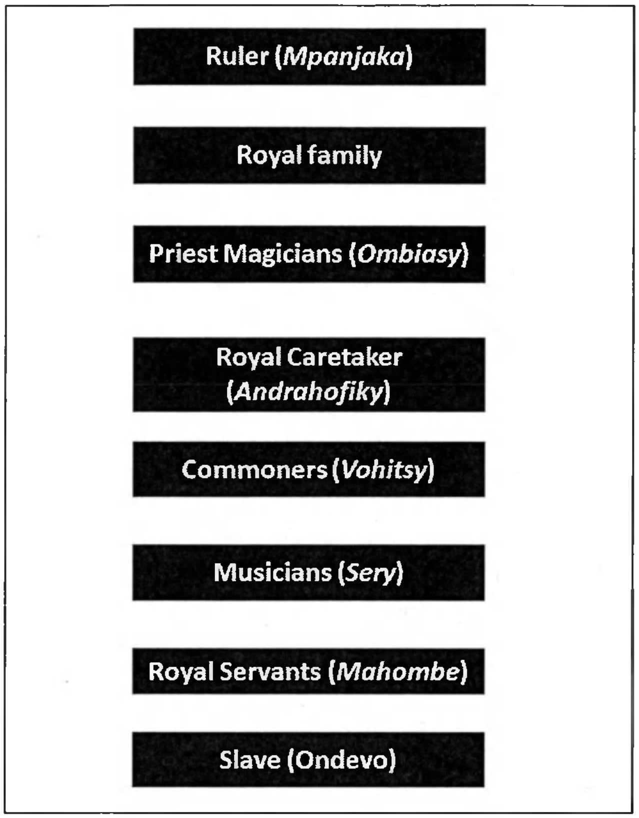

Figure 4.5: Social Structure of Bara Vinda Society during the Fahaky Mpanjaka Period

4.3. Previous Archaeological and Social-Ecological Research in the Southwest

Since the late 19th century, the study of the Madagascar's past has focused on early human settlement. Social scientists and humanities scholars used evidence from linguistics, ethnology, physical anthropology and history (Grandidier and Filhol 1892; Ferrand 1909), while paleontologists studied the impact of early settlers on the island's biodiversity and botanists investigated changes in land cover over time (Humbert 1927; Lavauden 1934; Grandidier and Filhol 1892; Lamberton 1946). There were no efforts to combine these lines of research.

Although a few excavations of important archaeological sites were done before the 1960s (Gaudebout and Vernier 1941; Poirier 1947), only after the University of

Madagascar was founded in 1962 did the prehistory of the island become the subject of systematic archaeological research (see Radimilahy 1998: 14; Vérin 1981: 693). The French archaeologist Pierre Vérin, then Director of the *Musée d'Art et d'Archéologie*, conducted archaeological surveys and excavations in several regions of the island, but the vast size of the country versus the small number of professional archaeologists rendered the investigated archaeological sites geographically fragmentary (Rakotoarisoa 1981: 133). Vérin's research interests focused on "the nature and origin of human settlement, the influence of Islam and the Swahili world in Madagascar and the historical archaeology of the kingdoms of the central highland" (Vérin 1966; Radimilahy and Crossland 2015: 495). Most of the systematic investigation was carried out on ditched settlements in the central highlands and Swahili architecture in the northwest (Vérin 1981: 702). A few surveys and excavations were conducted here and there in the south, southwest, and southeast. Despite Vérin's extensive archaeological fieldwork, regional settlement phases were not established until the American archaeologist Henry Wright came to Madagascar in the 1970s and established the first ceramic phases in the central highlands (Dewar and Wright 1993; Radimilahy and Crossland 2015; Wright 2005), the Mananara River Valley in the northeast (Wright and Fanony 1992), and the Boeny Bay and Mahavavy River valley in the northwest (Wright *et al.* 1996). Along with Susan Kus, Henry Wright promoted a processual approach to investigate changes in social, economic and political organizations through analyses of ceramic attributes and settlement patterns (Wright and Kus 1979; Kus and Wright 1986).

The late 1970s through the 1990s saw the training of Malagasy archaeologists, but they depended on external funds obtained through Vérin and were constrained to follow his lead (Rakotoarisoa 1981). The key site-based works by Chantal Radimilahy (1998) at the Swahili town of Mahilaka in the northwest, David Rasamuel (1984)'s intrasite spatial analysis at Fanongoavana, Andrianaivoarivony Rafolo's (1989) at Lohavohitra, and Barthelemy Manjakahery (1997) at Erimoho in south central Madagascar are all good examples of this. Jean-Aimé Rakotoarisoa (1998) rejected the site-based approach and followed in the footsteps of Henry Wright, conducting an extensive regional survey along the Ifaho River in the southeast and establishing the settlement phases of the region. Rakotoarisoa and Chantal Radimilahy (2004) developed the same approach for the archaeology of the deep south. Their work was amplified by the British archaeologist Michael Parker Pearson, who produced refined settlement phases in the Androy region of southern Madagascar (Parker Pearson 2010). Although Rakotoarisoa included environmental setting and natural resource exploitation in his reports, he did not conduct systematic social-ecological research to build narratives of human-environment interactions.

In the southwest, a few archaeological sites have been excavated, notably Andasy Merina, Asambalahy and Rezoky (Vérin 1971), Sarodrano (Battistini and Vérin 1971), and Teniky (Ramilisonina and Rakotoarisoa 1971) (see Figure 4.5). Investigated under the influence of Vérin's site-based approach, these sites are thematically and geographically disjointed (Rakotoarisoa 1981: 134). This fragmentary aspect of archaeological sites led historians (e.g. Manassé Esoavelomandroso 1995) to conclude that the dynamism of the unpredictable climate and harsh environment prevented early settlers from establishing large settlements in the region. But I think it is too early to draw this conclusion, for archaeologists have not yet systematically surveyed most of the southwest (see Figure 4.5). The earliest reliable date for human settlement was, until recently, the 10th century, from the site of Asambalahy and Rezoky (Radimilahy and Crossland 2015: 505). This date is now pushed back to 362-542 CE by the work of Kristina Douglass (2016: 172) at Velondriake.

In the 1980-1990s, paleontological and paleoecological work hinted at early human settlement in the southwest. The analysis of extinct pygmy hippopotamus remains – carrying cut-marks – recovered from Andolonomby and Lamboharana (Grandidier and Filhol 1892) provided AMS dates ranging from the 1st to 4th centuries CE (MacPhee and Burney 1991), and Andolonomby yielded paleoecological stratigraphy extending from 5000 years BP to the present (Burney 1993). Paleoecological proxies indicate that the climate during the Holocene was oscillating, with frequent changes in vegetation cover (MacPhee and Burney 1991). Based on sediment core information, Burney (1993) and Burney *et al.* (1999: 146) inferred human intervention from the beginning of the first millennium CE by identifying "(1) a large increase in ruderal pollen influx, (2) appearance of exotic pollen types, (3) a sudden and pronounced increase in microscopic charcoal particles, and (4) Paleolimnological evidence for cultural eutrophication (pollution of aquatic system by artificial nutrients)". Although none of these four alone is sufficient to confirm human presence (ruderal and unusual taxa, wildfires, and eutrophic waters also happen through natural processes), the consistency of these phenomena with the paleontological evidence indicating human presence supports their anthropogenic nature. Chronological correlation with contemporaneous archaeological evidence would further confirm them.

The finding of human-modified bones of extinct animals prompted researchers such as the American archaeologist Robert Dewar to search for human settlement associated with 'anthropogenic' ecofacts. He revisited a few subfossil sites and assessed the validity of assertions about the hunting of megafauna (Wright et al. 2013: 534). Dewar took forward research on human contributions to the megafauna extinctions, advocating the use of a transdisciplinary approach involving archaeology, paleontology, history, linguistics, ethnology, genetics, paleoecology, geological micromorphology and climate modeling in the study of Madagascar's past (Wright et al. 2013: 535). He teamed up with American and Malagasy paleontologists and archaeologists to study sites with Holocene remains all over the island. Meanwhile, as his research developed, Dewar became more interested in fieldwork in the north where he and his collaborators uncovered the first microlithic tools discovered in Madagascar dating back to 2000 BCE (Dewar et al. 2013) and gave up archaeological fieldwork in the southwest.

In 2005, analysis of bones of extinct giant lemurs carrying cut-marks from the paleontological site of Taolambiby along the middle Onilahy (~65 km downstream from my study area) yielded AMS dates going back to the 5th century BCE (Perez *et al.* 2005). Although these bones were not found associated with human settlement, they at least indicate human presence in the southwest by then. Despite these indications, no conclusive archaeological site with a date this early has been discovered in the region until recently. The African Archaeology Network collaborating with the *Musée d'Art et d'Archéologie* of the University of Antananarivo and the *Musée CEDRATOM* of the University of Toliara conducted surveys along the rivers of the southwest searching for early human settlements, but did not find any, and the project leaders were not interested in studying human-environment interactions as conceived in this thesis.

Since 2011, the Morombe Archaeological Project, directed by then Yale Ph.D. candidate of Kristina Douglass, has been studying the interaction between coastal populations and the now-extinct giant elephant bird along the Velondriake coast in the southwest. By examining subsistence strategies and natural resource exploitation at different archaeological sites, she conducted a diachronic case study of the long-term dynamics of human-environment interactions in the area between 900 BCE and 1900 CE (Douglass 2016), predating the *hitherto* secure earliest date for human settlement in the southwest. Douglass' study also likely confirms previous paleoecological and paleontological indications of early interactions between ancient society and the now-extinct elephant bird.

More regional survey is still needed to understand the dynamics of human-environment interactions in the southwest. This is one of several reasons why the present study seeks to establish a narrative of human decision-making in the face of unpredictable climate and intergroup conflicts along the MSV. The study area was until recently unknown to archaeological research. It is archaeologically bordered some 100 km to the north by the sites of Teniky (Ramilisonina and Rakotoarisoa 1971), Rezoky and Asambalahy (Vérin 1971a). To the south, the closest sites are located some 130 km away along the upper Manambovo and upper Linta (Parker Pearson 2010). To the west, the closest sites are some 140 km away around the mouth of Onilahy (Vérin 1971b) and some 170 km away around the mouth of Manombo (Radimilahy 2011). The first archaeological work done in the area was my 2010 MA field project on rock paintings at

Ampasimaiky rockshelter (Rasolondrainy 2012). This thesis is the sequel of that endeavor.

Figure 4.4: Map of the Distribution of Archaeological and Paleontological Sites in the Southwest Mentioned in the Text (Adapted from Radimilahy 2011: 826).

4.4. Occupation Phases of the Southwest

It may seem premature to synthesize the occupation phases of the Southwest based on the archaeological sites currently available. In relation to the region's large size, sites discovered so far are scarce. In addition, the research has been geographically and thematically fragmentary. As a result, this section is primarily a demonstration of the tremendous need to fill the gap.

4.4.1. Early Human Arrival (Before 10th century CE)

The timing of the initial arrival of people in the southwest is unclear (Ekblom *et al.* 2016; Radimilahy 2011: 826), suggested only by few indications from paleoecology and paleontology without archaeological context (Battistini and Vérin 1971; Burney 1993; and Burney *et al.* 1999: 146; Burney *et al.* 2004; Douglass 2016: 149, 363; Ekblom *et al.* 2016: 197; Grandidier and Filhol 1892; MacPhee and Burney 1991; Perez *et al.* 2005). Yet these indications were used to argue that the arrival of people on the island caused the extinction of animals known only as subfossils. By clearing forests for livestock and swidden agriculture, the argument goes, early Malagasy contributed to the drying of climate and deforestation and resulting loss of habitat for wildlife. The clearing of forest might also have made it easier to hunt large animals that sought refuge in remaining forest blocks (Raison and Vérin 1967: 134, 141). Réné Battistini (1966) suggested earlier, however, that the drying of swamps along the southwest littoral driven by climate change 2000 years ago might have been a more important driver of the extinctions.

The earliest conclusive archaeological evidence in the southwest was found at the site of Enijo at the mouth of the Menarandra River. Parker Pearson (2010: 83) discovered potsherds resembling the East African Triangular Incised Ware (TIW) tradition, suggesting that people in the south had contact with the East African coast between the 7th and 10th century CE.

4.4.2. The 11th to 15th centuries CE:

Communities were established at Belo-sur-Mer slightly before and during this period (Wright in prep.). They used locally produced pottery decorated with large impressions and false chevrons. No associated imported goods have been found.

Further south, a coastal community was established at Antseranananagy, in the Velondriake area, around 1051-1224 CE (Douglass 2016: 172; 363). Their pottery shares affinities with pottery found at Sambalahy in the hinterland, although they date a bit earlier. Antseranananagy occupants ate domesticated cattle (Douglass 2016: 366). The presence of cattle before 600 BP challenges earlier assumption about the development of pastoralism in the southwest (see Crowley 2010; Esoavelomandroso 1995).

In the 14th -16th centuries CE, a community was established at Asambalahy. They herded and ate cattle, hunted lemurs and tenrecs, worked and used iron, used locally produced pottery wares and had limited imported ceramics and beads (Verin 1971: 42-45). This iron-using herder-hunter-gatherer community practiced subsistence strategies similar to the Mahafale described by Etienne de Flacourt in the mid-17th century CE:

> "*Toute leur subsistence et nourriture se tire du bétail qu'ils mangent, de laitage, et de racines qu'ils trouvent à foison dans les bois*" (Flacourt 1661: 62).
>
> All their subsistence and foods come from livestock which they eat, dairy products, and tubers that they find in the woods. [My translation]

This lifeway could have been widespread in the southwest since groups were constantly on the move:

> "*Ils n'ont aucun village et lieux assurés de demeure, car ils en changent à mesure que les paturages manquent dans une étendue de 25 ou 40 lieues de pays qu'ils ont à camper. Ils font leur huttes ou cabanes dans les bois, eloignées les unes des autres, suivant les parcs où ils retirent leurs bestiaux.* (Flacourt 1661: 62)"
>
> They have no villages and places of abode, for they change depending on the availability of pastures in the 25 or 40 leagues of countryside where they camp. They make their huts or cabins in the woods, distant from each other, depending on the parks where they keep their cattle [My translation].

It is unclear whether this herding-foraging lifeway is of Austronesian or East African origin (CITE). Heutebize and Vérin (1974: 118) were convinced that Bantu were early settlers of western and southern Madagascar and that they kept cattle.

Other communities using local pottery similar to that of Asambalahy were also established along the coast at the mouth of the Manombo and Fiseranamasay rivers during this period (Radimilahy 2011: 836-838).

Further south, in the Upper Linta, a community was established at Andasy Meriñe from the 11th to 15th centuries CE. This site is surrounded by a defensive earthen wall (Parker Pearson 2010: 105). Apart from local pottery (restricted globular vessels decorated with cordon applique and incised decorations), occupants of the site also had imported items such as Middle Eastern sgraffiato and Chinese celadon wares.

4.4.3. The 16th-17th centuries CE:

Between the 16th and 17th centuries CE, communities using pottery decorated with small triangle impressions and parallel wavy lines incisions were established around Belo-sur-Mer (Wright *in prep.*).

Further inland, a community was established at Rezoky between the 16th and 17th centuries CE. People herded and ate cattle, worked and used iron, hunted tenrecs, lemurs, and *fosa* (*Cryptoprox ferox*), collected freshwater snails (*Helicophanta vesicalis* and *Clavator clavator*), used locally produced pottery and limited imported ceramics and beads, and probably made their own beads out of quartz (Vérin 1971: 29-41). This iron-using herder-forager community might have been different from those that Flacourt described as sowing the land around the 17th century CE:

> *"... le long de la rivière d'Yonghe-Lahe, le pays est très beau, et les habitants y cultivent du riz et autres choses nécessaires à la vie."* (Flacourt 1661: 64)
>
> ... along the Yonghe-Lahe [Onilahy] River, the country is very beautiful, and the inhabitants cultivate rice and other things necessary for life. [My Translation]

Not far from Rezoky, in the interior of the northern Isalo massif, the so-called Portuguese cave, locally known as Lakato Teniky, has yielded imported ceramics from 16th century CE (Ramilisaonina and Rakotoarisoa 1971; Vérin 1971). Little is known about the subsistence strategies and social organization of the users of this pottery.

4.4.4. The 18th to 19th centuries CE:

Communities were present around Belo-sur-Mer in the 18th-19th centuries CE (Wright *in prep.*). They used local pottery traditionally known as Vezo-Antavelo pottery.

In the Velondriake area, fishing communities using combed pottery known as Vezo-Antavelo occupied Andamotibe, Antseranasoa, and Antserananangy (Douglass 2016: 123, 172, 184). Their livelihood relied on maritime resources from coral reefs and lagoons.

5. CONCLUSION

This review shows that large areas in the southwest (including the upper Onilahy) have yet to be subjects of archaeological research and that very limited attention has been given to later periods of its culture history. More surveys at different spatial and temporal scales are needed to increase knowledge of the region's culture history and social-ecological systems.

CHAPTER FIVE: RESEARCH STRATEGIES AND METHODS

This chapter outlines the strategies and methods used to gather evidence. Within the framework of historical ecology, I combined archaeological excavation, geospatial analyses, ethnohistory, and to some extent paleoclimatology.

This chapter is divided into three sections. The first explains the use of ethnohistorical records; the second details strategies and methods used during archaeological field seasons described below; finally, the third describes methods for collecting and analyzing geospatial data.

5.1. ETHNOHISTORICAL APPROACHES

Measurable aspects of social-ecological systems such as site location, material distribution, material characteristics, and probabilities are very valuable. However, as I discussed in Chapter 2, the agency of people and the motivations behind their decision-making cannot adequately be assessed by these measures (Hodder 2007: 5-7), and I used an ethnohistorical approach to explore the cognitive aspects of people's decision-making in the historical context of Madagascar (Balée 2006; Crumley 2007; McIntosh *et al.* 2000; Winterhalder 1994).

Ethnohistory explores the cultures and history of people by investigating historical records and oral traditions. I used both these sources, relating them to archaeological materials in order to understand how local people perceived and used the riverine landscape of the MSV (see Chapter 3 and Chapter 4). Information of interest included but was not limited to people's belief, worldview, and ecological knowledge. These are expected to play essential roles in community decision-making (Butzer 1982: 32;

McIntosh 2005: 45-100; Tilley 1994), and to be vital to the interpretation of landscape perception and models of land use during the past (Sutton and Anderson 2010: 104; Tilley 2010).

In some cases, ethnohistorical information was also helpful in designing my field methods. For instance, the placement of one of the excavation units at Ankilivalo was based on the ethnohistorical expectation that the house of a village leader is traditionally located at the northeast corner of a village, a place associated with the cosmological value for power and sacredness (see *5.2.3.* in this chapter). Also, some of the selection criteria used to target survey areas were based on the ethnohistorical knowledge that people in the past left sacrificial materials and offerings at places such as large trees, rock shelters, boulders, and so forth (Faublée 1948).

5.2. ARCHAEOLOGICAL FIELDWORK

I conducted fieldwork during the summers of 2014, 2015 and 2016. I spent 45 days in 2014 conducting systematic surveys along the Middle Sakamarekely Valley (MSV) and in the Isalo Massif; In 2015, I devoted 120 days for continuing systematic surveys along the MSV in conjunction with intrasite survey and excavation at Ankilivalo. Finally, in 2016, I spent 90 days carrying out an intrasite survey at Keliangebo and continuing excavations at Ankilivalo.

5.2.1. Systematic Surveys

In 2010, within the framework of my MA dissertation (Rasolondrainy 2011), I conducted a reconnaissance survey of the MSV. Drawing on this preliminary work, I decided to conduct systematic surveys for this thesis. This is the first systematic surveys conducted along the MSV and the adjacent Isalo Massif. The primary goal was to systematically find and record archaeological sites in the area.

I used the *Create Fishnet* tool in ArcMap (*ArcToolbox > Data Management Tools > Sampling > Create Fishnet*) to divide the study area in 500m x 500 m grids (Figure 5.1). I then sampled quadrats where I had already encountered archaeological sites and where I expected to find more. I based my prediction on the presence of water sources, modern fields, tamarind trees, forest patches, boulders, foothill, hilltop, etc. (Table 5.1; Table 5.2; Razafimisa 1987: 50). These places are known for human activities to take place (Faublee 1954). With the help of local informants, I selected 174 grids, totaling 4350 Ha. I assigned GPS coordinates to the four corners of each grid (Appendix 5.1). To do so, I put points at every corner of the selected grids, and extracted their location coordinates using the *Add XY Coordinates* tool in ArcMap (*ArcToolbox > Data Management Tools > Features > Add XY Coordinates*). I then assigned a numeric identifier (from 1 to 174) to each grid (see Figure 5.2). The quadrats were intensively surveyed by walking linear-oriented transects south-north spaced 10 apart, except in hilly and densely vegetated areas.

Once a site was discovered, I used two different collection methods depending on the size of the site and the density of surface materials. I collected all isolated items but left surface materials on larger sites for a separate intrasite survey.

My survey team carried specially designed site recording forms that I developed, including grid number, site name or number, GPS reading, possible boundary, visible features, and surface finds (see Appendix 6.1).

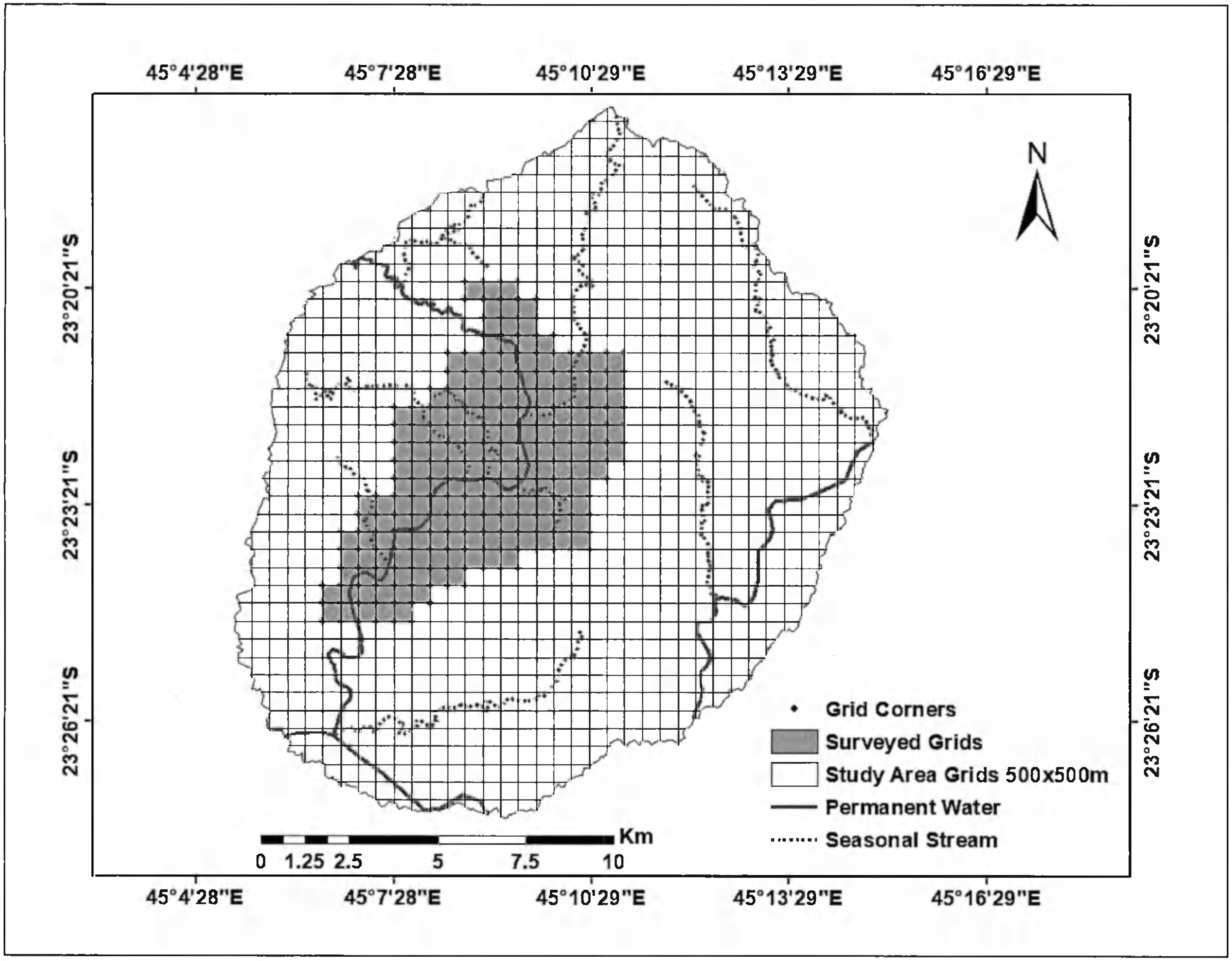

Figure 5.1: Survey Grids 500mx500m (Field Season 2014-2015)

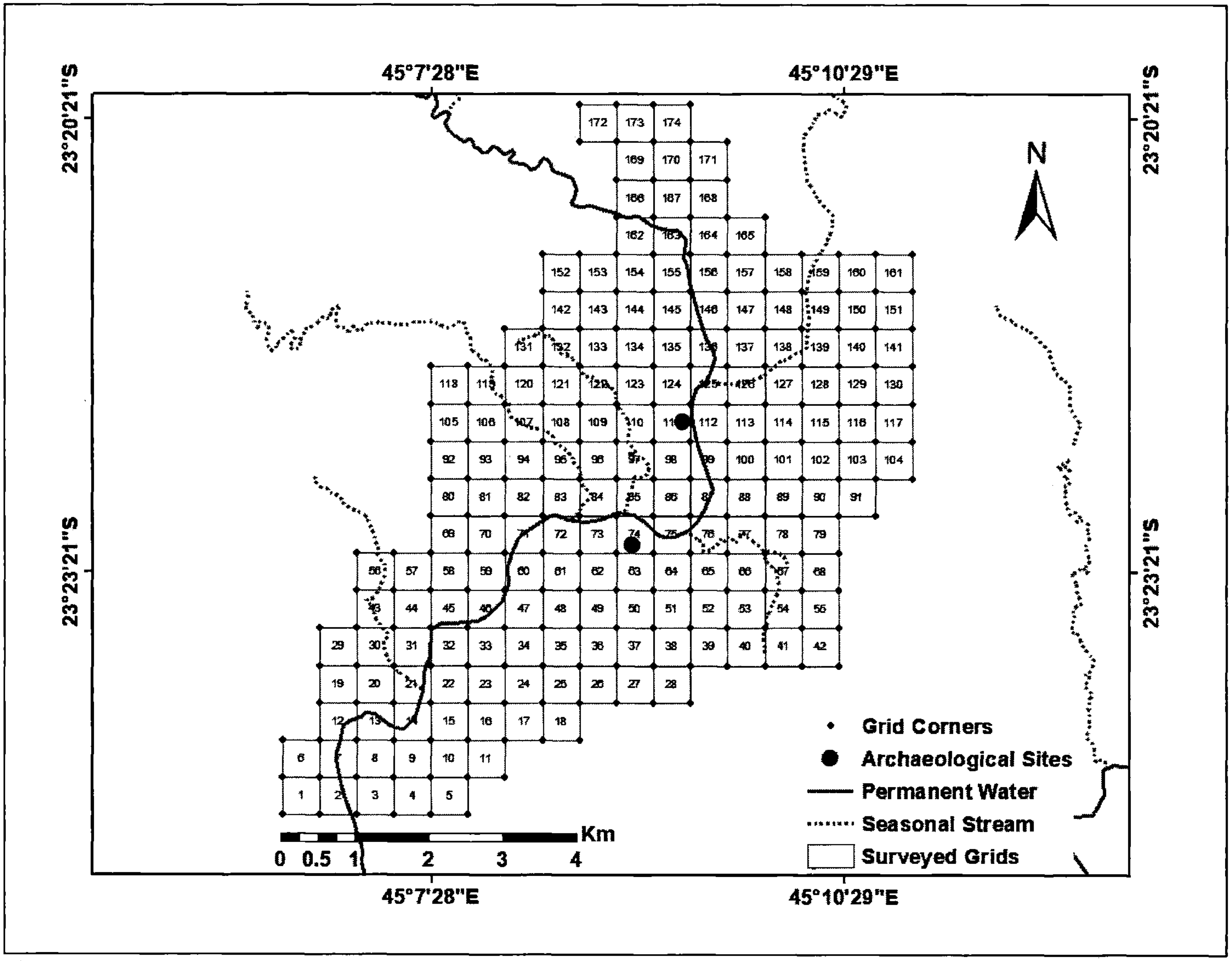

Figure 5.2: Surveyed Grids Numbered and the Main Archaeological Sites (Field Season 2014-2015)

Survey team members included three assistants from the departments of History and Earth Sciences at the University of Toliara, two high school students from Benenitse, and four local villagers. I trained them in advance on how to document sites and materials, as well as how to use equipment such as GPS, compass, and walkie-talkie.

Depending on the density of vegetation cover, the concentration of finds to be recorded, and the weather, my team could finish surveying 1 – 3 grids per day.

Details of the systematic survey results for 2014 and 2015 field seasons are presented in Chapter 6. Below I provide details about survey methodology for each year.

5.2.1.1. Field Season 2014

The 2014 field season aimed to survey and document archaeological sites located along the Sakamarekely Valley and in the Isalo Massif. My team systematically surveyed 67 grids (Figure 5.3; Plate 5.1; Table 5.1) over a period of 45 days.

Plate 5.1: Systematic Survey of Grid 111 Underway (Field Season 2014)

Table 5.1: Grids Surveyed during the 2014 Field Season

#	Grid #	NW Corner	NE Corner	SE Corner	SW Corner	Features for Selection of the Grid
1	69	-23.383; 45.1245	-23.383; 45.129	-23.3871; 45.1245	-23.3871; 45.129	Temporary Stream, Hilltop, and Foothill
2	70	-23.383; 45.129	-23.383; 45.1335	-23.3871; 45.129	-23.3871; 45.1335	Hilltop
3	71	-23.383; 45.1335	-23.383; 45.138	-23.3871; 45.1335	-23.3871; 45.138	River Bank, Foothill, Farming Fields, and Forest Patches
4	72	-23.383; 45.138	-23.383; 45.1425	-23.3871; 45.138	-23.3871; 45.1425	River Bank, Farming Fields, Foothill, Tamarind Trees, Forest Patches, and Boulders
5	73	-23.383; 45.1425	-23.383; 45.147	-23.3871; 45.1425	-23.3871; 45.147	River Bank, Foothill, Farming Fields, and Potsherds
6	74	-23.383; 45.147	-23.383; 45.1515	-23.3871; 45.147	-23.3871; 45.1515	River Bank, Farming Fields, Hilltop, Foothill, Forest Patches
7	75	-23.383; 45.1515	-23.383; 45.156	-23.3871; 45.1515	-23.3871; 45.156	River Bank, Temporary Stream, Farming Fields, Forest Patches
8	76	-23.383; 45.156	-23.383; 45.1605	-23.3871; 45.156	-23.3871; 45.1605	River Bank, Temporary Stream, Farming Fields, and Forest Patches

9	80	-23.3789; 45.1245	-23.3789; 45.129	-23.383; 45.1245	-23.383; 45.129	Hilltop
10	81	-23.3789; 45.129	-23.3789; 45.1335	-23.383; 45.129	-23.383; 45.1335	Hilltop
11	82	-23.3789; 45.1335	-23.3789; 45.138	-23.383; 45.1335	-23.383; 45.138	Hilltop
12	83	-23.3789; 45.138	-23.3789; 45.1425	-23.383; 45.138	-23.383; 45.1425	River Bank, Foothill, Farming Fields
13	84	-23.3789; 45.1425	-23.3789; 45.147	-23.383; 45.1425	-23.383; 45.147	River Bank, Foothill, Farming Fields, and Forest Patches
14	85	-23.3789; 45.147	-23.3789; 45.1515	-23.383; 45.147	-23.383; 45.1515	River Bank, Temporary Stream, Farming Fields, and Tamarind Trees
15	86	-23.3789; 45.1515	-23.3789; 45.156	-23.383; 45.1515	-23.383; 45.156	Foothill, Farming Fields, and Forest Patches
16	87	-23.3789; 45.156	-23.3789; 45.1605	-23.383; 45.156	-23.383; 45.1605	River Bank, Farming Fields, and Forest Patches
17	92	-23.3748; 45.1245	-23.3748; 45.129	-23.3789; 45.1245	-23.3789; 45.129	Hilltop
18	93	-23.3748; 45.129	-23.3748; 45.1335	-23.3789; 45.129	-23.3789; 45.1335	Hilltop
19	94	-23.3748; 45.1335	-23.3748; 45.138	-23.3789; 45.1335	-23.3789; 45.138	Hilltop
20	95	-23.3748; 45.138	-23.3748; 45.1425	-23.3789; 45.138	-23.3789; 45.1425	Temporary Stream, Foothill, Forest Patches
21	96	-23.3748; 45.1425	-23.3748; 45.147	-23.3789; 45.1425	-23.3789; 45.147	Hilltop, Foothill, and Forest Patches
22	97	-23.3748; 45.147	-23.3748; 45.1515	-23.3789; 45.147	-23.3789; 45.1515	Temporary Stream, Foothill, and Forest Patches
23	98	-23.3748; 45.1515	-23.3748; 45.156	-23.3789; 45.1515	-23.3789; 45.156	Foothill, Farming Fields, and Forest Patches
24	99	-23.3748; 45.156	-23.3748; 45.1605	-23.3789; 45.156	-23.3789; 45.1605	River Bank, and Farming Fields
25	105	-23.37065; 45.1245	-23.37065; 45.129	-23.3748; 45.1245	-23.3748; 45.129	Hilltop
26	106	-23.37065; 45.129	-23.37065; 45.1335	-23.3748; 45.129	-23.3748; 45.1335	Temporary Stream, and Foothill
27	107	-23.37065; 45.1335	-23.37065; 45.138	-23.3748; 45.1335	-23.3748; 45.138	Temporary Stream, and Foothill
28	108	-23.37065; 45.138	-23.37065; 45.1425	-23.3748; 45.138	-23.3748; 45.1425	Temporary Stream, Foothill, Forest Patches
29	109	-23.37065; 45.1425	-23.37065; 45.147	-23.3748; 45.1425	-23.3748; 45.147	Hilltop
30	110	-23.37065; 45.147	-23.37065; 45.1515	-23.3748; 45.147	-23.3748; 45.1515	Temporary Stream, Hilltop, Foothill, Forest Patches
31	111	-23.37065; 45.1515	-23.37065; 45.156	-23.3748; 45.1515	-23.3748; 45.156	River Bank, Hilltop, Foothill, Farming Fields, and Forest Patches
32	118	-23.3665; 45.1245	-23.3665; 45.129	-23.37065; 45.1245	-23.37065; 45.129	Hilltop
33	119	-23.3665; 45.129	-23.3665; 45.1335	-23.37065; 45.129	-23.37065; 45.1335	Temporary Stream, and Foothill
34	120	-23.3665; 45.1335	-23.3665; 45.138	-23.37065; 45.1335	-23.37065; 45.138	Hilltop

35	121	-23.3665; 45.138	-23.3665; 45.1425	-23.37065; 45.138	-23.37065; 45.1425	Hilltop
36	122	-23.3665; 45.1425	-23.3665; 45.147	-23.37065; 45.1425	-23.37065; 45.147	Temporary Stream, and Foothill
37	123	-23.3665; 45.147	-23.3665; 45.1515	-23.37065; 45.147	-23.37065; 45.1515	Hilltop, and Foothill
38	124	-23.3665; 45.1515	-23.3665; 45.156	-23.37065; 45.1515	-23.37065; 45.156	Foothill, and Forest Patches
39	125	-23.3665; 45.156	-23.3665; 45.1605	-23.37065; 45.156	-23.37065; 45.1605	River Bank, and Farming Fields
40	131	-23.3625; 45.1335	-23.3625; 45.138	-23.3665; 45.1335	-23.3665; 45.138	Temporary Stream, Foothill, and Forest Patches
41	132	-23.3625; 45.138	-23.3625; 45.1425	-23.3665; 45.138	-23.3665; 45.1425	Temporary Stream, Foothill, and Forest Patches
42	133	-23.3625; 45.1425	-23.3625; 45.147	-23.3665; 45.1425	-23.3665; 45.147	Foothill, and Forest Patches
43	134	-23.3625; 45.147	-23.3625; 45.1515	-23.3665; 45.147	-23.3665; 45.1515	Hilltop, and Foothill
44	135	-23.3625; 45.1515	-23.3625; 45.156	-23.3665; 45.1515	-23.3665; 45.156	Hilltop, Foothill, and Forest Patches
45	136	-23.3625; 45.156	-23.3625; 45.1605	-23.3665; 45.156	-23.3665; 45.1605	River Bank, Farming Fields, and Forest Patches
46	142	-23.35825; 45.138	-23.35825; 45.1425	-23.3625; 45.138	-23.3625; 45.1425	Foothill, Forest Patches
47	143	-23.35825; 45.1425	-23.35825; 45.147	-23.3625; 45.1425	-23.3625; 45.147	Foothill, Forest Patches
48	144	-23.35825; 45.147	-23.35825; 45.1515	-23.3625; 45.147	-23.3625; 45.1515	Foothill, Forest Patches
49	145	-23.35825; 45.1515	-23.35825; 45.156	-23.3625; 45.1515	-23.3625; 45.156	Temporary Stream, Farming Fields, Foothill, and Forest Patches
50	146	-23.35825; 45.156	-23.35825; 45.1605	-23.3625; 45.156	-23.3625; 45.1605	Temporary Stream, Farming Fields, and Forest Patches
51	152	-23.3542; 45.138	-23.3542; 45.1425	-23.35825; 45.138	-23.35825; 45.1425	Hilltop, Foothill, and Forest Patches
52	153	-23.3542; 45.1425	-23.3542; 45.147	-23.35825; 45.1425	-23.35825; 45.147	Foothill, and Forest Patches
53	154	-23.3542; 45.147	-23.3542; 45.1515	-23.35825; 45.147	-23.35825; 45.1515	Foothill, and Forest Patches
54	155	-23.3542; 45.1515	-23.3542; 45.156	-23.35825; 45.1515	-23.35825; 45.156	Temporary Stream, Farming Fields, Foothill, and Forest Patches
55	162	-23.35; 45.147	-23.35; 45.1515	-23.3542; 45.147	-23.3542; 45.1515	River Bank, Hilltop, Foothill, and Forest Patches
56	163	-23.35; 45.1515	-23.35; 45.156	-23.3542; 45.1515	-23.3542; 45.156	River Bank, Foothill, and Forest Patches
57	164	-23.35; 45.156	-23.35; 45.1605	-23.3542; 45.156	-23.3542; 45.1605	Hilltop, Foothill, and Forest Patches
58	165	-23.35; 45.1605	-23.35; 45.16495	-23.3542; 45.1605	-23.3542; 45.16495	Foothill, and Forest Patches
59	166	-23.3459; 45.147	-23.3459; 45.1515	-23.35; 45.147	-23.35; 45.1515	River Bank, Foothill, and Forest Patches
60	167	-23.3459; 45.1515	-23.3459; 45.156	-23.35; 45.1515	-23.35; 45.156	Hilltop, Foothill, and Forest Patches

61	168	-23.3459; 45.156	-23.3459; 45.1605	-23.35; 45.156	-23.35; 45.1605	Foothill, and Forest Patches
62	169	-23.34175; 45.147	-23.34175; 45.1515	-23.3459; 45.147	-23.3459; 45.1515	Hilltop, Foothill, and Forest Patches
63	170	-23.34175; 45.1515	-23.34175; 45.156	-23.3459; 45.1515	-23.3459; 45.156	Hilltop, Foothill, and Forest Patches
64	171	-23.34175; 45.156	-23.34175; 45.1605	-23.3459; 45.156	-23.3459; 45.1605	Foothill, and Forest Patches
65	172	-23.33765; 45.1425	-23.33765; 45.147	-23.34175; 45.1425	-23.34175; 45.147	Hilltop, Foothill, and Forest Patches
66	173	-23.33765; 45.147	-23.33765; 45.1515	-23.34175; 45.147	-23.34175; 45.1515	Hilltop, Foothill, and Forest Patches
67	174	-23.33765; 45.1515	-23.33765; 45.156	-23.34175; 45.1515	-23.34175; 45.156	Foothill, and Forest Patches

5.2.1.2. Field Season 2015

The 2015 field season extended the systematic survey along the MSV, adding a further 107 grids during 90 days (Figure 5.3; Table 5.2).

Table 5.2: Grids Surveyed during the 2015 Field Season

#	Grid #	NW Corner	NE Corner	SE Corner	SW Corner	Features for Selection of the Grid
1	1	-23.4119; 45.1066	-23.4119; 45.111	-23.416; 45.1066	-23.416; 45.111	Temporary Stream, Farming Fields, and Tamarind Trees
2	2	-23.4119; 45.111	-23.4119; 45.1155	-23.416; 45.111	-23.416; 45.1155	Farming Fields, and Tamarind Trees
3	3	-23.4119; 45.1155	-23.4119; 45.12	-23.416; 45.1155	-23.416; 45.12	Farming Fields
4	4	-23.4119; 45.12	-23.4119; 45.1245	-23.416; 45.12	-23.416; 45.1245	Tamarind Trees
5	5	-23.4119; 45.1245	-23.4119; 45.129	-23.416; 45.1245	-23.416; 45.129	Forest Patches, and Buffer
6	6	-23.4078; 45.1066	-23.4078; 45.111	-23.4119; 45.1066	-23.4119; 45.111	Stream, Foothill, and Forest Patches
7	7	-23.4078; 45.111	-23.4078; 45.1155	-23.4119; 45.111	-23.4119; 45.1155	River, Streams, Farming Fields, and Tamarind Trees
8	8	-23.4078; 45.1155	-23.4078; 45.12	-23.4119; 45.1155	-23.4119; 45.12	Tamarind Trees
9	9	-23.4078; 45.12	-23.4078; 45.1245	-23.4119; 45.12	-23.4119; 45.1245	Tamarind Trees
10	10	-23.4078; 45.1245	-23.4078; 45.129	-23.4119; 45.1245	-23.4119; 45.129	Farming Fields, and Forest Patches
11	11	-23.4078; 45.129	-23.4078; 45.1335	-23.4119; 45.129	-23.4119; 45.1335	Forest Patches, and Buffer
12	12	-23.4036; 45.111	-23.4036; 45.1155	-23.4078; 45.111	-23.4078; 45.1155	River, Farming Fields, Forest Patches, and Foothill

13	13	-23.4036; 45.1155	-23.4036; 45.12	-23.4078; 45.1155	-23.4078; 45.12	River bank, Farming Fields, and Forest Patches
14	14	-23.4036; 45.12	-23.4036; 45.1245	-23.4078; 45.12	-23.4078; 45.1245	River Bank, Farming Fields, and Tamarind Trees
15	15	-23.4036; 45.1245	-23.4036; 45.129	-23.4078; 45.1245	-23.4078; 45.129	Temporary Stream, Farming Fields, Tamarind Trees
16	16	-23.4036; 45.129	-23.4036; 45.1335	-23.4078; 45.129	-23.4078; 45.1335	Temporary Stream, and Few Farming Fields
17	17	-23.4036; 45.1335	-23.4036; 45.138	-23.4078; 45.1335	-23.4078; 45.138	Forest Patches
18	18	-23.4036; 45.138	-23.4036; 45.1425	-23.4078; 45.138	-23.4078; 45.1425	Forest Patches, and Buffer
19	19	-23.39945; 45.111	-23.39945; 45.1155	-23.4036; 45.111	-23.4036; 45.1155	Hilltop
20	20	-23.39945; 45.1155	-23.39945; 45.12	-23.4036; 45.1155	-23.4036; 45.12	Foothill, Temporary Stream, Farming Fields, Tamarind Trees
21	21	-23.39945; 45.12	-23.39945; 45.1245	-23.4036; 45.12	-23.4036; 45.1245	River, Farming Fields, and Tamarind Trees
22	22	-23.39945; 45.1245	-23.39945; 45.129	-23.4036; 45.1245	-23.4036; 45.129	Farming Fields, and Tamarind Trees
23	23	-23.39945; 45.129	-23.39945; 45.1335	-23.4036; 45.129	-23.4036; 45.1335	Temporary Stream, and Forest Patches
24	24	-23.39945; 45.1335	-23.39945; 45.138	-23.4036; 45.1335	-23.4036; 45.138	Temporary Stream, Farming Fields, and Forest Patches
25	25	-23.39945; 45.138	-23.39945; 45.1425	-23.4036; 45.138	-23.4036; 45.1425	Temporary Stream, and Forest Patches
26	26	-23.39945; 45.1425	-23.39945; 45.147	-23.4036; 45.1425	-23.4036; 45.147	Forest Patches
27	27	-23.39945; 45.147	-23.39945; 45.1515	-23.4036; 45.147	-23.4036; 45.1515	Forest Patches
28	28	-23.39945; 45.1515	-23.39945; 45.156	-23.4036; 45.1515	-23.4036; 45.156	Forest Patches and Buffer
29	29	-23.39535; 45.111	-23.39535; 45.1155	-23.39945; 45.111	-23.39945; 45.1155	Hilltop, Foothill, and Forest Patches
30	30	-23.39535; 45.1155	-23.39535; 45.12	-23.39945; 45.1155	-23.39945; 45.12	Temporary Stream, Farming Fields, and Forest Patches
31	31	-23.39535; 45.12	-23.39535; 45.1245	-23.39945; 45.12	-23.39945; 45.1245	River Bank, Farming Fields, Tamarind Trees, and Forest Patches
32	32	-23.39535; 45.1245	-23.39535; 45.129	-23.39945; 45.1245	-23.39945; 45.129	River Bank, Farming Fields, and Tamarind Trees
33	33	-23.39535; 45.129	-23.39535; 45.1335	-23.39945; 45.129	-23.39945; 45.1335	Temporary Stream, and Forest Patches
34	34	-23.39535; 45.1335	-23.39535; 45.138	-23.39945; 45.1335	-23.39945; 45.138	Hilltop, and Foothill
35	35	-23.39535; 45.138	-23.39535; 45.1425	-23.39945; 45.138	-23.39945; 45.1425	Hilltop and Foothill
36	36	-23.39535; 45.1425	-23.39535; 45.147	-23.39945; 45.1425	-23.39945; 45.147	Foothill, and Forest Patches
37	37	-23.39535; 45.147	-23.39535; 45.1515	-23.39945; 45.147	-23.39945; 45.1515	Forest Patches
38	38	-23.39535; 45.1515	-23.39535; 45.156	-23.39945; 45.1515	-23.39945; 45.156	Forest Patches

39	39	-23.39535; 45.156	-23.39535; 45.1605	-23.39945; 45.156	-23.39945; 45.1605	Foot Hill, and Forest Patches
40	40	-23.39535; 45.1605	-23.39535; 45.16495	-23.39945; 45.1605	-23.39945; 45.16495	Hilltop
41	41	-23.39535; 45.16495	-23.39535; 45.1695	-23.39945; 45.16495	-23.39945; 45.1695	Foothill, and Forest Patches
42	42	-23.39535; 45.1695	-23.39535; 45.174	-23.39945; 45.1695	-23.39945; 45.174	Hilltop, and Buffer
43	43	-23.39125; 45.1155	-23.39125; 45.12	-23.39535; 45.1155	-23.39535; 45.12	Temporary Stream, Foothill, and Forest Patches
44	44	-23.39125; 45.12	-23.39125; 45.1245	-23.39535; 45.12	-23.39535; 45.1245	Foothill, and Forest Patches
45	45	-23.39125; 45.1245	-23.39125; 45.129	-23.39535; 45.1245	-23.39535; 45.129	River Bank, Foothill, Farming Fields, and Forest Patches
46	46	-23.39125; 45.129	-23.39125; 45.1335	-23.39535; 45.129	-23.39535; 45.1335	River Bank, Farming Fields, and Forest Patches
47	47	-23.39125; 45.1335	-23.39125; 45.138	-23.39535; 45.1335	-23.39535; 45.138	River Bank, Farming Fields, and Forest Patches
48	48	-23.39125; 45.138	-23.39125; 45.1425	-23.39535; 45.138	-23.39535; 45.1425	Temporary Stream, Foothill, and Forest Patches
49	49	-23.39125; 45.1425	-23.39125; 45.147	-23.39535; 45.1425	-23.39535; 45.147	Temporary Stream, Foothill, and Forest Patches
50	50	-23.39125; 45.147	-23.39125; 45.1515	-23.39535; 45.147	-23.39535; 45.1515	Foothill, and Forest Patches
51	51	-23.39125; 45.1515	-23.39125; 45.156	-23.39535; 45.1515	-23.39535; 45.156	Forest Patches
52	52	-23.39125; 45.156	-23.39125; 45.1605	-23.39535; 45.156	-23.39535; 45.1605	Foothill, and Forest Patches
53	53	-23.39125; 45.1605	-23.39125; 45.16495	-23.39535; 45.1605	-23.39535; 45.16495	Hilltop, Foothill, and Forest Patches
54	54	-23.39125; 45.16495	-23.39125; 45.1695	-23.39535; 45.16495	-23.39535; 45.1695	Temporary Stream, Foothill, and Forest Patches
55	55	-23.39125; 45.1695	-23.39125; 45.174	-23.39535; 45.1695	-23.39535; 45.174	Foothill, Forest Patches, and Buffer
56	56	-23.3871; 45.1155	-23.3871; 45.12	-23.39125; 45.1155	-23.39125; 45.12	Temporary Stream, Foothill, and Forest Patches
57	57	-23.3871; 45.12	-23.3871; 45.1245	-23.39125; 45.12	-23.39125; 45.1245	Hilltop
58	58	-23.3871; 45.1245	-23.3871; 45.129	-23.39125; 45.1245	-23.39125; 45.129	Hilltop, Foothill, and Forest Patches
59	59	-23.3871; 45.129	-23.3871; 45.1335	-23.39125; 45.129	-23.39125; 45.1335	Foothill, River Bank, Farming Fields, and Forest Patches
60	60	-23.3871; 45.1335	-23.3871; 45.138	-23.39125; 45.1335	-23.39125; 45.138	River Bank, Temporary Stream, Farming Fields, Forest Patches
61	61	-23.3871; 45.138	-23.3871; 45.1425	-23.39125; 45.138	-23.39125; 45.1425	Foothill, and Forest Patches
62	62	-23.3871; 45.1425	-23.3871; 45.147	-23.39125; 45.1425	-23.39125; 45.147	Hilltop, and Foothill
63	63	-23.3871; 45.147	-23.3871; 45.1515	-23.39125; 45.147	-23.39125; 45.1515	Foothill, and Forest Patches
64	64	-23.3871; 45.1515	-23.3871; 45.156	-23.39125; 45.1515	-23.39125; 45.156	Temporary Stream, and Forest Patches

65	65	-23.3871; 45.156	-23.3871; 45.1605	-23.39125; 45.156	-23.39125; 45.1605	Forest Patches
66	66	-23.3871; 45.1605	-23.3871; 45.16495	-23.39125; 45.1605	-23.39125; 45.16495	Foothill, and Forest Patches
67	67	-23.3871; 45.16495	-23.3871; 45.1695	-23.39125; 45.16495	-23.39125; 45.1695	Temporary Stream, and Forest Patches
68	68	-23.3871; 45.1695	-23.3871; 45.174	-23.39125; 45.1695	-23.39125; 45.174	Foothill, Forest Patches, and Buffer
69	77	-23.383; 45.1605	-23.383; 45.16495	-23.3871; 45.1605	-23.3871; 45.16495	Temporary Stream, and Forest Patches
70	78	-23.383; 45.16495	-23.383; 45.1695	-23.3871; 45.16495	-23.3871; 45.1695	Foothill, and Forest Patches
71	79	-23.383; 45.1695	-23.383; 45.174	-23.3871; 45.1695	-23.3871; 45.174	Foothill, and Forest Patches
72	88	-23.3789; 45.1605	-23.3789; 45.16495	-23.383; 45.1605	-23.383; 45.16495	Forest Patches
73	89	-23.3789; 45.16495	-23.3789; 45.1695	-23.383; 45.16495	-23.383; 45.1695	Forest Patches
74	90	-23.3789; 45.1695	-23.3789; 45.174	-23.383; 45.1695	-23.383; 45.174	Forest Patches
75	91	-23.3789; 45.174	-23.3789; 45.1785	-23.383; 45.174	-23.383; 45.1785	Temporary Stream, Forest Patches, and Buffer
76	100	-23.3748; 45.1605	-23.3748; 45.16495	-23.3789; 45.1605	-23.3789; 45.16495	Farming Fields
77	101	-23.3748; 45.16495	-23.3748; 45.1695	-23.3789; 45.16495	-23.3789; 45.1695	Forest Patches
78	102	-23.3748; 45.1695	-23.3748; 45.174	-23.3789; 45.1695	-23.3789; 45.174	Forest Patches
79	103	-23.3748; 45.174	-23.3748; 45.1785	-23.3789; 45.174	-23.3789; 45.1785	Foothill, and Forest Patches
80	104	-23.3748; 45.1785	-23.3748; 45.183	-23.3789; 45.1785	-23.3789; 45.183	Hilltop, and Forest Patches
81	112	-23.37065; 45.156	-23.37065; 45.1605	-23.3748; 45.156	-23.3748; 45.1605	River Bank, Farming Fields, and Tamarind Trees
82	113	-23.37065; 45.1605	-23.37065; 45.16495	-23.3748; 45.1605	-23.3748; 45.16495	Farming Fields, and Forest Patches
83	114	-23.37065; 45.16495	-23.37065; 45.1695	-23.3748; 45.16495	-23.3748; 45.1695	Forest Patches
84	115	-23.37065; 45.1695	-23.37065; 45.174	-23.3748; 45.1695	-23.3748; 45.174	Forest Patches
85	116	-23.37065; 45.174	-23.37065; 45.1785	-23.3748; 45.174	-23.3748; 45.1785	Foothill, and Forest Patches
86	117	-23.37065; 45.1785	-23.37065; 45.183	-23.3748; 45.1785	-23.3748; 45.183	Hilltop, and Buffer
87	126	-23.3665; 45.1605	-23.3665; 45.16495	-23.37065; 45.1605	-23.37065; 45.16495	River Bank, and Farming Fields
88	127	-23.3665; 45.16495	-23.3665; 45.1695	-23.37065; 45.16495	-23.37065; 45.1695	River Bank, Forest Patches
89	128	-23.3665; 45.1695	-23.3665; 45.174	-23.37065; 45.1695	-23.37065; 45.174	Forest Patches
90	129	-23.3665; 45.174	-23.3665; 45.1785	-23.37065; 45.174	-23.37065; 45.1785	Forest Patches
91	130	-23.3665; 45.1785	-23.3665; 45.183	-23.37065; 45.1785	-23.37065; 45.183	Foothill

92	137	-23.3625; 45.1605	-23.3625; 45.16495	-23.3665; 45.1605	-23.3665; 45.16495	Farming Fields, and Forest Patches
93	138	-23.3625; 45.16495	-23.3625; 45.1695	-23.3665; 45.16495	-23.3665; 45.1695	Temporary Stream, and Forest Patches
94	139	-23.3625; 45.1695	-23.3625; 45.1745	-23.3665; 45.1695	-23.3665; 45.1745	Temporary Stream, Farming Fields, and Forest Patches
95	140	-23.3625; 45.1745	-23.3625; 45.178	-23.3665; 45.1745	-23.3665; 45.178	Farming Fields, and Forest Patches
96	141	-23.3625; 45.178	-23.3625; 45.183	-23.3665; 45.178	-23.3665; 45.183	Foothill, Forest Patches, and Buffer
97	147	-23.35825; 45.1605	-23.35825; 45.16495	-23.3625; 45.1605	-23.3625; 45.16495	Arable Lands, and Forest Patches
98	148	-23.35825; 45.16495	-23.35825; 45.1695	-23.3625; 45.16495	-23.3625; 45.1695	Farming Fields, and Forest Patches
99	149	-23.35825; 45.1695	-23.35825; 45.174	-23.3625; 45.1695	-23.3625; 45.174	Temporary Stream, Farming Fields, and Forest Patches
100	150	-23.35825; 45.174	-23.35825; 45.178	-23.3625; 45.174	-23.3625; 45.178	Temporary Stream, and Forest Patches
101	151	-23.35825; 45.1785	-23.35825; 45.183	-23.3625; 45.178	-23.3625; 45.183	Temporary Stream, and Forest Patches
102	156	-23.3542; 45.156	-23.3542; 45.1605	-23.35825; 45.156	-23.35825; 45.1605	Temporary Stream, and Forest Patches
103	157	-23.3542; 45.1605	-23.3542; 45.16495	-23.35825; 45.1605	-23.35825; 45.16495	Forest Patches
104	158	-23.3542; 45.16495	-23.3542; 45.1695	-23.35825; 45.16495	-23.35825; 45.1695	Forest Patches
105	159	-23.3542; 45.1695	-23.3542; 45.174	-23.35825; 45.1695	-23.35825; 45.174	Temporary Stream, and Forest Patches
106	160	-23.3542; 45.174	-23.3542; 45.1785	-23.35825; 45.174	-23.35825; 45.1785	Forest Patches
107	161	-23.3542; 45.1785	-23.3542; 45.183	-23.35825; 45.1785	-23.35825; 45.183	Forest Patches

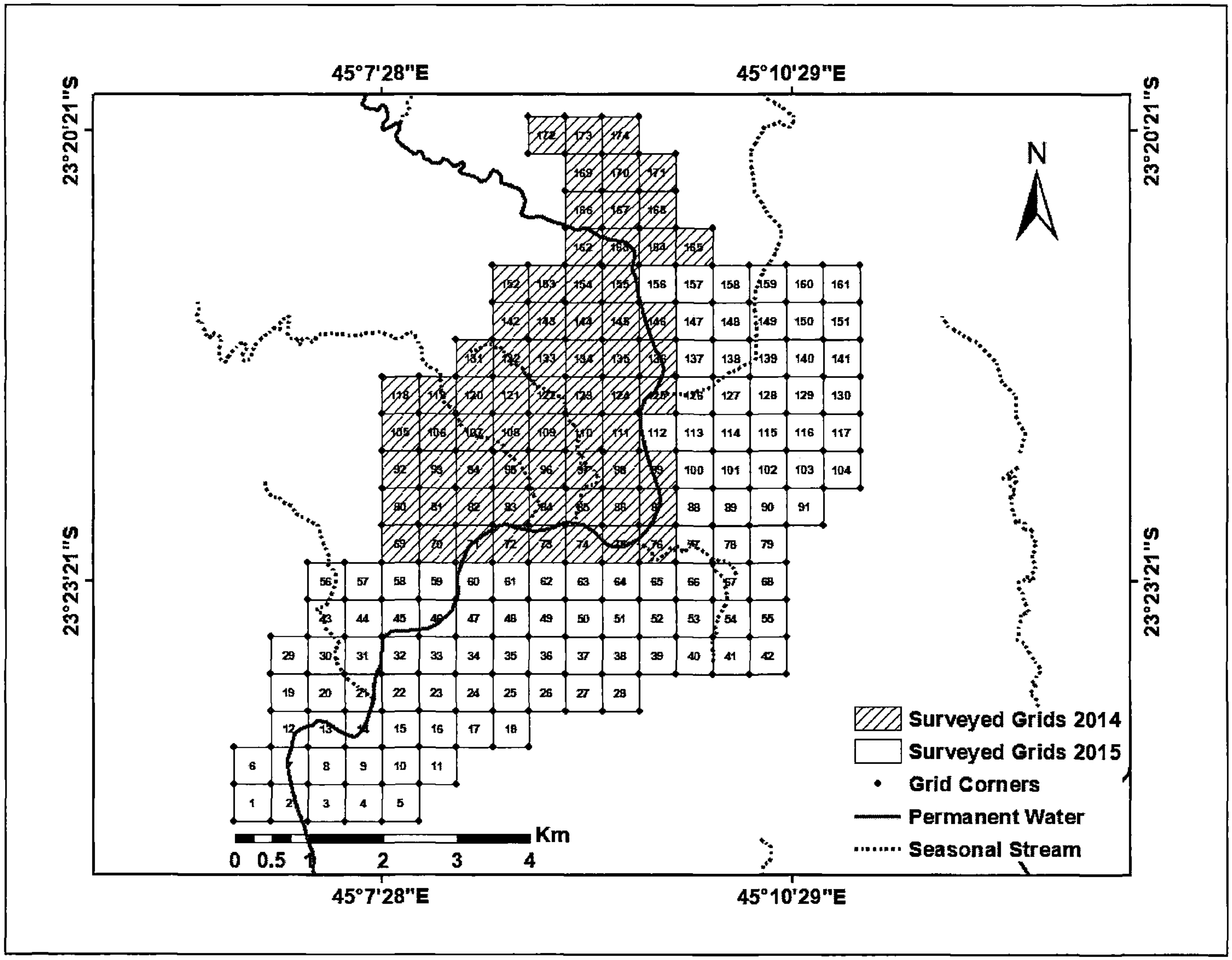

Figure 5.3: Grids Surveyed during the 2014 and 2015 Field Seasons

5.2.2. Intrasite Spatial Patterning

Before establishing an excavation unit, it is useful to understand the spatial patterning of aggregates within a site (Butzer 1982: 4). The purposes of this are to document and interpret the distribution of human activities within the site, estimate its size, identify potential areas to excavate, and collect surface materials (see Chami 1994: 21; Radimilahy 1998: 73). The first two objectives help understand the social structure and lifeways of the site's occupants, as well as to determine the site's function.

To document the spatial distribution of artifacts and other traces within AK and KG, I laid out 5mx5m grids (Figure 5.4 and Figure 5.5). I then mapped the site using a total station (Plate 5.2). Finally, I systematically collected all surface artifacts and ethnobiological traces.

Although the intrasite survey method was time consuming, it paid off. The method revealed the distribution of artifacts and ethnobiological traces within a site, therefore helped to locate different activities and estimate the size of the sites.

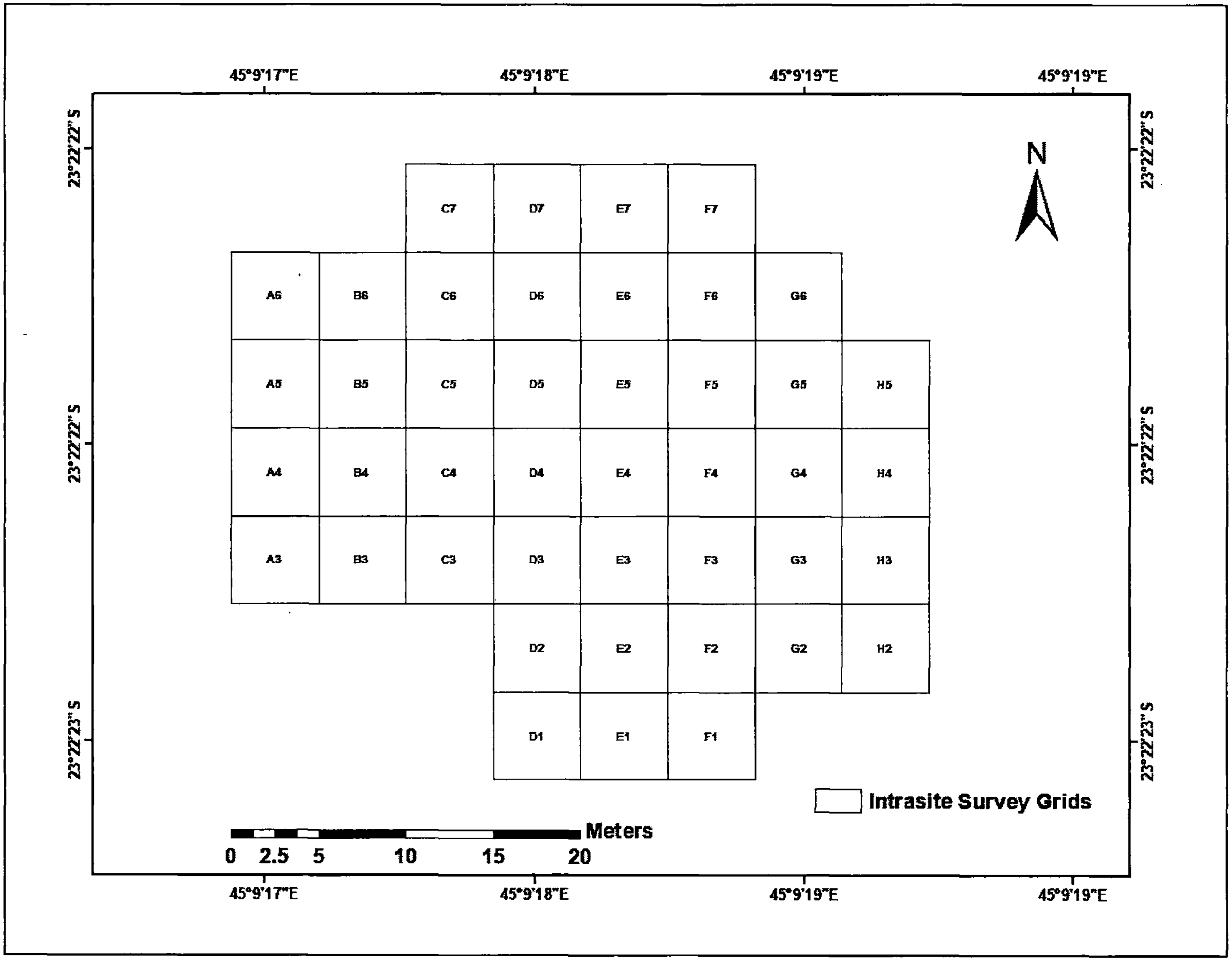

Figure 5.4: Intrasite Survey Grids at Ankilivalo (Field Season 2015)

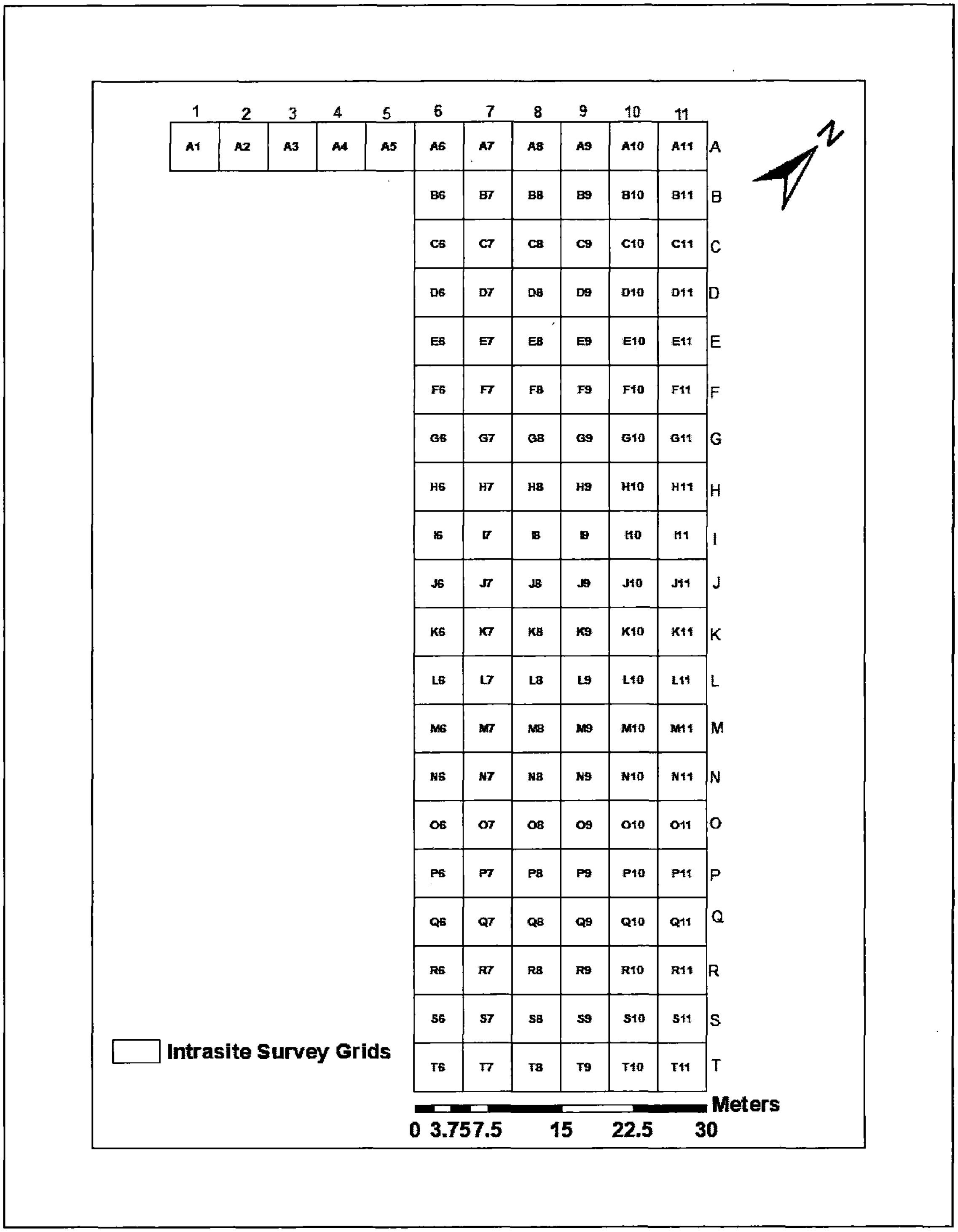

Figure 5.5: Intrasite Survey Grids at Keliangebo (Field Season 2016)

Plate 5.2: Total Station Mapping in Action at Ankilivalo (Field Season 2015)

5.2.3. Excavation

Initially, I aimed to excavate the two sites of Ankilivalo and Keliangebo. However, due to funding and time constraints, I had to choose only one site to excavate.

After the systematic surface collections, I could judge at face value that surface materials (especially ceramics) encountered at Keliangebo were more diagnostics and recognizable than those of Ankilivalo. I could recognize the graphite-coated pottery decorated with incised lines and triangular impressions from Keliangebo as a pottery tradition from 15th to early 18th centuries CE in different parts of Madagascar. For the plain ware tradition from Ankilivalo, on the other hand, I had to consult Dr Henry Wright and Dr Chantal Radimilahy, who later visited Ankilivalo in the summer of 2016 to help identify the pottery tradition and document the stratigraphic layers. Meanwhile, by the end of 2015 field season, I already chose Ankilivalo over Keliangebo for excavation, to understand more on the function of the site and its occupants' lifeways, as well as to collect dateable material from a secured context.

The distribution of cultural objects at Ankilivalo was uneven. They were more concentrated in the northwest and northeast sides of the site, and almost absent in the southern part (see Figure 6.2). My first impression was that because the terrain at Ankilivalo inclines from south to north (see Figure 6.3), materials might have been washed down by rainwater from the adjacent hill towards the lower part (north) of the site. However, Makboul Beny, my assistant from the Department of Earth Sciences at the University of Toliara, observed that the nature of the upper soil in the southern part of the site is different from those around the north. The former originated from the exfoliation of the adjacent sandstone hill. I thus suspected that this colluvial soil layer buried a cultural layer associated with the upper soil in the north. To find out, we tried to auger-test the subsurficial soil deposits, in order to have more insight of the stratification of layers at the site before excavation (Plate 5.3). However, due to the loose nature of soil deposits, the auger did not hold enough soil for analysis and I decided to shovel-test instead (Plate 5.4). We opened 4 test pits of 50cm x 100cm, running from South to North (Figure 5.6), and documented the stratification of the layer deposits.

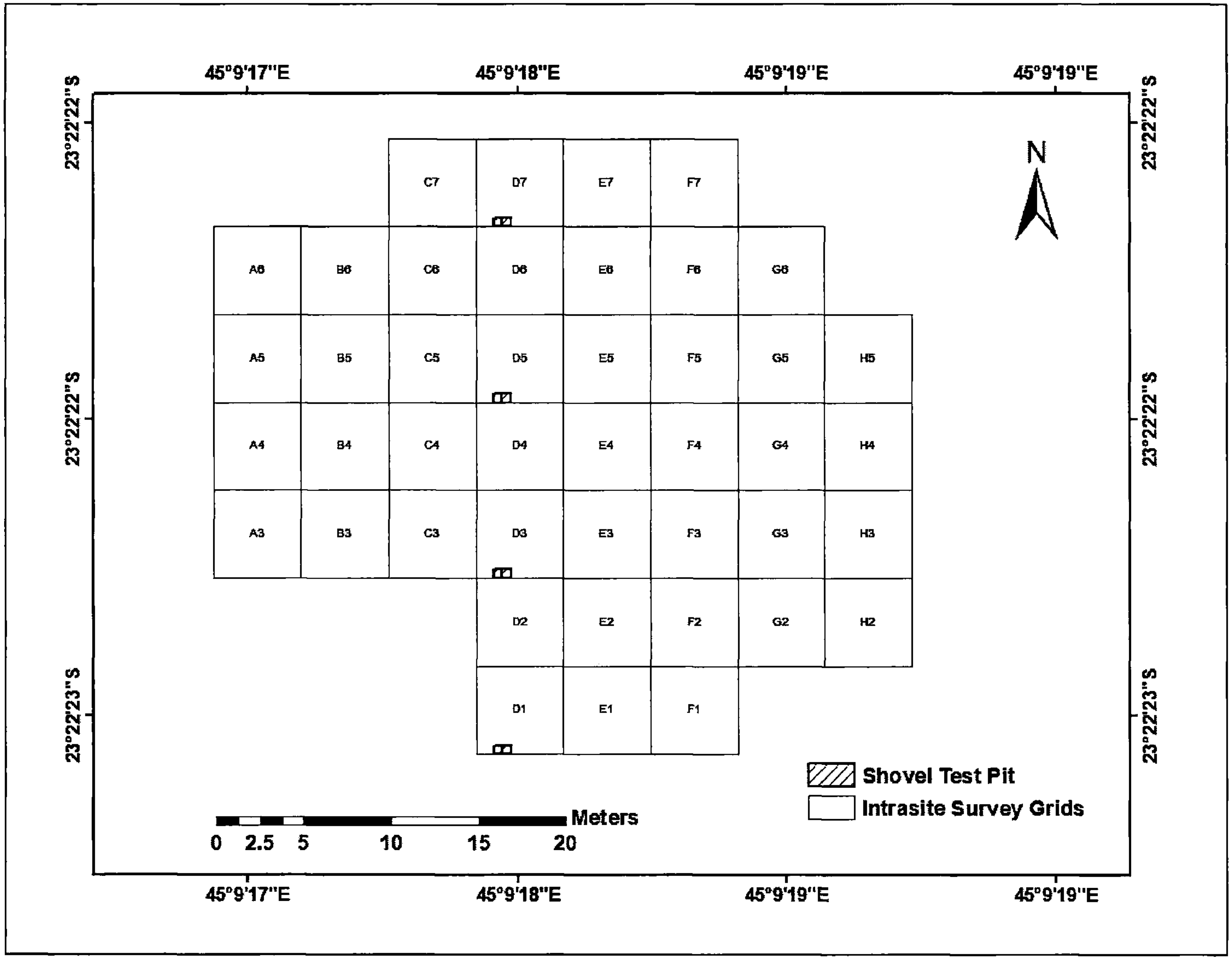

Figure 5.6: Location of Shovel Test Pits (STP) at Ankilivalo (Field Season 2015)

Plate 5.3: Auger Testing Underway at Ankilivalo (Field Season 2015)

Plate 5.4: Makboul Beny Documenting Soil Colors and Textures from STP (Field Season 2015)

After the shovel test-pitting, I started to open excavation units at the site of Ankilivalo late in the 2015 field season. The excavations aimed to document subsurficial artifacts and collect dateable materials. I continued to excavate this site during the 2016 field season. In total, I opened three excavation units at Ankilivalo (Figure 5.7): Unit 1 was within Grid E3, located at the center of the site (Figure 5.8). I opened this unit in 2015 to assess a feature that I suspected to be a house floor; Unit 2 was within Grids G6 and F6 in the northeast corner of the site (Figure 5.9). I opened this unit based on the assumption that the house of a *mpisoro* – the spiritual head of the group – should be located at the northeast of a village (Faublée 1954: 46-47; Kus 1990: 48; Razafimisa 1987: 50); Unit 3 was at the site's southwest corner (Figure 5.10). I opened this unit to extend a buried cultural layer I encountered during the shovel test-pitting (Figure 5.7).

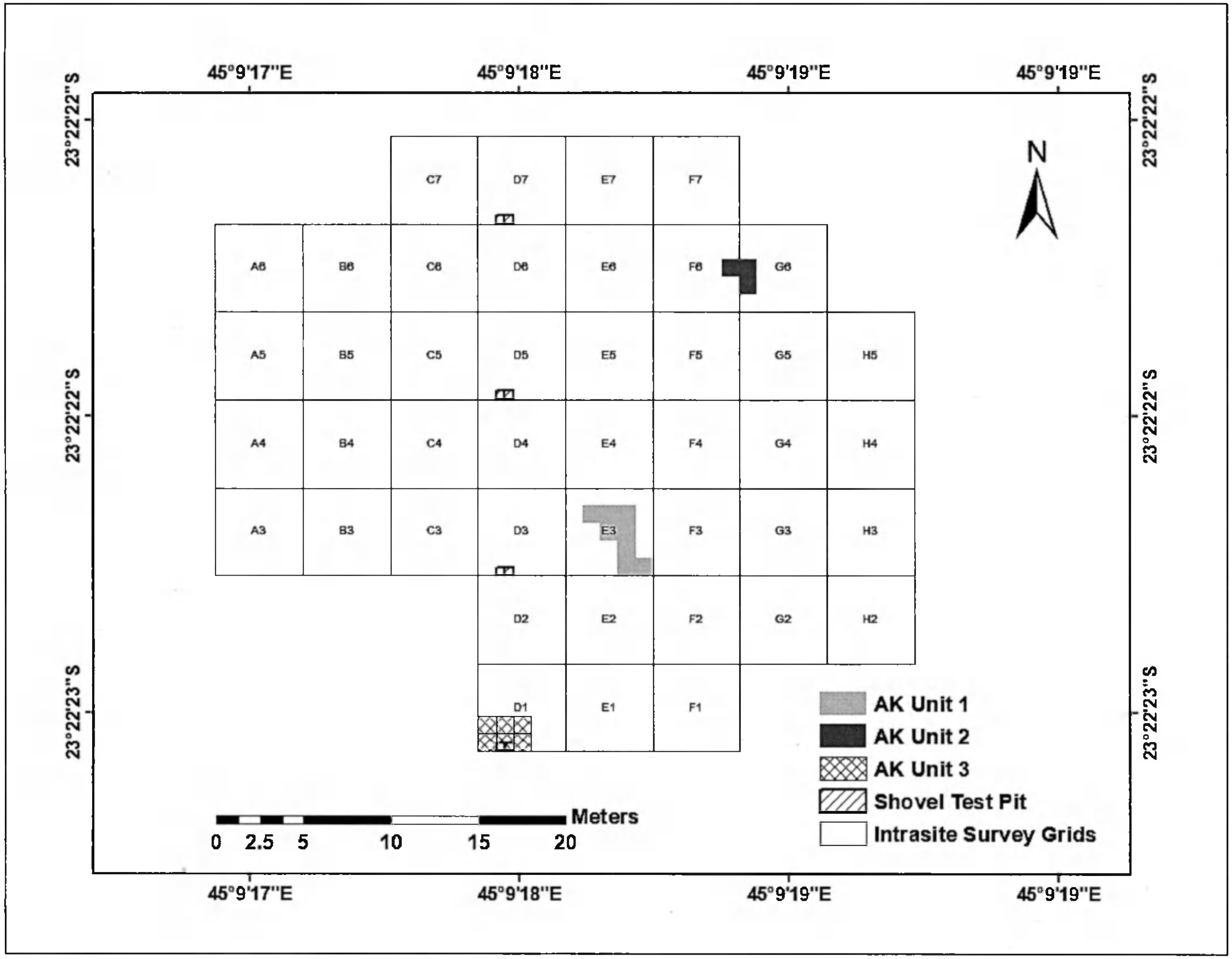

Figure 5.7: Excavation Units at Ankilivalo (Field Season 2015 and 2016)

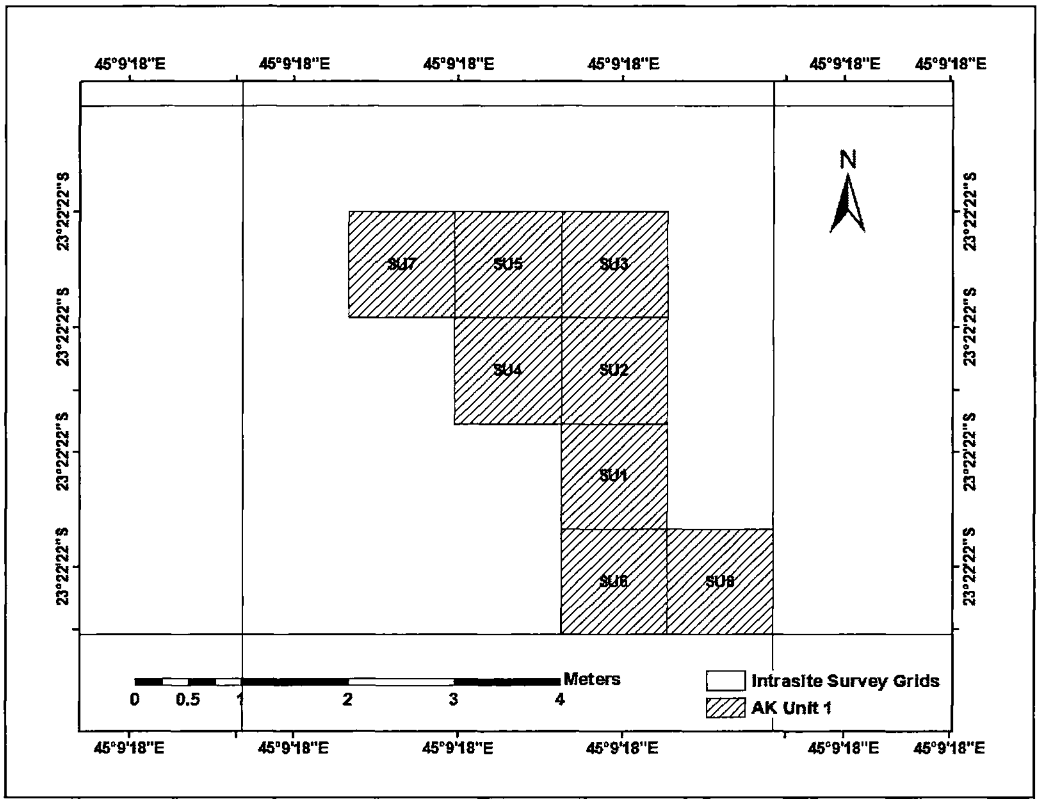

Figure 5.8: AK Unit 1 and Its Sub-Units

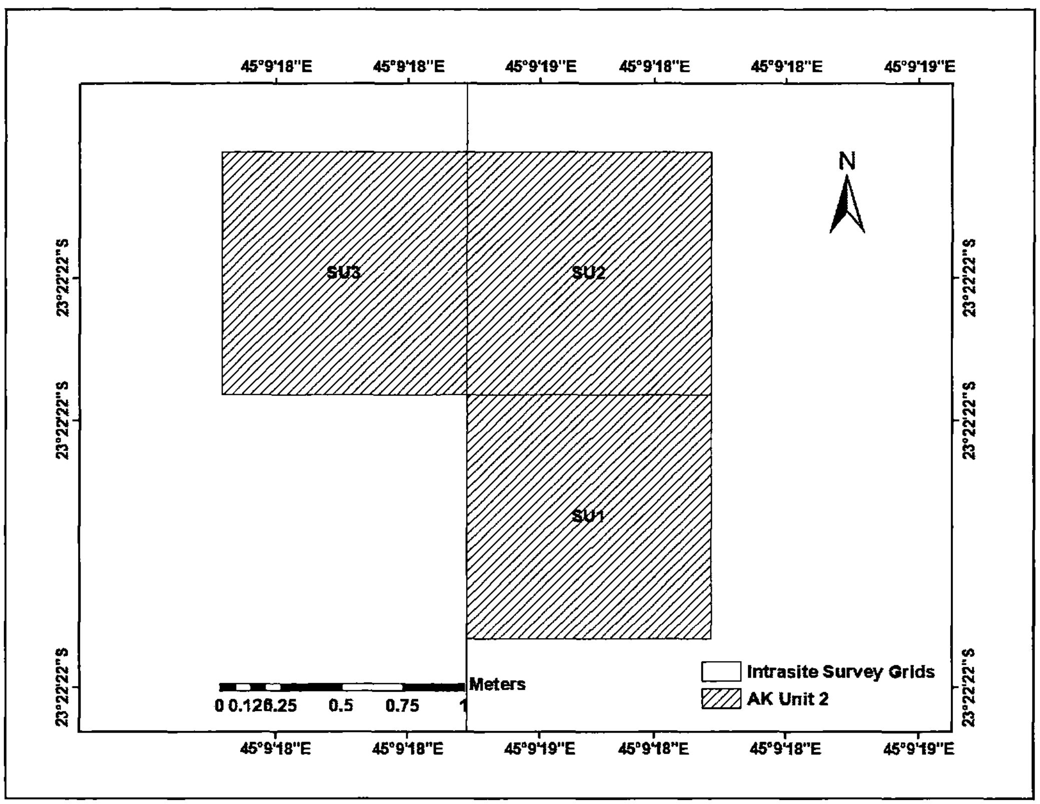

Figure 5.9: Unit 2 and Its 3 Sub-Units

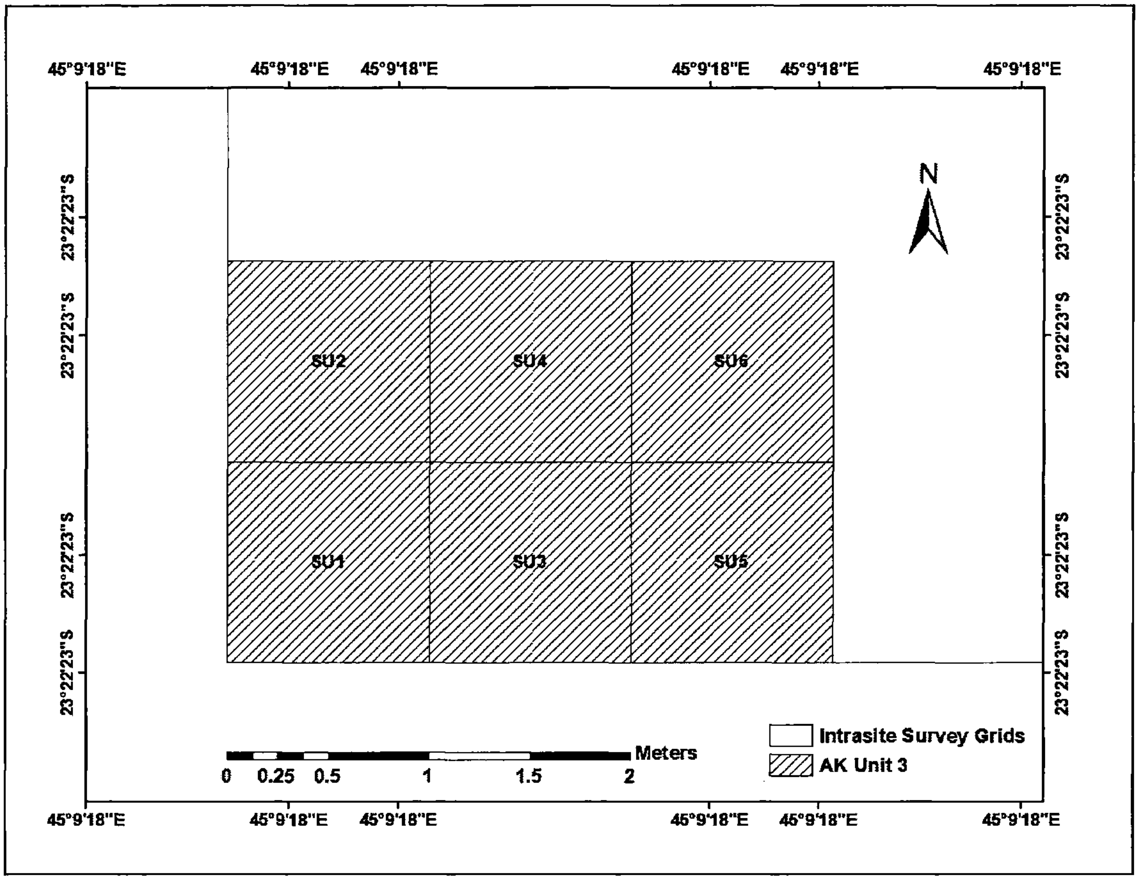

Figure 5.10: Unit 3 and Its Sub-Units

Vertical excavation techniques were used to uncover stratified archaeological deposits (Plate 5.5 and Plate 5.6). Excavation levels followed natural layers where possible. Where the natural layer was hard to detect, an arbitrary level of 10 cm was applied. The first level started from a certain depth referred to a 0 leveled line (sub-datum point) placed on a peg at one of the corners of the excavation unit. I documented the character of each level/layer on an excavation form. I classified soil colors according to the Munsell soil color chart, and soil texture following a geotechnical gauge chart.

I sampled 20 liters of soil from each cultural layer to extract archaeobotanical macro- and micro-remains through flotation techniques (Plate 5.7). Following Dolores Piperno (2006)'s procedure, the surface of the sediment was cleaned with a cleaned trowel before collecting samples with another cleaned stainless-steel trowel, and putting them in double bags labeled with a date, site name, unit number, level number, depth, sample number, and the initial of the sampler. I inserted a flyer with the same information between the two bags. Before sampling, the contents of each cultural layer were tested with a soil pH tester to assess whether samples were likely to be well preserved or not. Soil containing a level of alkalinity over nine might not preserve archaeobotanical remains, hence was not sampled. All archaeobotanical samples were stored at the CEDRATOM museum facilities in Toliara while awaiting analysis.

Sieves of 4 mm was used in general to sieve the dirt and retrieve materials (Plate 5.5). In case I encountered a feature suspected to contain small objects such as beads, I used a sieve of 2mm. Artifacts in a range of sizes from different cultural layers were documented to reconstruct ancient technology and understand past lifeways, natural resource exploitation, and other social dynamics (see Chapter 6). Samples for AMS dating were collected from secure contexts. At the end of the excavation of a unit, I recorded the profile of its wall stratigraphy (Plate 5.8).

Plate 5.5: Excavation of Unit 2 Underway (Field Season 2015)

Plate 5.6: Excavation of Unit 3 Underway (Field Season 2016)

Plate 5.7: Flotation Underway at the Sakamarekely River (Field Season 2016)

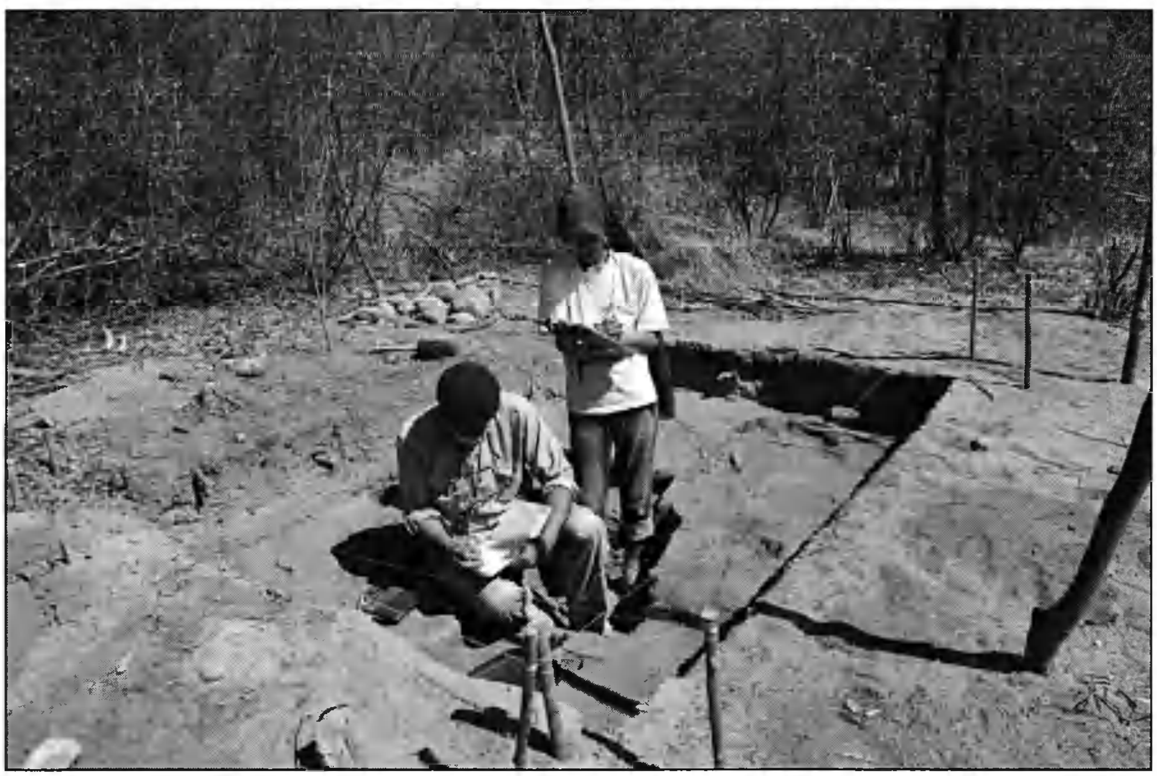

Plate 5.8: Dr. Henry T. Wright Recording Soil Stratigraphy at Unit 3 (Field Season 2016)

Due to time constraints for this dissertation, it was only possible to analyze faunal remains and potsherds from excavations and systematic surface collection. The faunal analysis was to investigate animal use, while the pottery analysis aimed to examine subsistence techno-cultural remains. Analysis of plant remains is forthcoming.

5.2.3.1. Faunal Analysis

My faunal analysis focused on specimens as food remains, exploring whether ethnobiological traces reflected land use and resource exploitation during the unpredictable climate of the 16^{th} -19^{th} centuries CE. I first assessed the context where each specimen was deposited: was it a kill site, residential refuse, or an intentional burial? (Reitz and Wing 2008: 120-121).

A *kill site* is a place where butchering took place. Remains at a kill site are the results of a single activity and mostly represented by a species (Reitz and Wing 2008: 120). Also, butchery tools might be encountered at the site.

Residential refuse is the garbage of a family or group of families occupying a habitation site (Reitz and Wing 2008: 120). The litter may reflect different subsistence activities of the site's occupants. Faunal remains discarded in residential refuse may exhibit chew-marks of scavengers.

Intentional burials are animals buried at a sacrificial, ritual or burial site. They are typified by skeletal completeness and are often untouched by scavengers (Reitz and Wing 2008: 121).

To begin with, I determined elements represented in the faunal assemblage from each unit, the taxonomic category to which they belonged, and number of species represented in the assemblage. To identify elements and taxonomic attributes, I sought help from Dr. Richard Redding to compare faunal remains from Ankilivalo with reference specimens at the Archaeozoological Laboratory in the Kelsey Museum of Archaeology at the University of Michigan. This lab has a full series of domestic animals likely to be present in southwestern Madagascar during the past.

Results of the faunal analysis are provided in *6.3.4.2*.

5.2.3.2. Pottery Analysis

I analyzed potsherds from systematic surface collections and excavations. Preliminary activities including gathering, cleaning, sorting and recording material were carried out during fieldwork. Due to time constraints, I conducted detailed analyses in the United States. Administrative rules, however, limited the number of materials I could carry out of Madagascar. Consequently, I had to sample materials I considered most diagnostic of assemblages at the two sites. I selected all cultural objects from the excavation of Unit 3 at Ankilivalo and sampled 138 potsherds from the surface at Keliangebo.

Pottery analysis in this study primarily investigated vessel functions linked with form and other attributes (Table 5.3), identifying correlates between subsistence practices and pottery attributes. My assumption is that subsistence practices go hand-in-hand with subsistence technology, and that changes in these practices might trigger the adoption of new techno-cultural materials (Teale 2013: 2; Wright 2005: 18). For instance, a cooking vessel suited for boiling suggests that the community boiled rice or other cereals and exploited arable lands in the surrounding area, depending on rains or irrigation technology. A storage jar suited for storing seeds might suggest that the community had concerns about resources scarcity. However, the proposed links are not deterministic (Rice 2015: 414), and people often use a pottery vessel for many different tasks (Rice 1987: 209, 224-225; 2015: 412; Skibo 2013: 4). Nevertheless, my pottery analysis considered the consistency of particular attributes as a result of deliberate manufacturing by the potters to meet consumers' needs/expectations (Wright 2005: 18). It should be noted that my pottery analysis focused only on the intended functions, not the actual ones, which are not known. Further residues analysis will determine traces left on the vessel's wall. Food remains are pertinent to what crops were adopted to cope with the unpredictability of the climate (Nathan 2017).

Table 5.3: Predicted Archaeological Correlates of Vessel Function (After Rice 1987: 238)

Functional Category	Shape	Material	Surface Treatment and Decoration	Depositional Context	Frequency	Clues
Storage vessel	- Restricted - Orifice with beak or lid; - Appendages for suspension or movement (tipping)	- Variable (possible concern for low porosity)	- Variable for display or messages - Slip or glaze to reduce permeability	- Dwellings (sometimes set into ground); - Trash middens	- Low (low replacement); - May be reuse of broken or old vessels	Residues of stored goods in pores
Cooking vessel	- Unrestricted - Rounded, conical, globular, - Lacking angles in general	- Coarse and porous, - Thin walls, - Thermal shock resistant	- Little to none; - Surface roughening for handling ease	- Dwellings, - Trash middens - Rarely in special deposits such as burials.	- High (frequent replacement)	- Patterns of exterior sooting or blackening - Burned contents
Food processing vessel	- Unrestricted - Simple shape	- Emphasis on mechanical strength - Relatively coarse and dense	- Variable - Generally low	- Dwellings - Trash middens	- Moderate	- Internal wear - Abrasion or pitting
Serving vessel	- Unrestricted for easy access - Often with handles - Flat bases or supports for stability	- Maybe fine	Generally high, for display or symbolic roles	- Dwellings, - Trash middens - Special deposits such as burials or caches	High (frequent use and replacement)	Sizes correspond to individual servings or group size
Vessel for transport	- Convenient for stacking - Handles - Lightweight - Restricted orifice	- Emphasis on mechanical strength - Dense - Hard	- Variable, - Generally low slip or glaze to reduce permeability	- Trash middens - Non-domestic areas such as transport	Variable	- Uniform size or multiple units of size - Residues of contents

Both Rice (1987: 224-226; 2015: 419) and Skibo (2013: 31) argued that assessing the capacity, stability, accessibility, transportability, and heating effectiveness of a vessel is key to understanding its intended functions.

Capacity refers to the volume of the vessel. This attribute hints at intended functions, as Rice (1987: 236; 2015: 413-414) puts it:

> "vessels used for long-term storage have greater volumes than those used for short-term storage; vessels used for transport over small distances have greater volumes than those carried over large distance; vessels used for cooking and heating have greater volumes than those used for eating."

With a whole vessel, one can measure capacity. With an incomplete vessel, capacity has to be estimated from the metric attributes of the sherds including the diameter of the rim (Smith 1988; Skibo 2013: 30). I used a vessel diameter chart to measure the rim diameter and the percentage of the total vessel orifice circumference. All measurements were recorded in MS Excel spreadsheets, converted to comma separated value (.csv) files and run in the R program to calculate their maximum, minimum, mean, and standard deviation.

Stability refers to the capability of a vessel to stand straight. The stability of a vessel, if complete, can be assessed by looking at its shape, that is, the distribution of its weight and its center of gravity. A vessel with its upper part disproportionally wider than its lower part, for instance, might struggle to stand alone. With potsherds, I assessed vessel stability through the form of its base. Curved and round bases struggle to stand stably, while a flat base stays put (Skibo 2013: 32). It is noteworthy, however, that legs, a tripod stove or hanger might have been used to help curved and round bases stay stable while resting.

Accessibility refers to how easy it is to reach the contents of the vessel. Rice (2015: 419) argued that a potter designs the upper part of a vessel to meet particular use(s) related to the need for easy access to its contents, and whether the vessel was intended for storing, cooking, processing or serving. Cooking and processing vessels tend to have larger orifices compared to liquids and solids storage vessels (Rice 1987: 236). It should be noted that there can be wide orifices for liquid storage if access is by scoop. For my accessibility analysis, I first examined the form of the vessel.

By and large, there are two types of vessel form, namely restricted and unrestricted/open vessels. A restricted vessel has a rim diameter smaller than its maximum diameter, while an unrestricted vessel has its maximum diameter at the orifice (Chami 1994: 75; Wright 2005: 20). The former is often conventionally called 'jar', while the latter is labeled as 'bowl' (Rice 1987: 211; 2015: 419; Wright 2005: 20). Restricted vessels might be associated with storing, transporting or serving liquids depending on the size of their orifices (Smith 1985: 305), while unrestricted/open vessels might have been designed for cooking and serving (Skibo 2013: 30-32). I used a vessel form model prepared by Felix Chami (1994: 78) for East African pottery as a reference. This distinguishes four types of vessel shape, namely independent restricted vessel, dependent restricted vessel, restricted bowl, and open or unrestricted bowl (Figure 5.11).

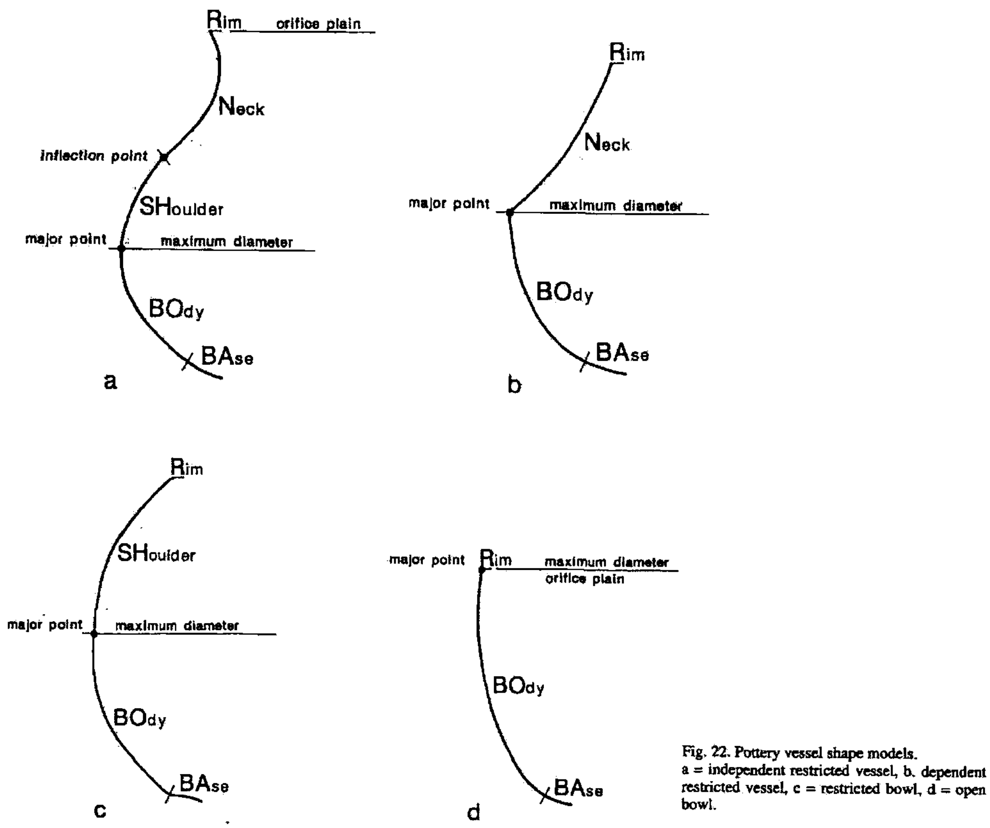

Figure 5.11: Pottery Vessel Shape Models (After Chami 1994: 78)

Since archaeologists rarely find complete vessels, one has to determine its shape from attributes displayed by potsherds. Following from Chami (1994), the following table summarizes the indications used to determine vessel shape types from East African potsherds (Table 5.4):

Table 5.4: Typology of Vessel Shapes and Their Indications from Potsherds

Vessel Shape Types	**Indications from Potsherds**
Unknown	Only rim (R), or Body (Bo), or Body-and-Base (Bo/Ba)
Restricted Jar (Independent or Dependent)	Only neck (N) or Rim-and-Neck (R/N)
Restricted Jar or Restricted Bowl	Shoulder (Sh) without seeing the neck (e.g., Sh, Sh/Bo, Sh/Bo/Ba)
Independent Restricted Vessel	Presence of Neck-and-Shoulder (e.g., R/N/Sh/Bo/Ba; R/N/Sh/Bo; R/N/Sh; N/Sh/Bo/Ba; N/Sh/Bo; N/Sh)
Dependent Restricted Vessel	Neck-and-Body without Shoulder (e.g., R/N/Bo/Ba; R/N/Bo; N/Bo/Ba; N/Bo)
Unrestricted Bowl	Rim-and-Body without Neck and Shoulder (e.g., R/Bo/Ba; R/Bo)

In addition to vessel form, I explored rim verticality by examining whether the rim stands straight, or everted, or inverted. I examined rim shapes to determine whether the rim wall is tapered, or parallel, or thickened. A thickened lip, for instance, eases lifting and pouring (Rice 2015: 420). Finally, I looked at the form of the lip to determine whether the form of the rim top is flattened, rounded, U-shaped, beveled, or angular.

Transportability refers to how easy it is to carry the vessel for short or long distances (Skibo 2013: 32). This characteristic hints at whether a community stored goods, and whether it was mobile or sedentary. Rice (1987: 236; 2015: 413-414) posited that massive vessels are transported over shorter distances than smaller and lighter ones. Also, Smith (1985: 305) argued that a restricted vessel with a narrow neck and/or small orifice limits spillage during transport (Skibo 2013: 30-31).

I assessed vessel transportability by looking at its size, spill-ability of its contents and graspability of its exterior surface.

To assess the vessel size, I measured the diameter of the orifice to assess its volume and the restrictedness of the orifice itself. I then looked at the presence/absence of a neck to assess the spill-ability of its contents. Lastly, I looked at surface treatment and patterning, and placement of decoration to evaluate the 'graspability' of a vessel (Rice 2015: 419). Surface treatment involves whether the surface was smoothed, burnished or patterned. A patterned surface is more graspable than a smoothed or burnished one. Patterning might be achieved by combing, stamping or rouletting the surface. Also, sets of decoration might be designed to make the vessel's surface graspable. In order to assess this, I looked at decoration motifs and their placement on the exterior surface.

Heating effectiveness refers to the ability of the vessel to let heat pass through its wall and reach the contents. This characteristic helps determine if the vessel was intended for cooking or other purposes. I assessed heating effectiveness by looking at wall thickness, types of temper and inclusion incorporated in the paste fabrics, surface treatment, and firing condition (Rice 1987: 227; Skibo 2013: 33).

The thicker the wall of a vessel, the lower its heat effectiveness is. I assessed vessel thickness by measuring the maximum and minimum thicknesses of the sherds with DigitalAid ® digital calipers.

The nature and composition of pastes and specific inclusions (whether intentionally added tempers, or natural in the clay) forming the vessel fabrics also condition its heating effectiveness (Chami 1994: 84; Skibo 2013: 39). Mineral inclusions are more thermally shock-resistant and have higher heating effectiveness than organic inclusions (Skibo 2013: 43). A vessel with a higher mineral inclusion is suited for cooking, while one with a less shock-resistant temper might have been used for other purposes without exposure to heat (Skibo 2013: 40). Therefore, I also estimated the proportion of inclusions within the paste fabrics, using a handheld magnifying glass to identify the composition of paste fabrics and types of temper. I assessed the texture of the paste with a Forestry Suppliers' sand grain sizing folder (Plate 5.9).

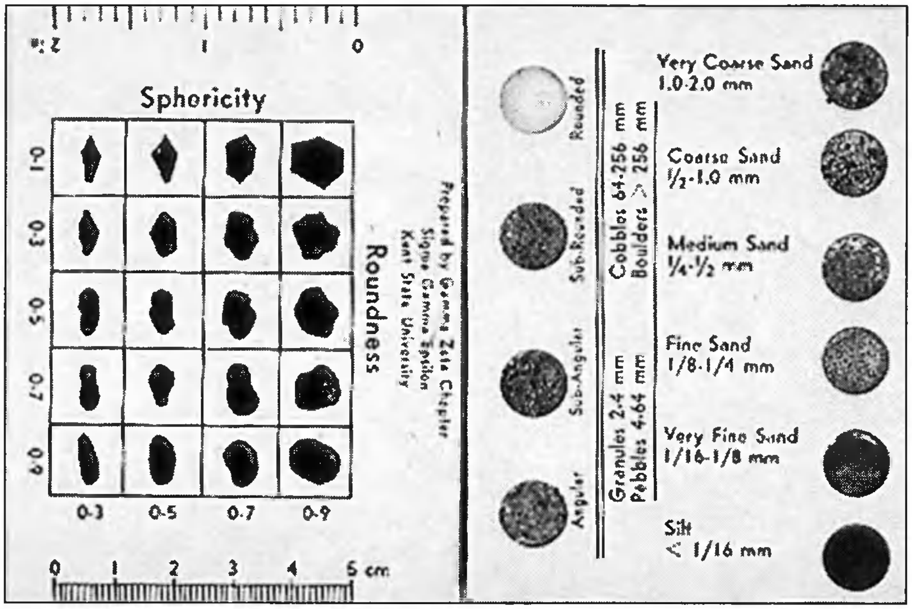

Plate 5.9: Sand Grain Sizing Folder Prepared by Kent State University's Gamma Zeta Chapter.

Surface treatments (such as smoothing, burnishing, and patterning), as well as the surface coating (such as slipping and graphite-burnishing) can also influence heating effectiveness in that they condition the permeability of the vessel's wall. Permeability allows water to leak, thus helping the vessel body to cool (Skibo 2013: 40). Smoothing, burnishing, slipping and coating of the wall reduce permeability.

Lastly, the higher the temperature at which a vessel is fired, the less permeable it is (Skibo 2013: 47). A low-fired vessel, due to its higher permeability, has greater heat effectiveness, and is thus suited for boiling/steaming. I analyze the firing condition of potsherds to assess the heating effectiveness of the vessel.

For East Africa and Madagascar, a well-fired vessel is fired in an oxidizing environment, while a low-fired vessel is fired in a reduced atmosphere (Chami 1994; Wright 2005). I distinguished the two by paste color. Oxidized firing produces a red paste, while a reduced atmosphere firing yields a darker color (Wright 2005: 120). Depending on the degree of firing, paste colors vary from black to red (see Skibo 2013). I used a Munsell Color Book to identify these colors, recording only the color of the sherd's inner paste.

The heating effectiveness of a vessel can also be altered by other attributes such as orifice form and presence/absence of lids. A narrower vessel mouth and lid increase heating effectiveness for boiling/steaming, while a wider orifice and absence of a lid reduce it, which is appropriate for simmering (Skibo 2013: 36).

5.3. GEOSPATIAL ANALYSES

Archaeological research is fundamentally associated with the meticulous recording of human behavior through space (Connoly and Lake 2006; Hodder and Orton 1976; Howey 2011: 2523; Wheatley and Gillings 2002), making geospatial analysis essential. Before the advent of GIS, archaeologists were already conducting spatial analysis (see Hodder and Orton 1976). Today, Geographical Information Systems (GIS) and remote-sensing techniques have enabled archaeologists to develop methods that allow better analysis of past behavior, and to advance theories of past social processes (Howey 2011: 2523; Wheatley and Gillings 2002).

This study explores the influence of climate variability and/or intergroup conflicts on settlement decisions by communities at Ankilivalo and Keliangebo. The spatial relationship between archaeological site locations and positioning of natural resources were analyzed to assess the influence of climate variability on decisions (see Jones 2010), and the defensibility of archaeological sites to assess the influence of intergroup conflicts. Both analyses approached with geospatial analyses in my study.

Geospatial analysis uses data with a geographic location. That is, it relies on the description and location of a given feature represented in a map (Conolly and Lake 2006). To visualize these, the GIS platform uses either vector or raster data.

Vector data yields a coordinate-based model representing geographic features as points, lines, and polygons, while raster data is a grid of pixels of uniform-sized cells representing spatial information (Wheatley and Gillings 2002; Conolly and Lake 2006). Vector data has more accuracy in terms of shapes and boundaries than raster data, because the latter breaks data into a grid, which results in a loss of precision. However, GIS platforms generally compute faster with raster data. Furthermore, raster data is recommended for data without well-defined boundaries (Conolly and Lake 2006: 30-31). This study uses both vector and raster datasets.

Most GIS software can capture, manipulate, analyze, and visualize vector and raster data. Different types of GIS platforms, including ArcGIS, QGIS, and GRASS, offer a range of geoprocessing tools, permitting proximity analysis (Jones 2017), cost surface analysis (Madry and Rakos 1996; Steele *et al.* 1998) and viewshed analysis (Llobera 1996; Lake *et al.* 1998; for more details see Conolly and Lake 2006). This project uses the ESRI platform of ArcMap 10.4.1 version.

To visualize spatial data, ArcGIS arithmetically converts the 3D space representing the Earth's surface into a 2D map. This conversion is called a projection system in ArcGIS. GIS analysts use a variety of projection systems, including the North American Datum 1983 (NAD83) projection, the Universal Transverse Mercator (UTM) projection, and the World Geodetic System 1984 (WGS84) projection. This study uses the WGS84

Mercator as a projection system, and the GCS WGS 1984 as a coordinate system to conform with the DEM projection.

While ArcMap can run basic spatial statistical analyses, I turned to the open source program "R" version 3.5.1 for more advanced spatial statistics. I prepared datasets in Microsoft excel (.xlsx) and comma separated value (.csv) prior to analysis.

For the geospatial analyses presented in Chapter 7, I prepared archaeological site locations, randomly generated site locations, and some thematic raster datasets (cost surfaces, natural resources distribution, etc.) derived from satellite images.

5.3.1. Mapping Archaeological Sites

To map archaeological sites, I recorded their geographical coordinates (latitude, longitude, altitude) in a MS excel worksheet (.xlsx) file, then converted the excel file to comma separated value (.csv) file. I then imported the .csv file into ArcMap using the *Add Data* icon. Once the .csv file was loaded in the map documents in ArcMap, I right clicked on it, and selected *Display XY Data*. A map of the distribution of archaeological sites encountered during surveys is provided in 6.1.2. (Figure 6.1).

5.3.2. Mapping Random Sites

To test the significance of the relationship between archaeological sites and natural resources, I compared the environmental contexts of actual archaeological sites with random sites within the same landscape (see Jones 2010; Maschner and Stein 1995; Nathan 2017), by generating 50 random site locations within the study area boundary using the *Generate Random Points* tool in ArcMap (*ArcToolbox* > *Data Management* >

Sampling > Generate Random Points). I set the minimum distance between random points at 2 km (Figure 5.12).

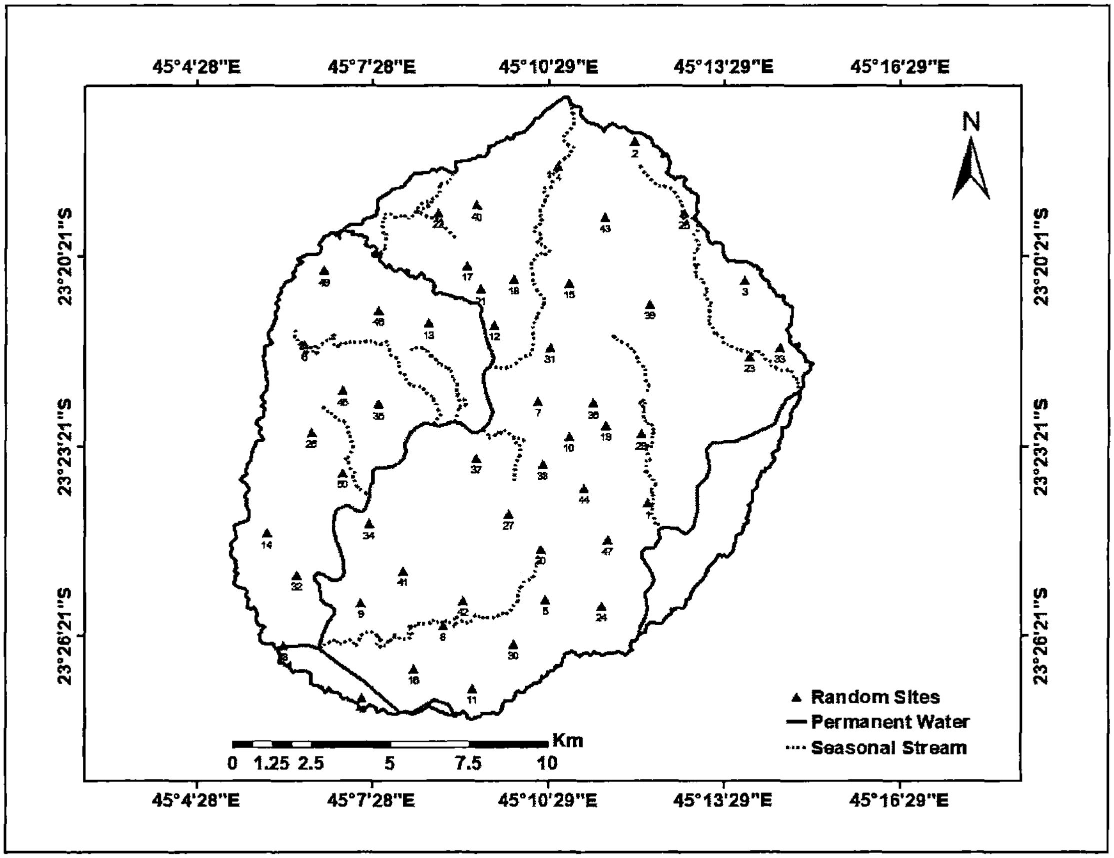

Figure 5.12: Distribution of Random Sites

I then assigned geographic coordinates (latitude and longitude) to the generated random points, using the *Add XY Coordinates* tool in ArcMap (*ArcToolbox > Data Management Tools > Features > Add XY Coordinates*). The coordinate system is set to GCS WGS 1984 decimal coordinates. To add elevation to the random points, I used the *Extract Values to Points* tool (*ArcToolbox > Spatial Analysts Tools > Extraction > Extract Values to Points*) by inserting the generated random points as 'Input point features' and the Digital Elevation Model (DEM) as the 'Input raster' (Table 5.4).

Table 5.4: Geographic Coordinates and Elevation of Random Sites

Random Sites #	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Elevation
Random Site 1	-23.404124	45.202821	297
Random Site 2	-23.308965	45.198966	462
Random Site 3	-23.345341	45.230403	335
Random Site 4	-23.315275	45.177175	322
Random Site 5	-23.429579	45.173744	327
Random Site 6	-23.362352	45.105005	393
Random Site 7	-23.377287	45.171777	335
Random Site 8	-23.436314	45.144676	249
Random Site 9	-23.43043	45.121068	242
Random Site 10	-23.386467	45.18048	418
Random Site 11	-23.452931	45.152819	285
Random Site 12	-23.357076	45.15914	293
Random Site 13	-23.356608	45.140494	503
Random Site 14	-23.411975	45.094531	247
Random Site 15	-23.346094	45.180715	310
Random Site 16	-23.447788	45.136477	242
Random Site 17	-23.341534	45.151489	456
Random Site 18	-23.345106	45.164816	313
Random Site 19	-23.383527	45.19084	374
Random Site 20	-23.416157	45.172464	381
Random Site 21	-23.347675	45.155206	510
Random Site 22	-23.327541	45.143299	409
Random Site 23	-23.365463	45.231809	306
Random Site 24	-23.431179	45.189742	308
Random Site 25	-23.327727	45.213295	428
Random Site 26	-23.385345	45.107258	367
Random Site 27	-23.406933	45.163406	551
Random Site 28	-23.441594	45.0991	182
Random Site 29	-23.385785	45.200929	330
Random Site 30	-23.441308	45.164757	300
Random Site 31	-23.36302	45.175371	296
Random Site 32	-23.423024	45.102934	229
Random Site 33	-23.363022	45.240616	318
Random Site 34	-23.409563	45.123456	248
Random Site 35	-23.37794	45.126112	371
Random Site 36	-23.377668	45.187494	440
Random Site 37	-23.392257	45.154106	303
Random Site 38	-23.393783	45.173259	553
Random Site 39	-23.351655	45.20347	455
Random Site 40	-23.325554	45.154157	472
Random Site 41	-23.421957	45.133248	280
Random Site 42	-23.429866	45.150274	233
Random Site 43	-23.328694	45.190684	473
Random Site 44	-23.400123	45.184726	371
Random Site 45	-23.374326	45.116055	387
Random Site 46	-23.353188	45.126294	422
Random Site 47	-23.413664	45.191615	300
Random Site 48	-23.455426	45.121356	244
Random Site 49	-23.3427	45.1109	342
Random Site 50	-23.396105	45.116071	253

5.3.3. Creating a Cost Surface Map

A *cost surface* is a raster grid in which each cell represents the cost value(s) of a factor or a combination of factors to traverse it (Connolly and Lake 2006: 215-225; De Silva and Pizziolo 2001: 281). Spatial analysts weigh factors that might affect the cost (e.g. time cost) of traveling across an area. Depending on the local context, a given area may have two or more factors that affect the time cost of travel (Ceballos-Silva and Lopez-Blanco 2003: 118; De Silva and Pizziolo 2001: 280). These can result from topographic, environmental, and social conditions. But the type of transport available to the traveler (Verhagen 2017: 16) also has an impact on cost. A cost surface for each considered factor, also known as cost-of-passage, should be created (Bell and Lock, 2000: 86; Connolly and Lake 2006: 215-221). Then, all cost-of-passages can be combined into a total or accumulated cost surface (Connolly and Lake 2006: 221-224; Howey 2007: 1831).

In order to combine cost surfaces, their unit values must be reclassified into the same scale value. This provides a manageable range of values suitable for smoothly calculating the total cost surface (Berry 2004; Howey 2007: 1831). Ranking values such as 1-9 is preferred for cost surface reclassification (see Figure 5.13).

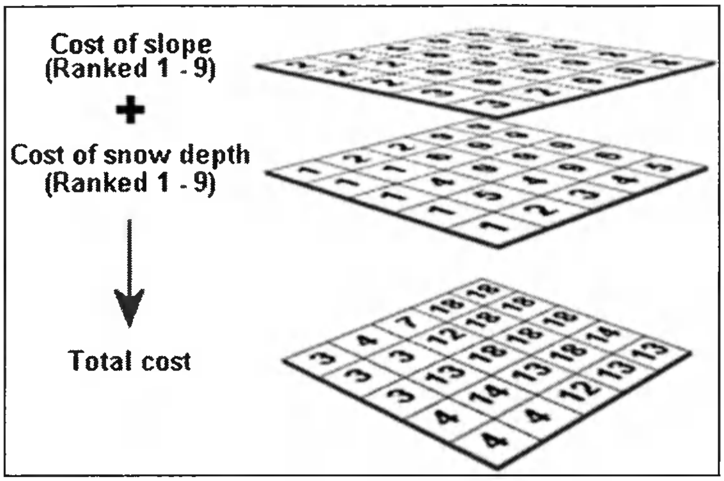

Figure 5.13: Example of Calculation of Total Cost Surface (Source: ESRI 2018)

To calculate the total time cost of travel across the landscape of the MSV, I first created two cost-of-passages based on slope degree impediment and land cover friction (see Sakaguchi *et al.* 2010: 1176). I then combined the two layers by summing them in the *Raster Calculator* tool to generate the total cost.

It should be noted that the geological landscape of the MSV was formed during the Middle Jurassic period, and continuously altered by fluvial erosions and aeolian effects (Petit 1996; Rakotomalala 2007: 18-19; Rasolofondrahanta 2005: 15; Sourdat 1970). Although the current landscape does not necessarily represent precise conditions even a few centuries ago, a modern map is a good approximative representation (Arikan 2012: 2911). I assume the topography of the MSV today resembles its state during the 16^{th} – 19^{th} century (see Llobera 2000).

5.3.3.1.Cost Surface from Topographic Slopes

To create a cost-of-passage based on topographic slope, a digital elevation model (hereafter DEM) from remotely sensed imagery is required.

Acquiring and Preparing Remotely Sensed Data

A remote sensor creates images based on four different types of resolution, namely spectral, spatial, temporal, and radiometric. *Spectral resolution* is the number and size of bands the sensor captures from the electromagnetic spectrum; *Spatial resolution* refers to the accuracy of the representation of features in pixels (Jensen 2007), that is, how many meters of the actual ground a pixel represents in the imagery. An image with a spatial resolution of 30 m, for instance, has an individual square pixel representing an area of 900 m^2 on the ground; *Temporal resolution* tells us how often the sensor takes images of the same location. And *radiometric resolution* shows the sensor's sensitivity at the time when it records an image, that is, how many bits the sensor used in capturing the images. The more bits used, the higher the radiometric resolution.

Imagery with a specific resolution type or types is selected depending on the project or research questions. To prepare the cost-of-passage map based on slope, this project considered spectral, spatial, and radiometric resolutions of the DEM (Llobera 2000).

Digital Elevation Model (DEM) for the Study Area

This project used a DEM from the newest iteration of the open source Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model Version 2 (ASTER GDEM V2), a product of the Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA) released in October 2011. I downloaded it from the United States Geological Survey (USGS) website.

The *spectral resolution* of the DEM is limited to a single band. The *spatial resolution* is 30m by 30m (i.e. 1 pixel for an area of 900m^2 in the actual ground or approximately the same as a 1:30,000 scale map), while the *radiometric resolution* is 16 Bits. This DEM uses the World Geodetic System 1984 (WGS84) projection and coordinate system.

The original DEM I downloaded comprised 3601 x 3601 columns and rows. Its visible extent is situated between the meridian -22.999861 and -24.000138 South and longitude of 44.999861 and 46.000138 East (Figure 5.14). In order to confine it to my area of interest, I decided to delimit it based on *cost distance* outwards from an archaeological site (see Conolly and Lake 2006: 209-211; 213-214). To do so, I first created a slope raster out of the DEM by using the *Slope* tool in ArcMap (*ArcToolbox > Spatial Analyst Tools > Surface > Slope*) (Figure 5.14).

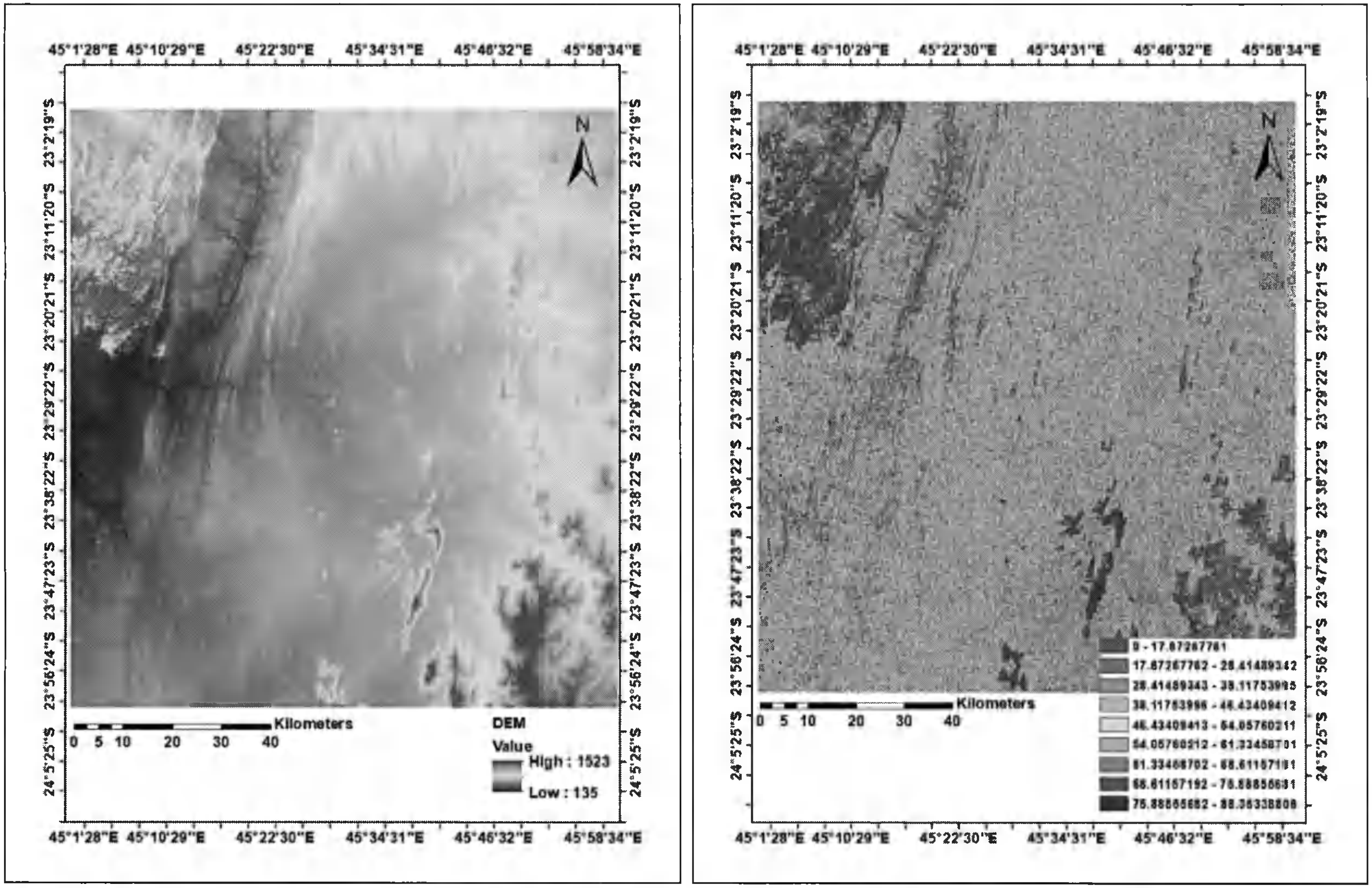

Figure 5.14: (1) Original Digital Elevation Model (DEM) from USGS and (2) the Slope Extracted from It.

I then created a cost distance from the slope raster, starting from the archaeological site, by using the *Cost Distance* tool (*ArcToolbox > Spatial Analyst Tools > Distance > Cost Distance*). More details are given in **5.3.4.1**. From the generated cost distance raster, I excluded the area beyond the unit value touching the Onilahy and Maloto rivers, by using the *Set Null* tool in ArcMap (*ArcToolbox > Spatial Analyst Tools > Conditional > Set Null*). The edges of the resulting raster layer became the boundary of my study area (Figure 5.15). I chose this boundary not only to restrict my study area but also to allow geoprocessing tools to work fast and efficiently. However, I had to take into account the fact that the edges of an artificial boundary, such as the one I created, tend to return incorrect values during geoprocessing calculation of raster data, because of the 'artificial truncation' ArcGIS has to apply to calculate one or more of the 8 neighboring cells that have been deleted by the clipping (Conolly and Lake 2006). The study area is thus delimited between 45°3' and 45°17' East, and 23°17' and 23°28' South (Figure 5.15).

I used this boundary to clip the original DEM and slope by using the *Extract by Mask* tool in ArcMap (*ArcToolbox > Spatial Analysts > Extraction > Extract by Mask*). The generated DEM and slope layers (see Figure 5.16) made it easier to work on subsequent geospatial analyses. The created slope map, for instance, is required to create a cost-of-passage map based on slope friction.

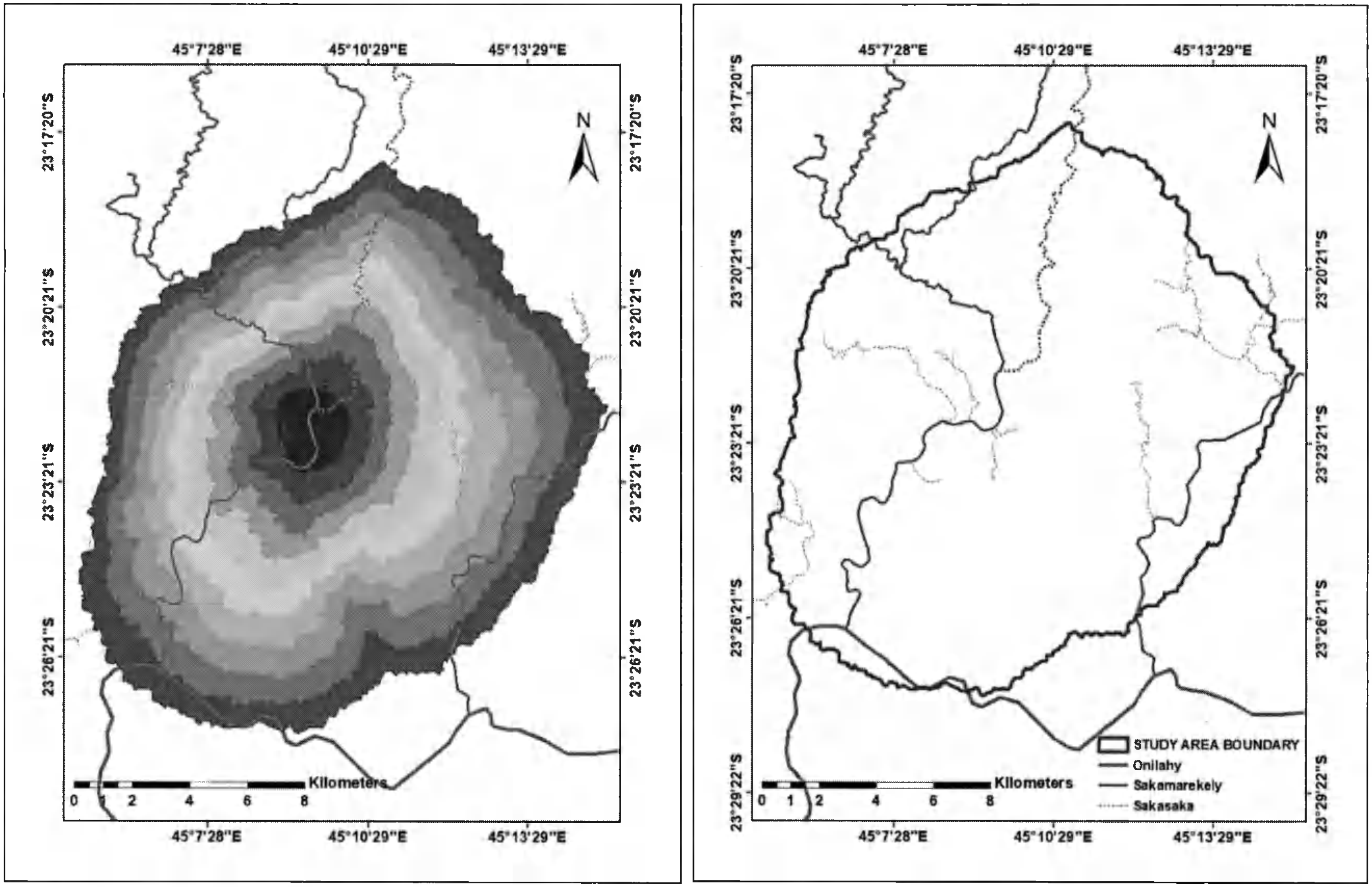

Figure 5.15: Cost Distances from Ankilivalo (Left) Used to Create the Boundary of the Study Area (Right)

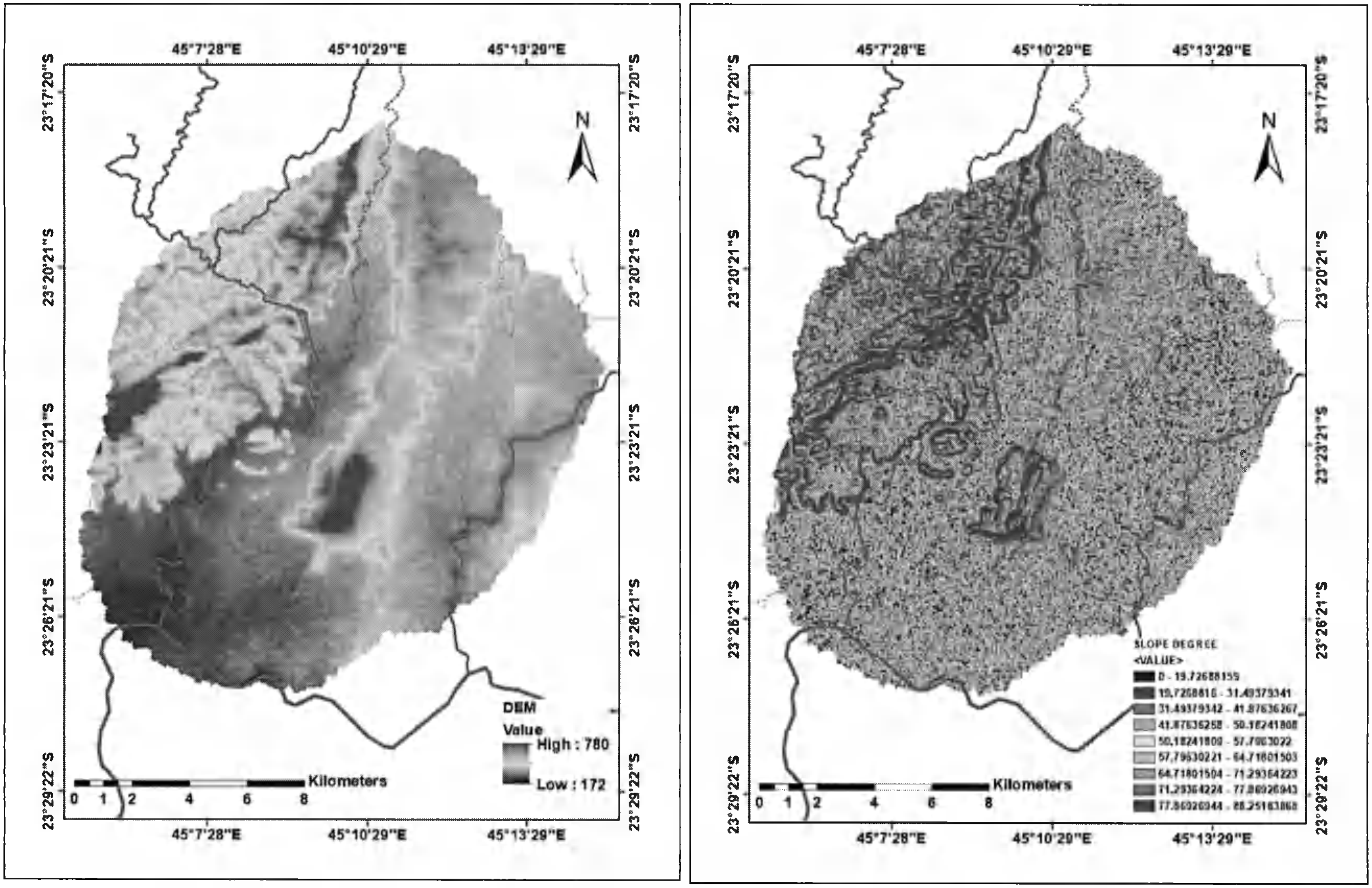

Figure 5.16: Digital Elevation Model (Left) and Slope Degree (Right) Clipped with the Study Area Boundary

To create a cost-of-passage map from the slope layer, I reclassified the slope degree values into ranking values from 1 to 9 (see Figure 5.17). This slope friction layer defines the time cost to traverse each raster cell representing different degrees of slope. The higher the ranking value of slope, the more costly/slower it is to pass through it. Since it is assumed people traveled on foot, I scaled the speed from 2 km (very steep ground) to 5 km (flat terrain) per hour.

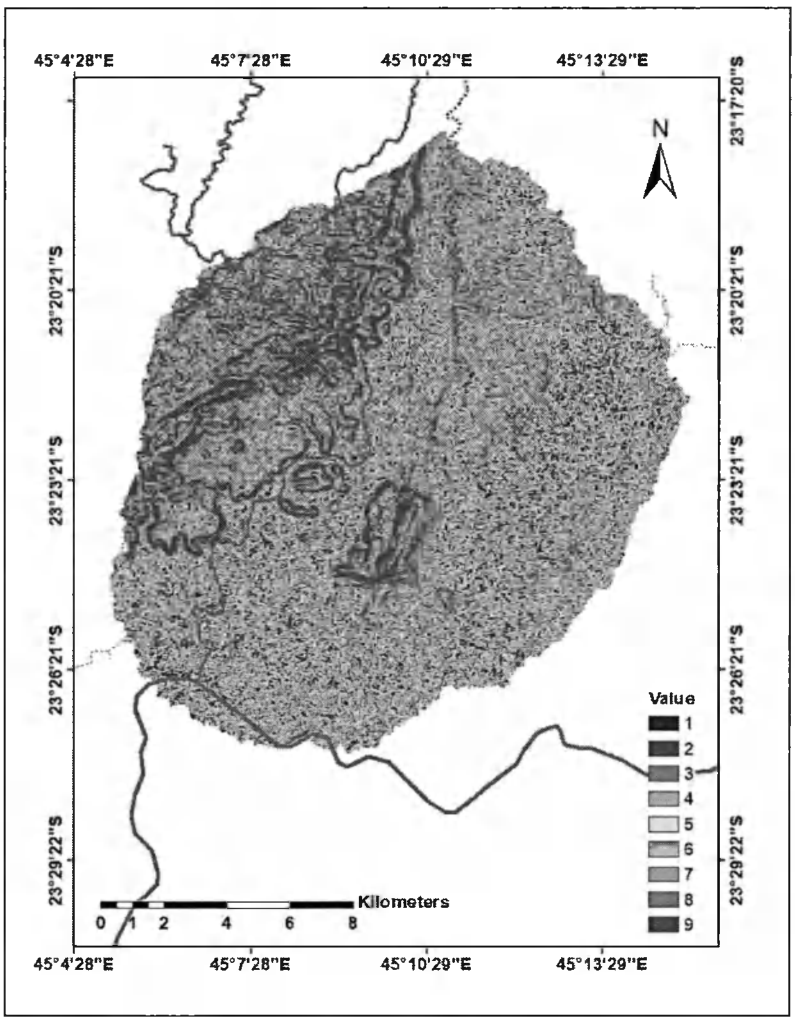

Figure 5.17: Reclassified Slope Layer

5.3.3.2. Cost Surface from Land Cover

This section describes the methods used to create a layer that defines the time cost of traversing raster cells representing different types of land cover, such as forests, grassland, scrub, and rivers.

Instead of using classified images of vegetation cover from Landsat imagery, I decided to digitize different types of land cover from ArcMap Imagery basemap. I combined all the digitized polygons representing the same type of land cover using the *Dissolve* tool in ArcMap (*ArcToolbox > Data Management Tools > Generalization > Dissolve*). I then converted them to raster datasets using the *Polygon to Raster* tool (*ArcToolbox > Conversion Tools > To Raster > Polygon to Raster*), making sure that their spatial resolutions are all set at 30m by 30m.

I first estimated a speed in km per hour (km/h) for moving across each land cover type. Then, I converted this speed to meters per second (m/s) to conform with the raster cell in ArcMap. I then multiplied the converted speed by the resolution of the raster cell (i.e. 30). For instance, a speed of 5km per hour (5000m/3600s = 1.38 m/s) on the actual ground is scaled to 41.4 m/s (1.38 x 30) when working with the raster cell in the ArcMap program. The following table summarizes the speed for moving across each land cover type (Table 5.5).

Table 5.5: Estimated Travel Time for Land Cover

Land Cover Types	Estimated Travel Time on the Ground (km/h)	Estimated Travel Time on the Ground (m/s)	Estimated Travel Time within Raster Cell
Horombe Grassland	5	1.38	41.4
Isalo Grassland	5	1.38	41.4
Scrubland	5	1.38	41.4
Deciduous Forest	4	1.11	33.3
Tapia Forest	4	1.11	33.3
River	3	0.83	24.9

I assigned these speed values as a time cost to their respective layers using the *Raster Calculator* tool (*ArcToolbox > Spatial Analyst Tools > Map Algebra > Raster Calculator*). The equation to assign speed value is as follows:

("%type_of_land_cover%" * 0) + speed value

I then reclassified the output raster data by using the *Reclassify* tool (*ArcToolbox > Spatial Analyst Tools > Reclass > Reclassify*). I reclassified the *Old Values* of 24.9, 33.3, 41.4, and NoData as 9, 6, 3, and 1 respectively in the *New Values*.

I then used the *Cell Statistics* tool (*ArcToolbox > Spatial Analyst Tools > Local > Cell Statistics*) to generate a new layer that combines the six land cover type layers associated with their friction values (Figure 5.18).

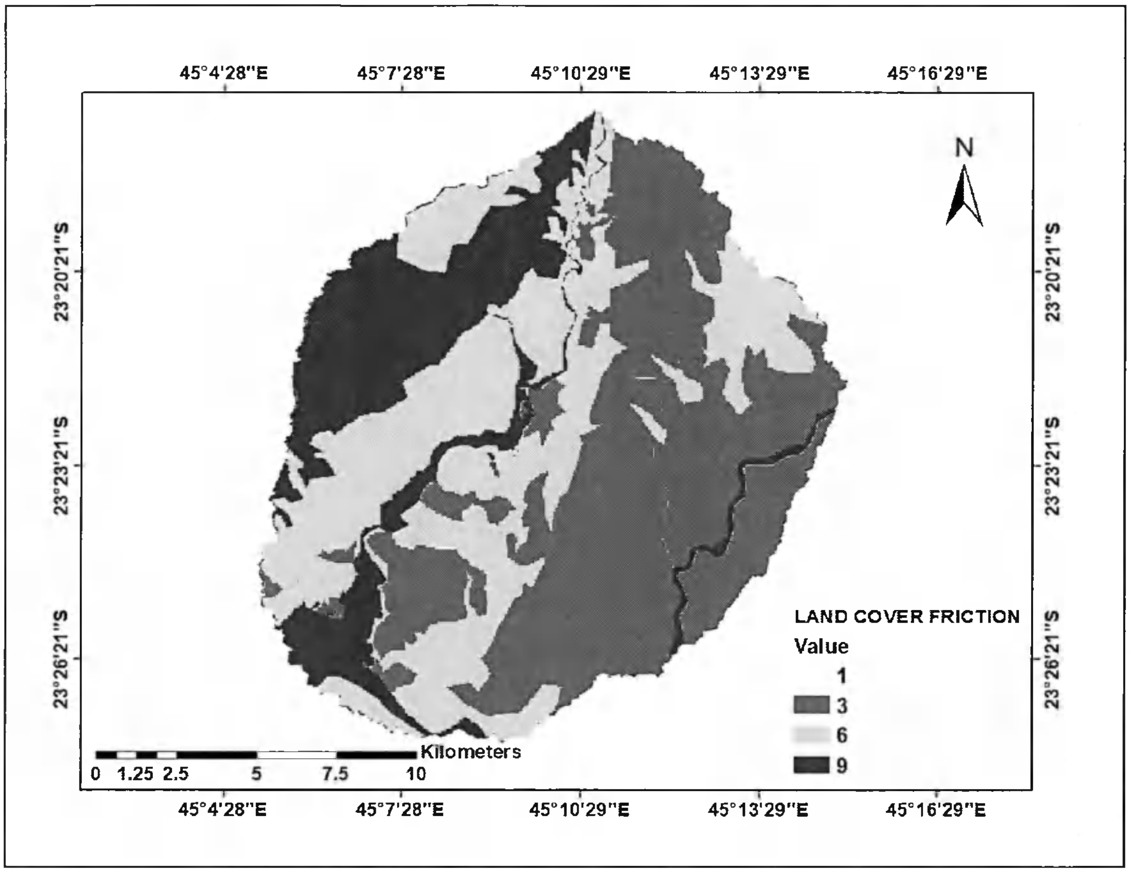

Figure 5.18: Land Cover Friction Layer

5.3.3.3. Total Cost Surface

A total cost surface is essential to calculate the cost distance and cost backlink (direction), which are required for the calculation of a cost path. For my analysis, I combined the slope and land cover cost-of-passage layers using the *Raster Calculator* tool to generate my total cost surface (Figure 5.19; Figure 5.20).

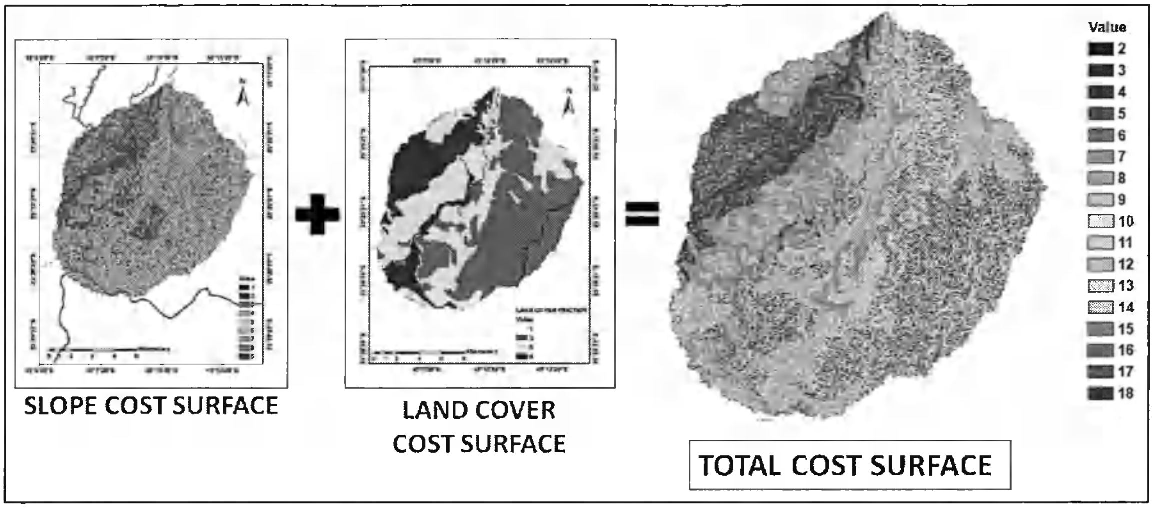

Figure 5.19: Total Cost Surface from the Sum of Reclassified Slope and Vegetation Cover Friction Layers

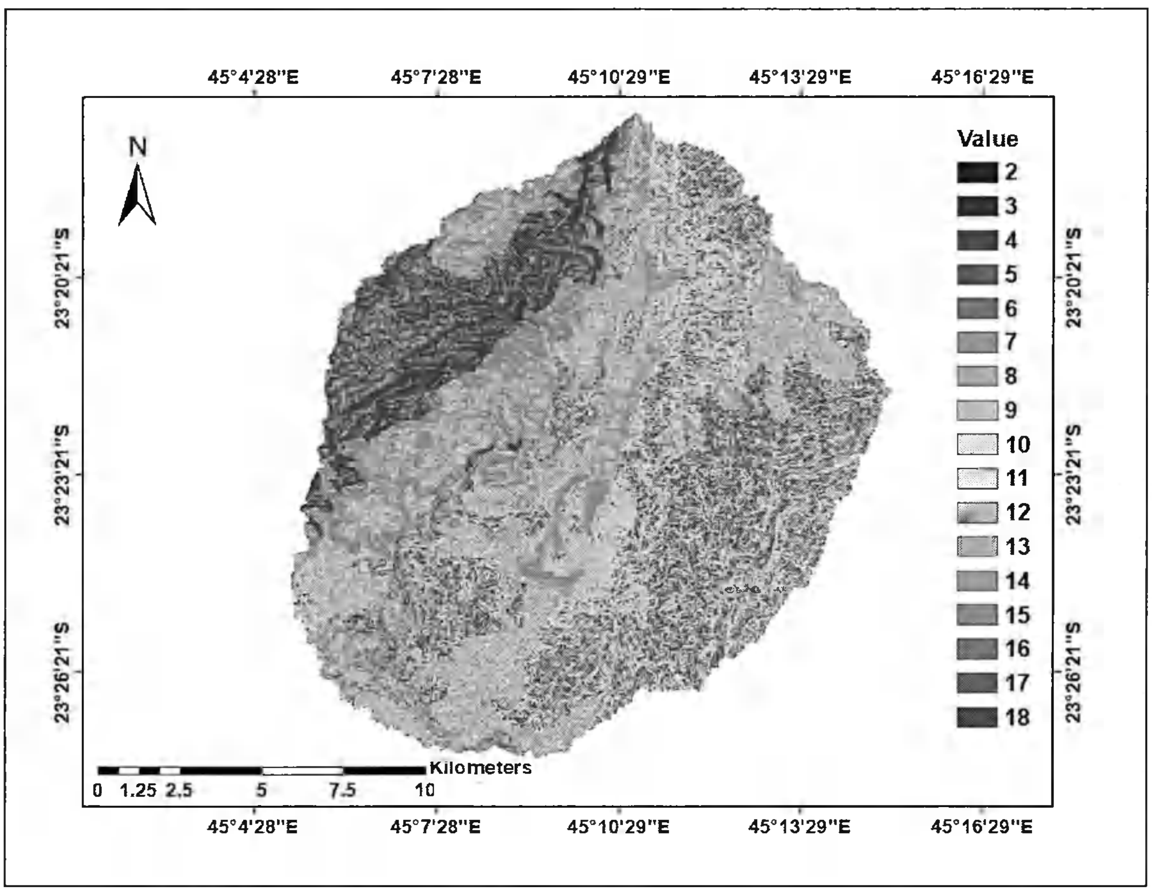

Figure 5.20: Close-Up of the Total Cost Surface

5.3.4. Proximity Analyses

The prime mover of this analysis is based on the assumption that the disposition and condition of environmental variables in the landscape affect the settlement decisions of people, and that they basically choose an 'optimal' location close to resources such as waterpoints, arable lands, grasslands, and forest resources (Volkmann 2018: 30).

To determine the proximity of an archaeological site to a given feature, I used the *Generate Near Table* geoprocessing tool in ArcMap (*ArcToolbox* > *Analysis Tools* > *Generate Near Table*; GEODESIC option selected). This analysis provides a list of environmental variables close to archaeological sites. It should be noted however that in practice, the closest feature is not always the most reachable. People may have to circumvent topographic and natural obstacles to reach a destination. This is the reason I decided not only to use the *Generate Near Table* tool, but also to perform a least cost path analysis to determine the cost of reaching the nearest features. To conduct my least cost path analysis, map layers of cost distance, cost backlink, and environmental variables had to be created.

5.3.4.1. Creating Cost Distance and Cost Backlink

In least cost path analysis, a cost distance evaluates a distance and the cost to traverse it, while a cost backlink determines the direction to follow by assessing which of the eight neighboring cells has the least cost (De Silva and Pizziolo 2001: 280). The cost distance and the cost backlink start this process from the source(s) and repeat it until they reach the destination(s). I used the archaeological sites as *Input Source Data* and the above created total cost surface as an *Input Cost Raster* in the *Cost Distance* tool to create map layers of cost distance and cost backlink (Figure 5.21 – 5.24).

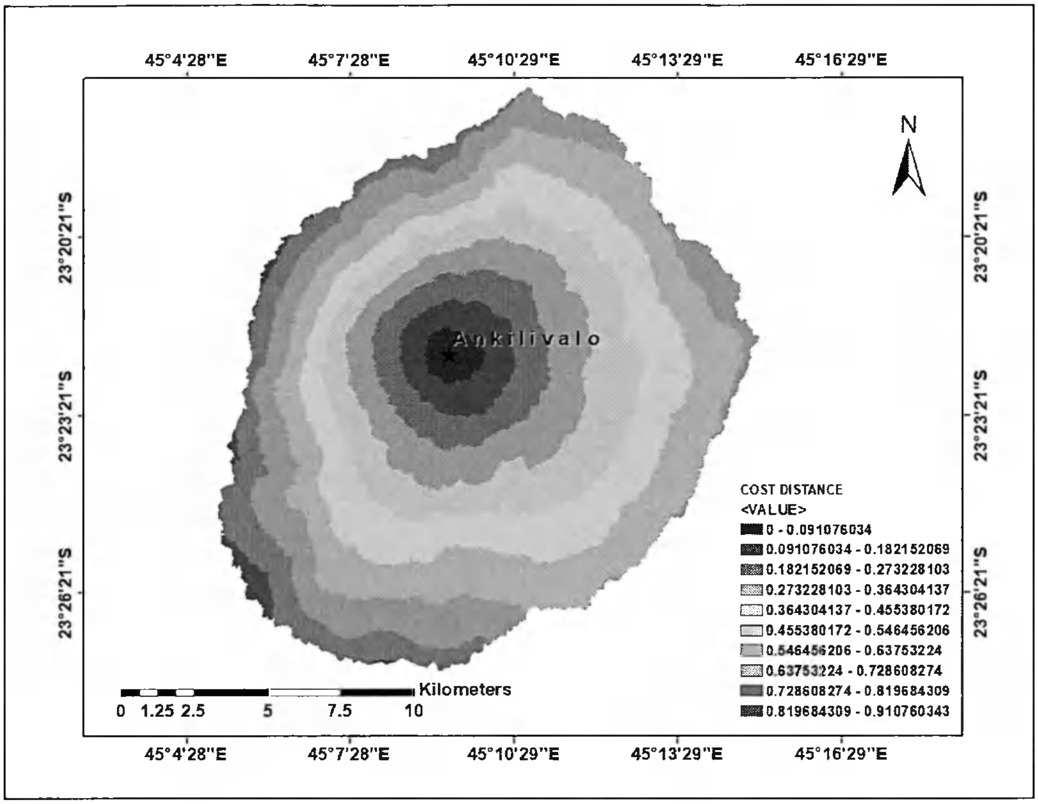

Figure 5.21: Cost Distance from Ankilivalo

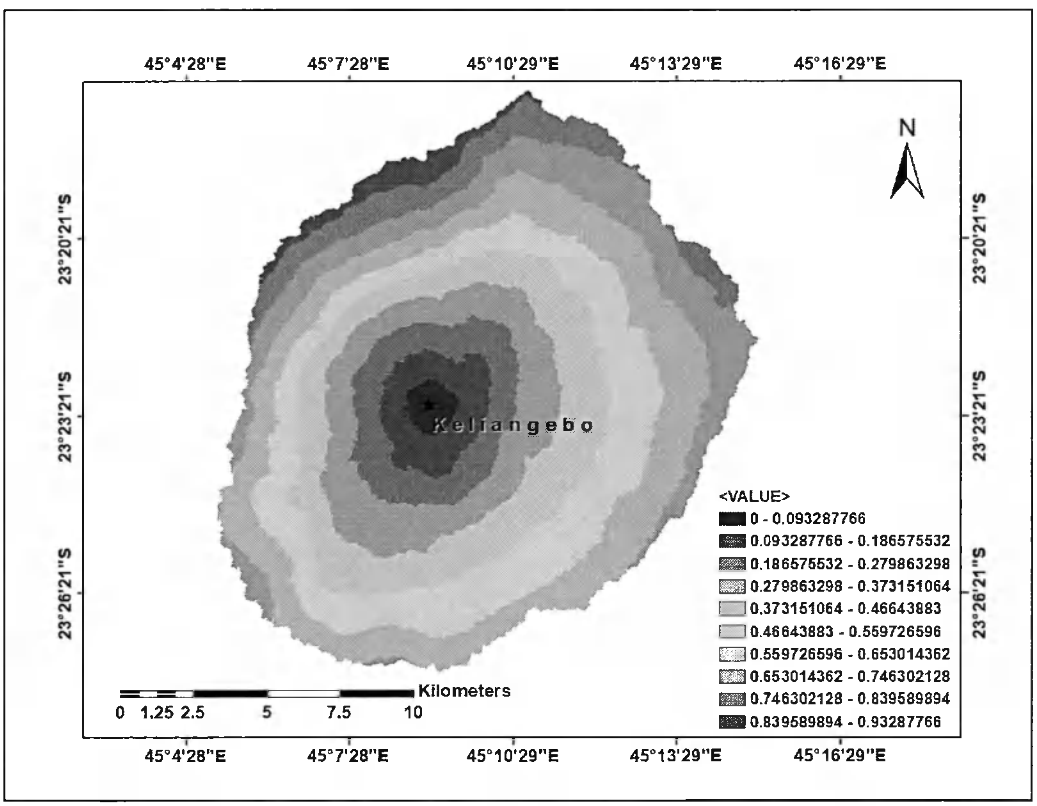

Figure 5.22: Cost Distance from Keliangebo

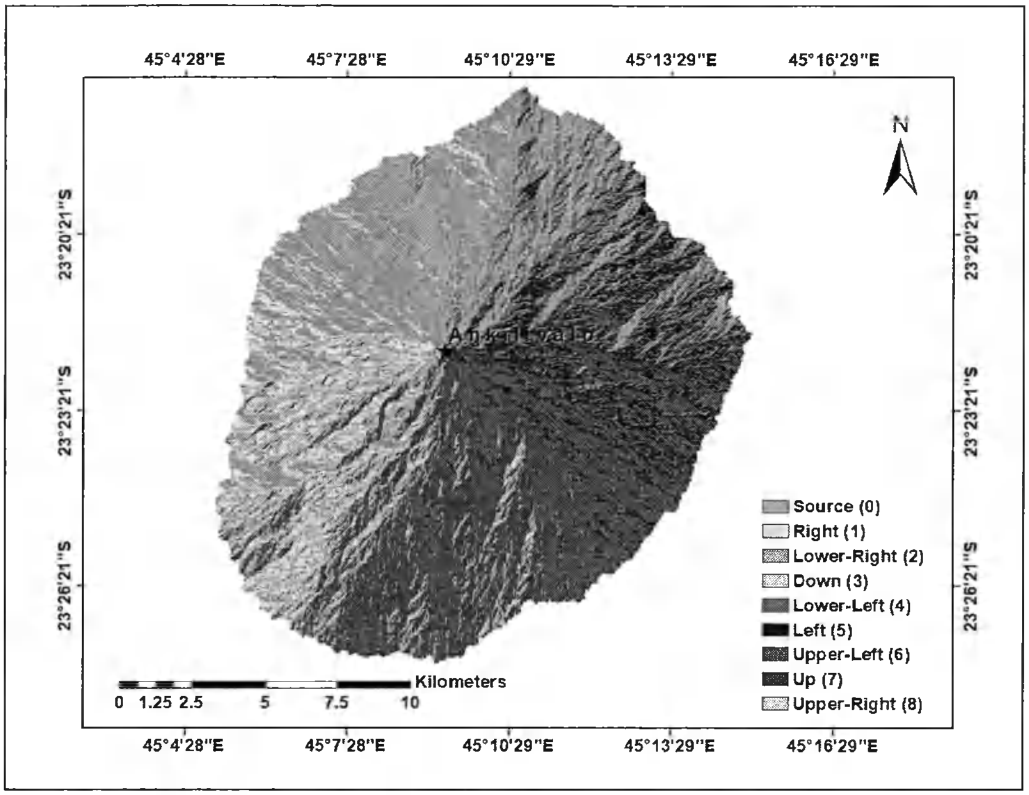

Figure 5.23: Cost Backlink from Ankilivalo

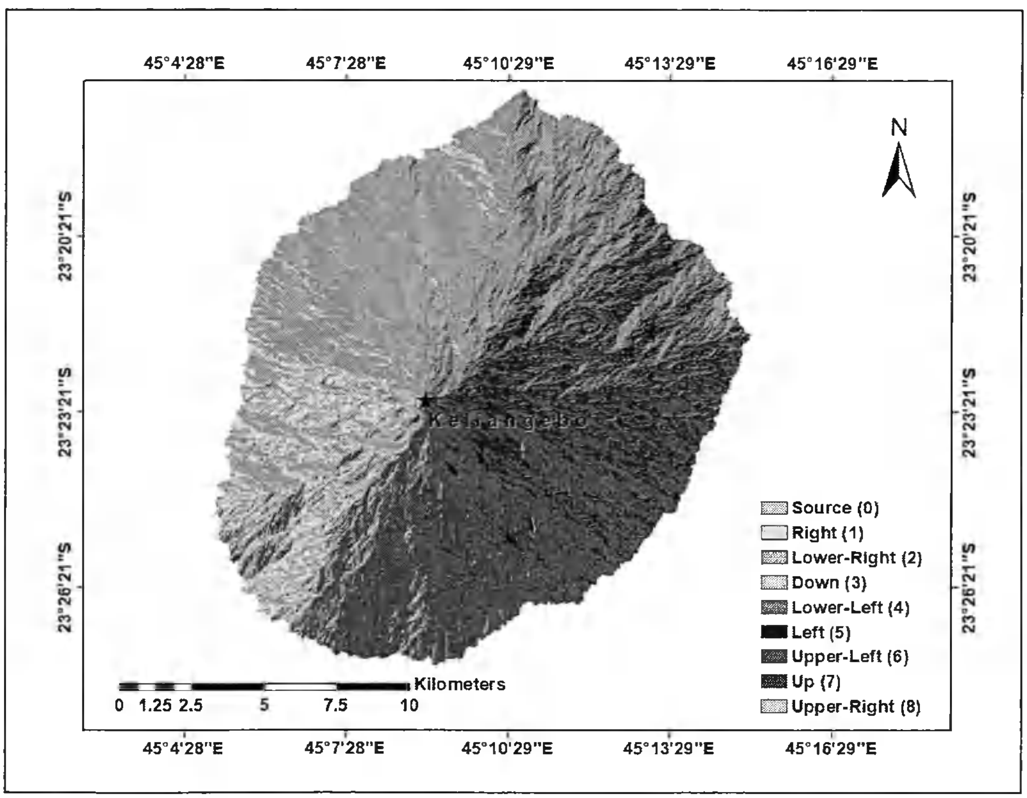

Figure 5.24: Cost Backlink from Keliangebo

It should be noted that the cost distance generated here is different from the one created earlier (see Figure 5.14) which was for boundary delimitation purposes only.

5.3.4.2.Mapping Waterpoints

It is assumed that the presence of permanent waterpoints encourages people to settle nearby (Jones 2017: 12; Nathan 2017: 197). In GIS, such permanent water sources are determined by using high flow accumulation data (Chang 2008: 310).

To map flow accumulations in the Middle Sakamarekely Valley, I first created a raster model of flow direction from the DEM using the *Flow Direction* tool (*ArcToolbox > Spatial Analyst Tools > Hydrology > Flow Direction*) (Figure 5.25).

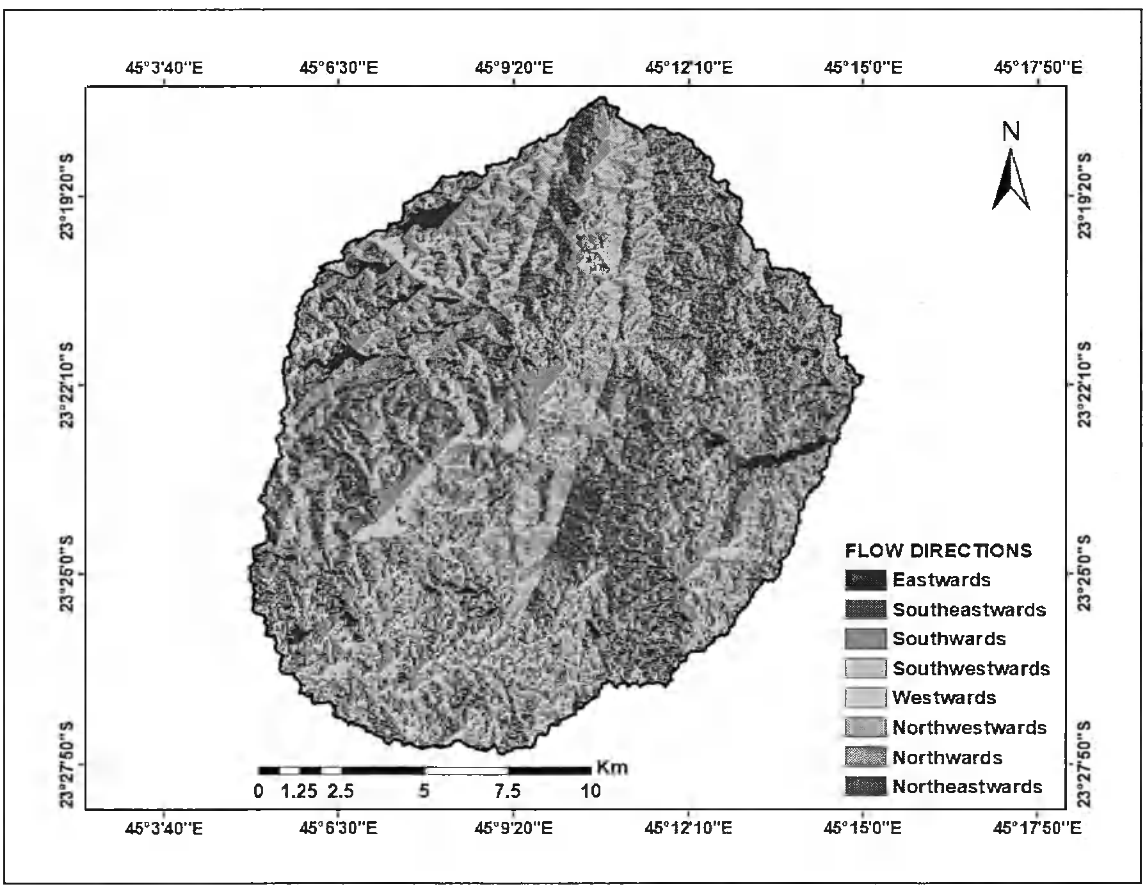

Figure 5.25: Flow Directions in the Study Area

Then, I ran the output raster through the *Flow Accumulation* tool (*ArcToolbox > Spatial Analyst Tools > Hydrology > Flow Accumulation*) to generate different sizes of flow accumulations in the study area (Figure 5.26).

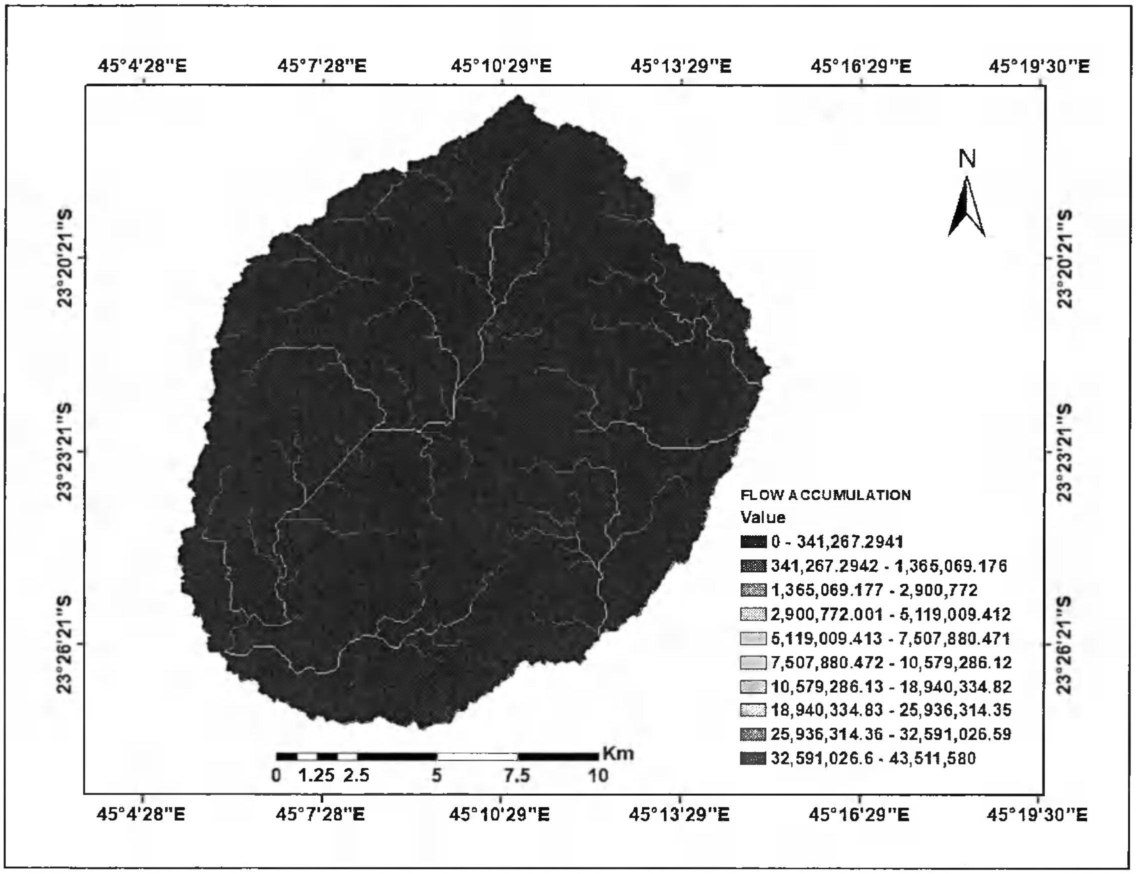

Figure 5.26: Flow Accumulations in the Study Area

The values for flow accumulations in the study area range from 0 to 43,511,580 (Figure 5.22). As my analysis is interested only on high flow accumulations, I used the *Set Null* tool to exclude flow accumulation values less than 5,119,009.413 (Figure 5.27).

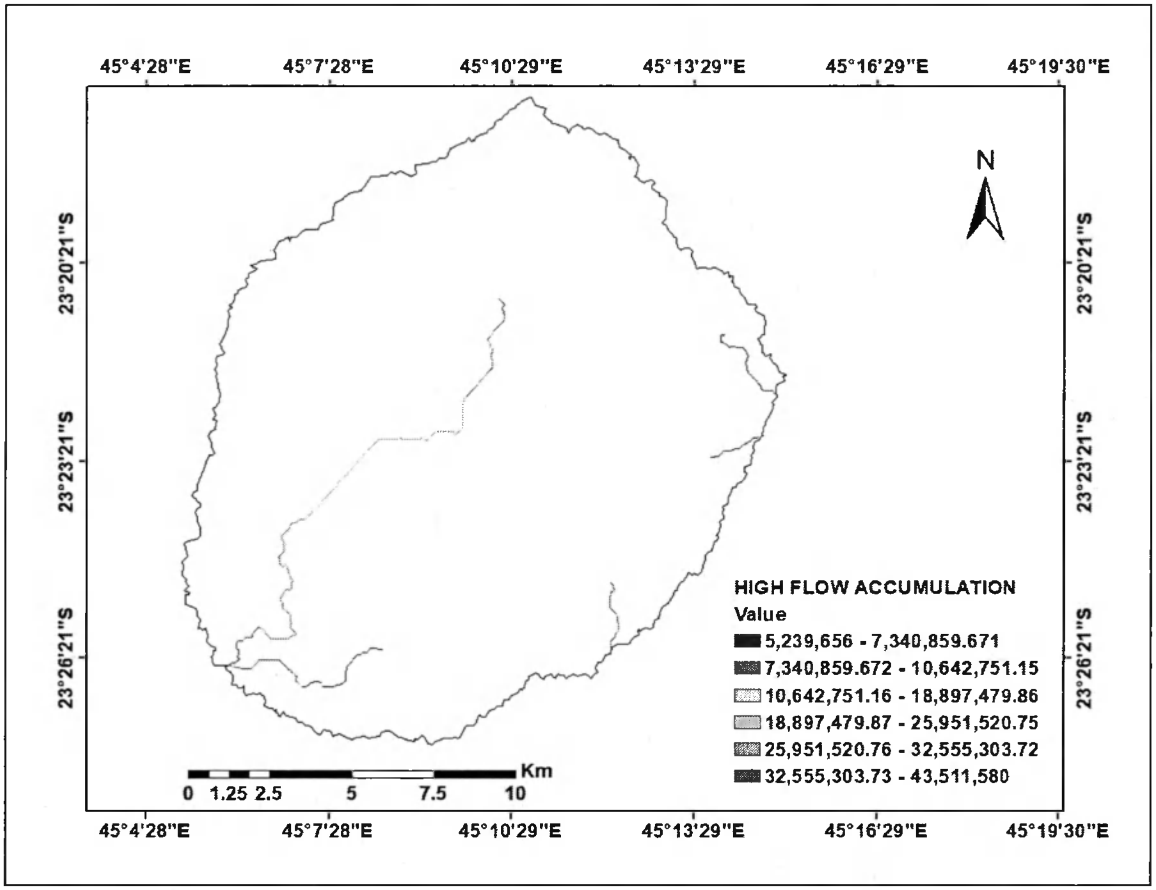

Figure 5.27: High Flow Accumulations in the Study Area

I then used the output raster as input in the *Stream Link* tool (*ArcToolbox > Spatial Analyst Tools > Hydrology > Stream Link*) to connect intersections and assign values to the streamlines (Figure 5.28). The flow accumulation values were assigned as follows (Table 5.6):

Table 5.6: Flow Accumulation Assigned Categories

Flow Accumulation Values	Assigned Categories
32,555,303.73 – 43,511,580	Category 1
25,951,520.76 – 32,555,303.72	Category 2
18,897,479.87 – 25,951,520.75	Category 3
10,642,751.16 – 18,897,479.86	Category 4
7,340,859.672 – 10,642,751.15	Category 5
5,239,656 – 7,340,859.671	Category 6

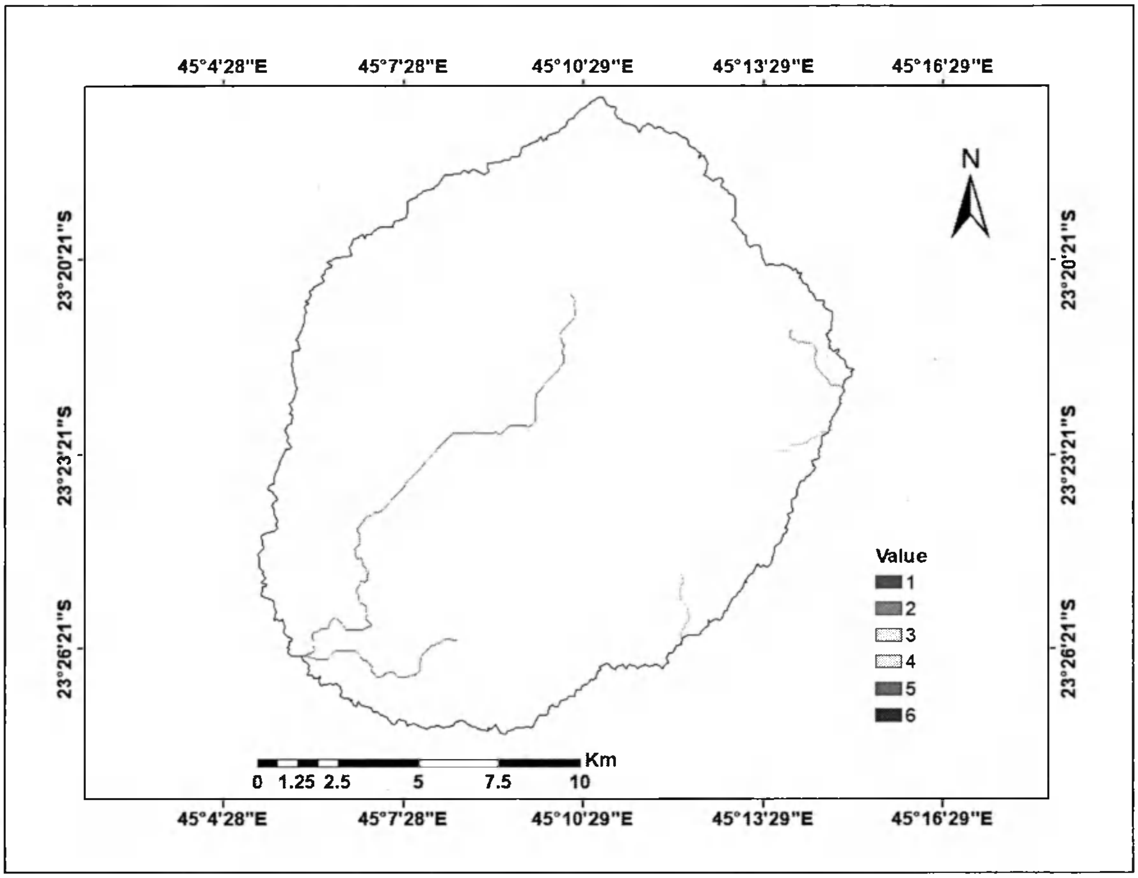

Figure 5.28: Assigned Categories of High Flow Accumulation

Before running the analysis in the *Generate Near Table* tool, I converted the stream raster to polyline using the *Stream to Feature* tool (*ArcToolbox > Spatial Analyst Tools > Hydrology > Stream to Feature*). Then I rectified the streamline features using the *Editor* and *Snapping* tool to fit the actual watercourses in the study area based on the ArcMap imagery basemap. The resulting feature is as follows (Figure 5.29):

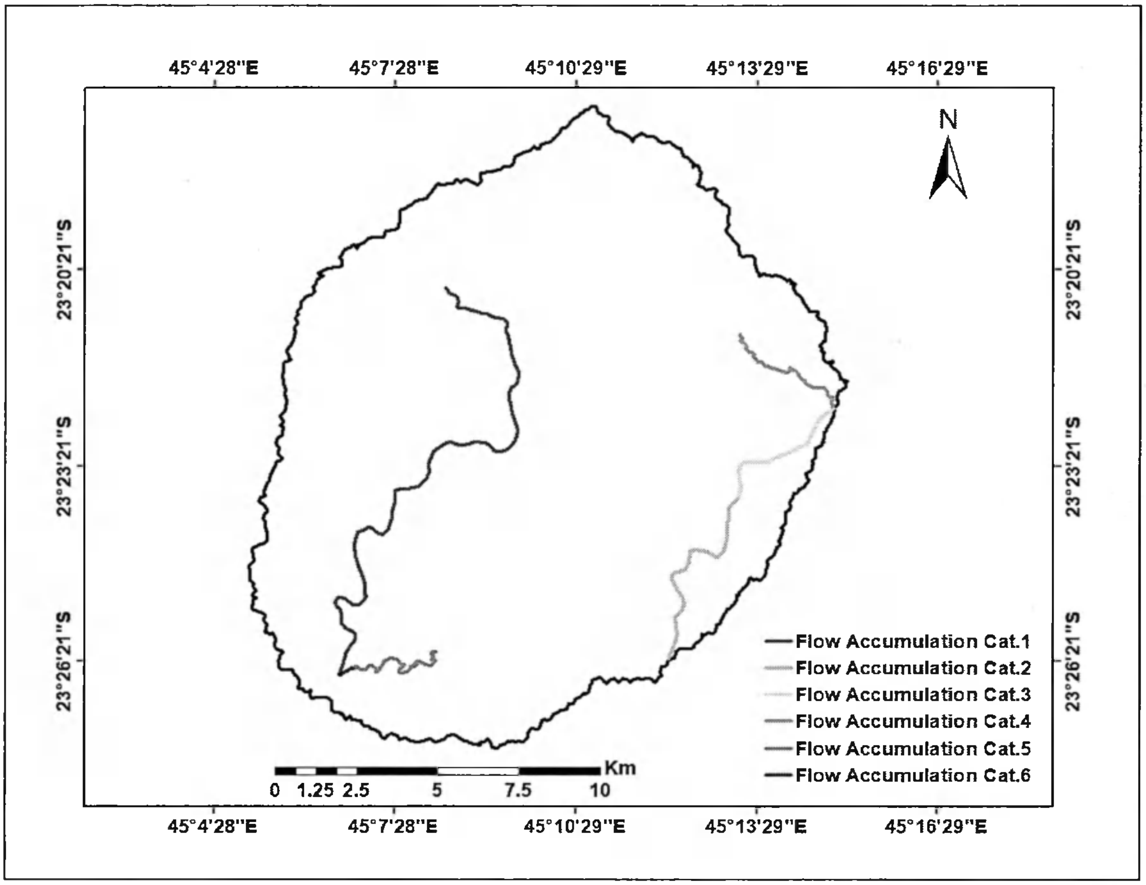

Figure 5.29: Different Categories of High Flow Accumulations in the Study Area After Rectifications.

I used the above map of high flow accumulation to conduct my analysis of the relationship between permanent water sources and archaeological sites in Chapter Seven. I used the *Generate Near Table* tool to determine this.

5.3.4.3.Mapping Arable Lands

A land is arable if it is conducive to cultivating crops. This is a function of soil fertility, which depends on many factors including physical and chemical properties. I assessed soil fertility based on organic carbon and clay content. High concentrations of organic carbon and clay are indications of soil fertility.

I downloaded raster maps of the organic carbon and clay of soils from the open source database of SoilGrids (www.soilgrids.org). This "data-driven system" uses machine learning algorithms to predict properties and classes of soil based on publicly available soil and environmental covariate data from around the globe (Hengl *et al.* 2014; 2017). The spatial resolution of the raster maps I downloaded is 250 m by 250 m, detailed enough for my analysis.

The extent of the downloaded maps was delimited between the meridian of -22.388315772 and -24.388315452, and the parallels of 44.1416308041 and 46.1416304841. But I clipped them to within my research area boundary.

The concentration value of organic carbon in the study area ranges from 6 to 28 g per kg. In order to generate a map of only the higher concentrations, I cleaned this raster layer with the *Set Null* tool to exclude values lower than 12 (Figure 5.30).

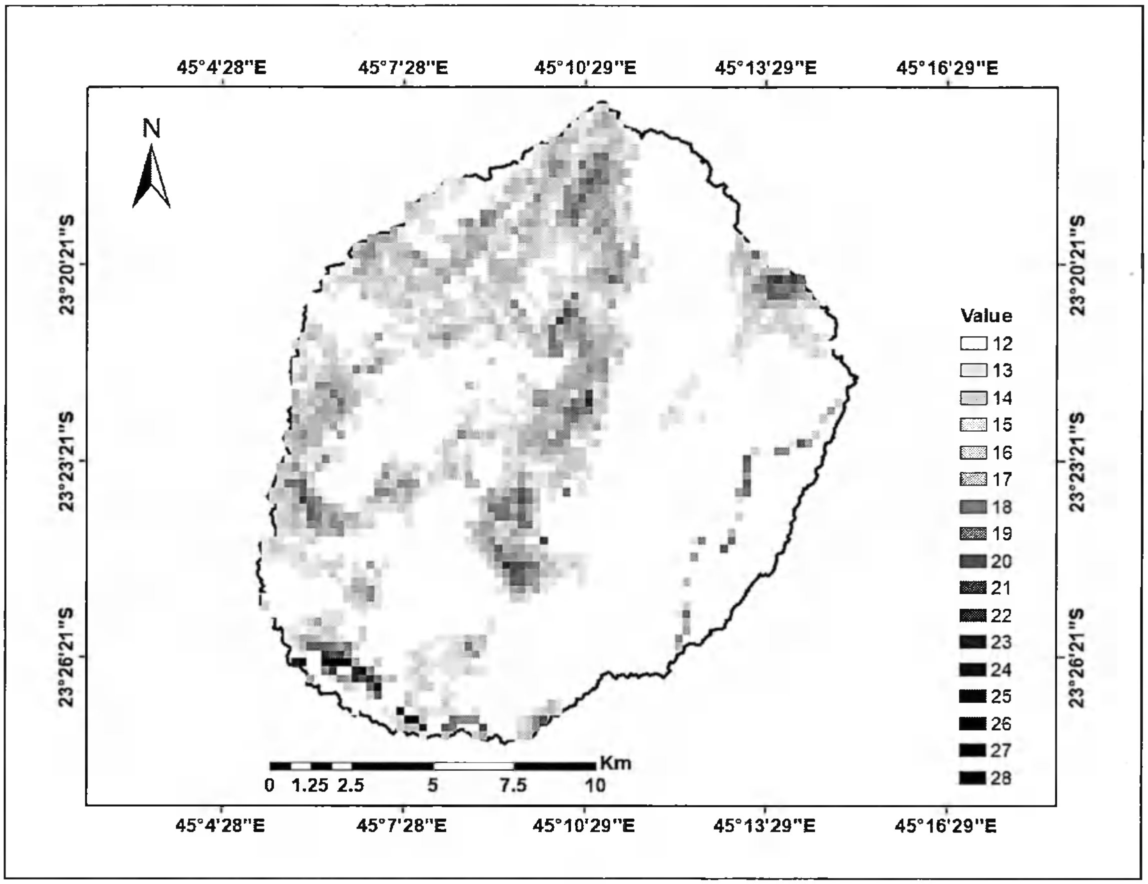

Figure 5.30: High Concentration of Soil Organic Carbon (in g per kg) in the Study Area

The concentration value of clay content ranges from 15 to 35 per cent. In order to generate a map of only the higher concentrations, I employed the *Set Null* tool to exclude values lower than 23. (Figure 5.31).

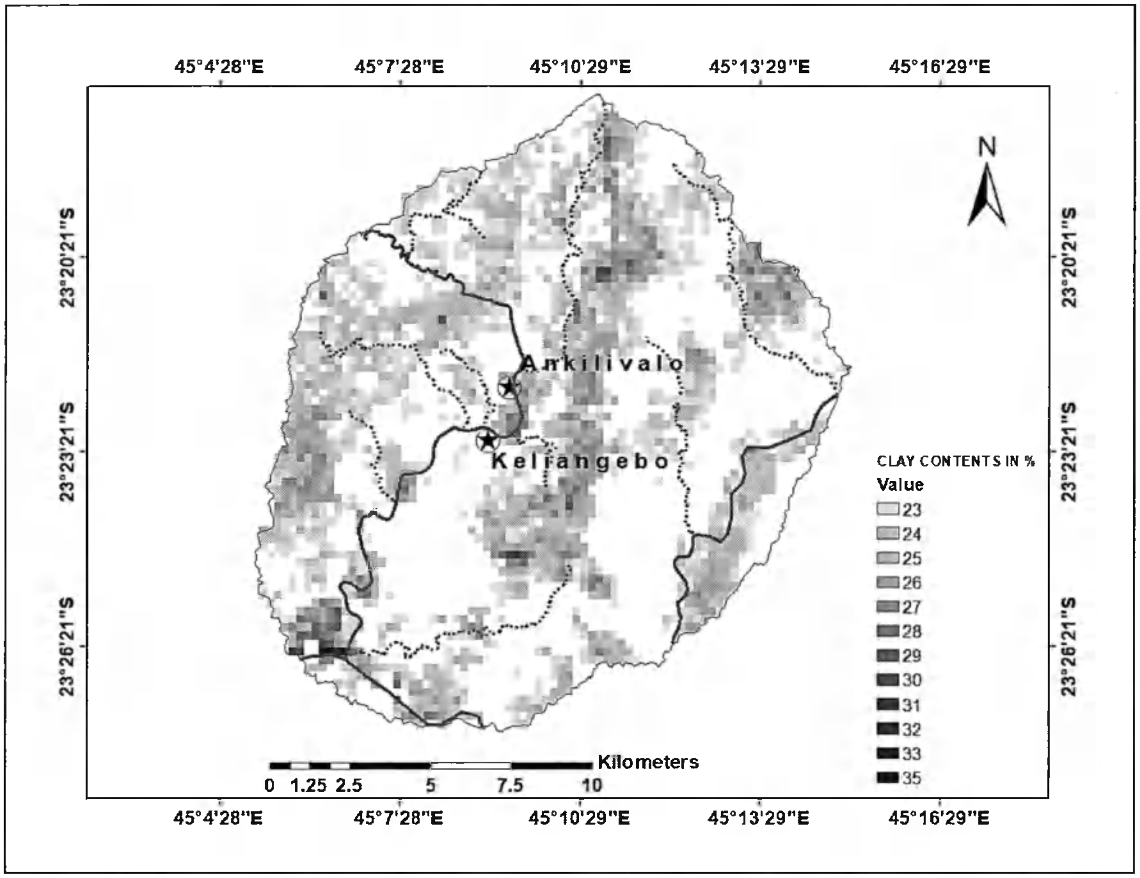

Figure 5.31: Higher Clay Contents Mass Fraction in % (Source: www.soilgrids.org)

I then ran the two layers in the *Raster Calculator* tool (*ArcToolbox* > *Spatial Analysis Tool* > *Map Algebra* > *Raster Calculator*) using the '&' function to find out where the two layers intersect. The resulting layer represents the potential fertile soil of the study area (Figure 5.32).

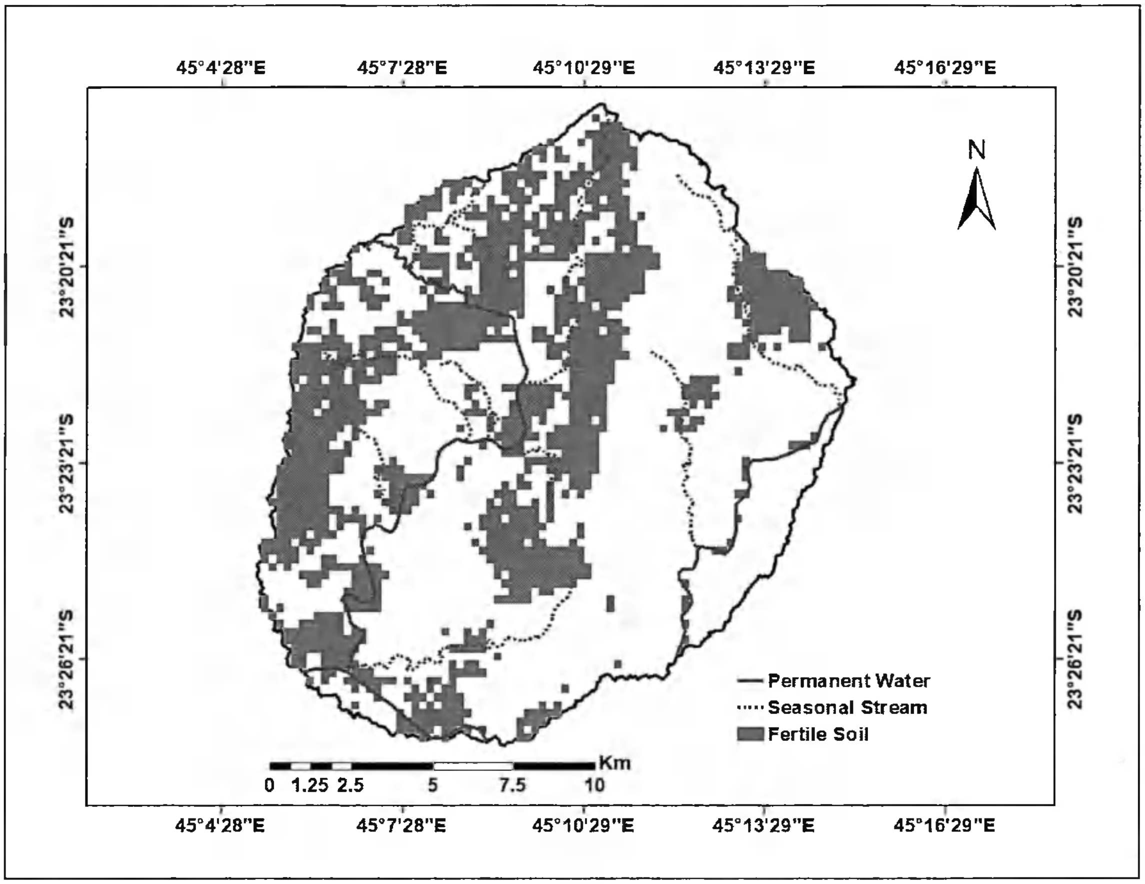

Figure 5.32: Potential Fertile Soils in the Study Area

Some of the generated fertile soils are located on steep slopes that could not have been tilled, and I intersected the layer with a layer of slope less than 45 degrees in order to generate a map of fertile soil on flatter (less than 45 degrees) terrains only, using the *Set Null* tool (Figure 5.33).

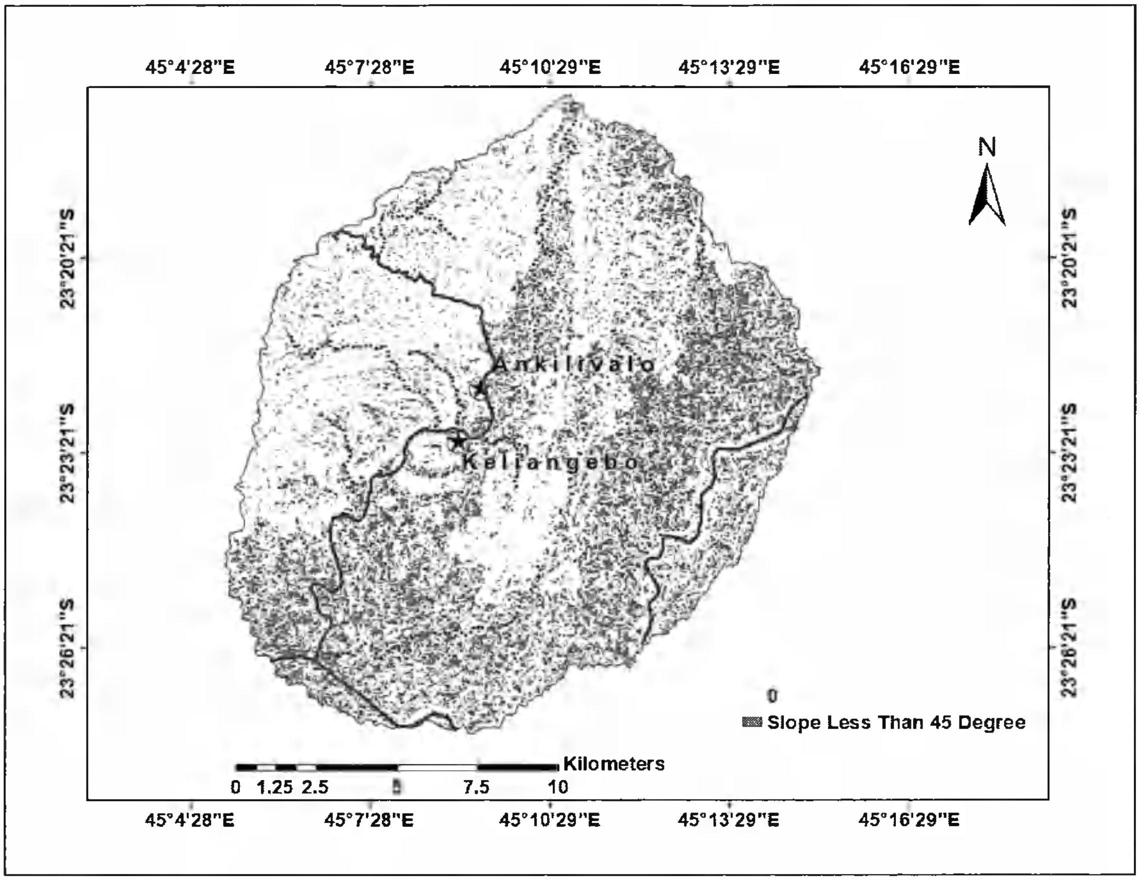

Figure 5.33: Slope Layer Less Than 45 Degrees in the Study Area

I then ran the *Raster Calculator* tool using the "&" function to generate a map of overlap between the slope layer of less than 45 degrees and the potential fertile soils. The output layer represents the potential arable lands in the study area (Figure 5.34).

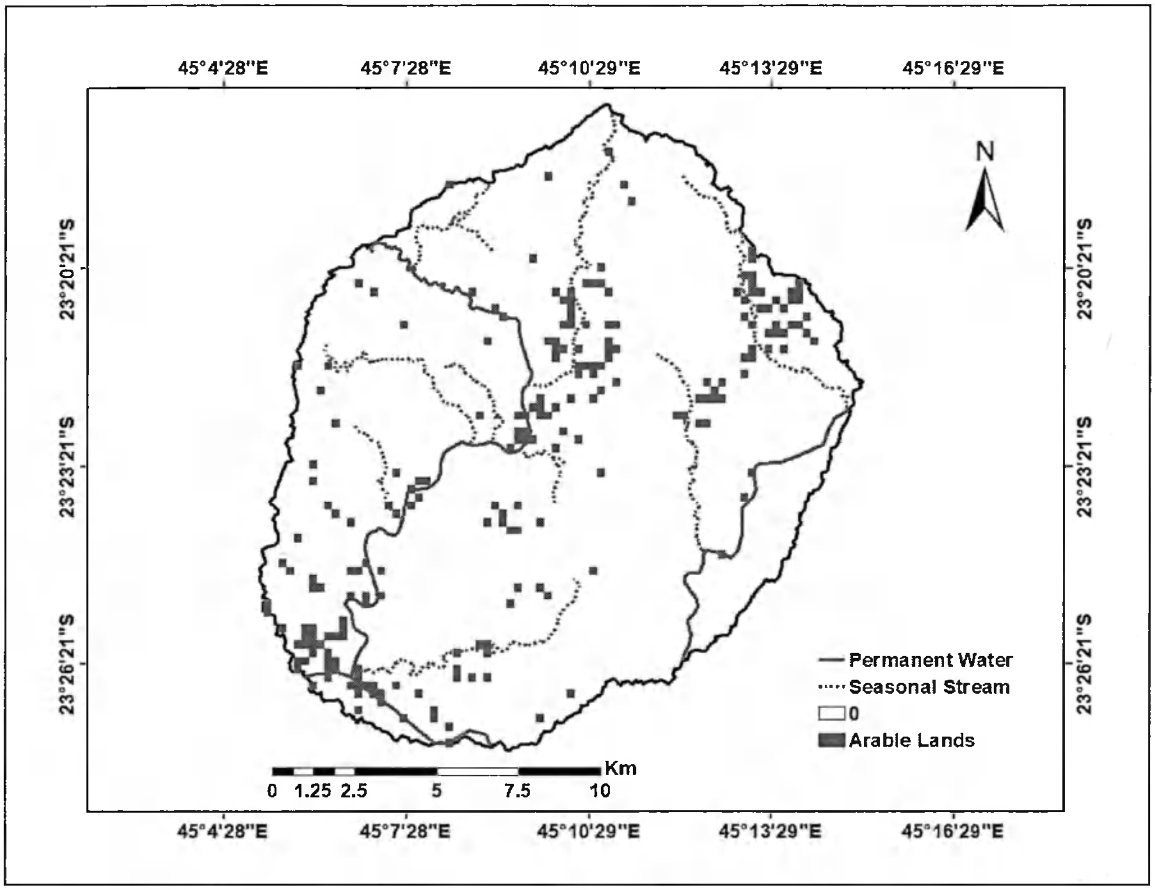

Figure 5.34: Potential Arable Lands in the Study Area

The above map is used in Chapter Seven to conduct a proximity analysis between archaeological sites and potential arable lands.

I matched a vector layer of current farming fields with the potential arable lands using the *Intersect* tool (*ArcToolbox* > *Analysis Tools* > *Overlay* > *Intersect*) to see where the two overlap. The result showed that 229.173 ha out of the 857.68 ha current farming fields (26.72 %) intersect with the distribution of arable lands (Figure 5.35).

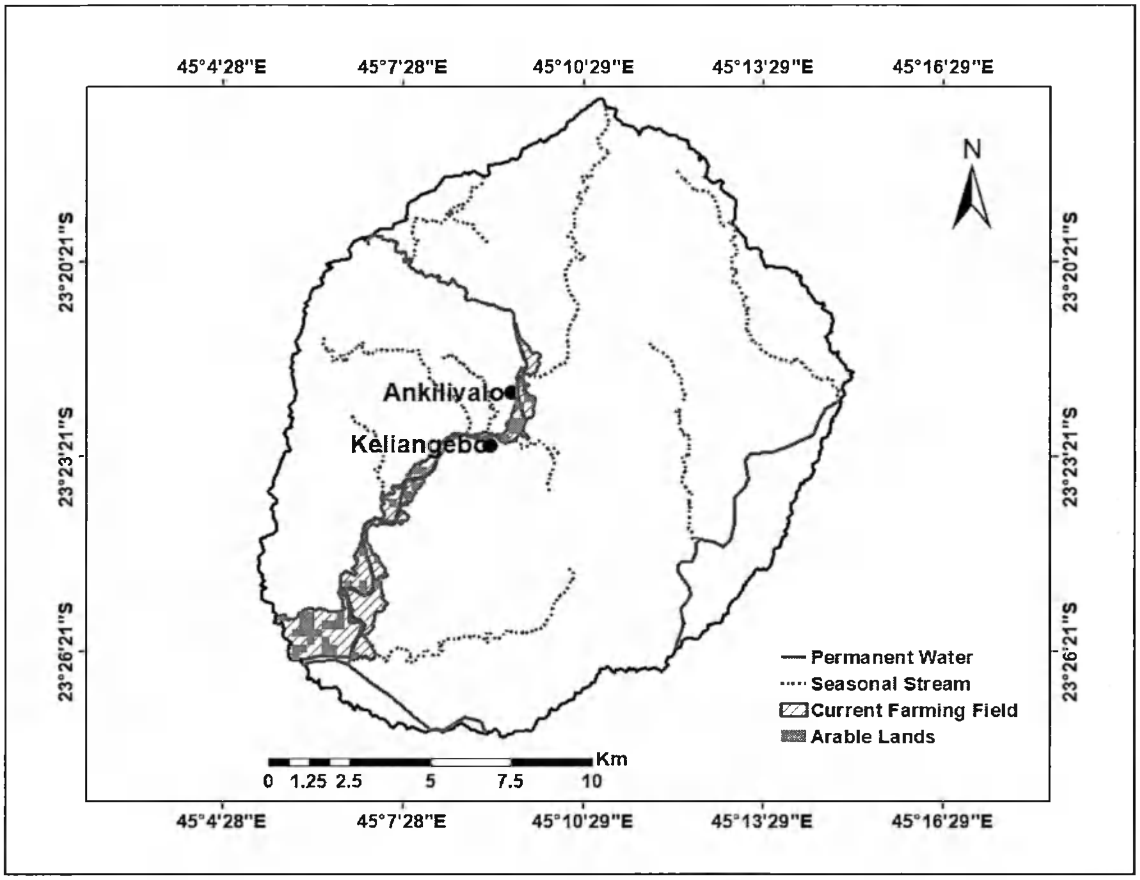

Figure 5.35: Potential Arable Lands Intersecting Current Farming Field

5.3.4.4.Mapping Vegetation Cover (Forests and Grasslands)

To determine whether proximity to grassland and forest patches influenced settlement decisions, I assessed their propinquity to archaeological sites.

Different types of vegetation cover were digitized from the ArcMap's Imagery basemap. Based on local land uses, I classified vegetation cover in five categories, namely deciduous forest, *Tapia* forest (Sclerophyllous 'Uapaca' woodland), scrubland, Horombe grassland, and Isalo grassland (Figure 5.36 and Figure 5.37). Local uses of these vegetation types are detailed in Chapter 3.

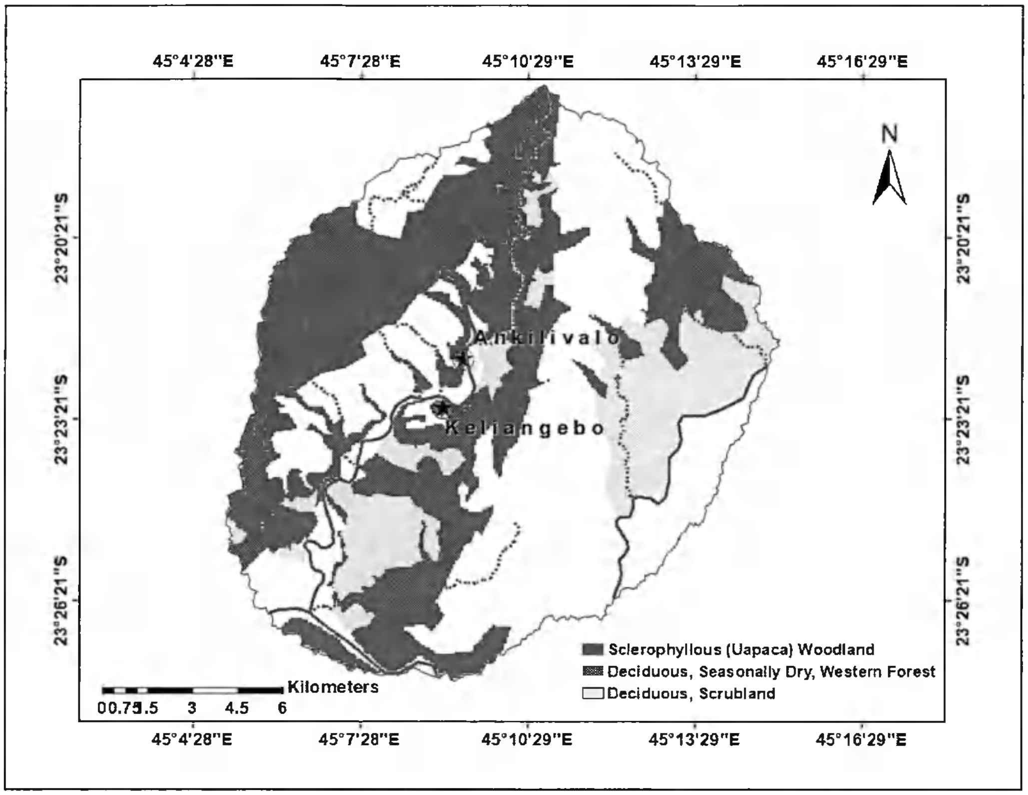

Figure 5.36: Forest Patches in the Study Area

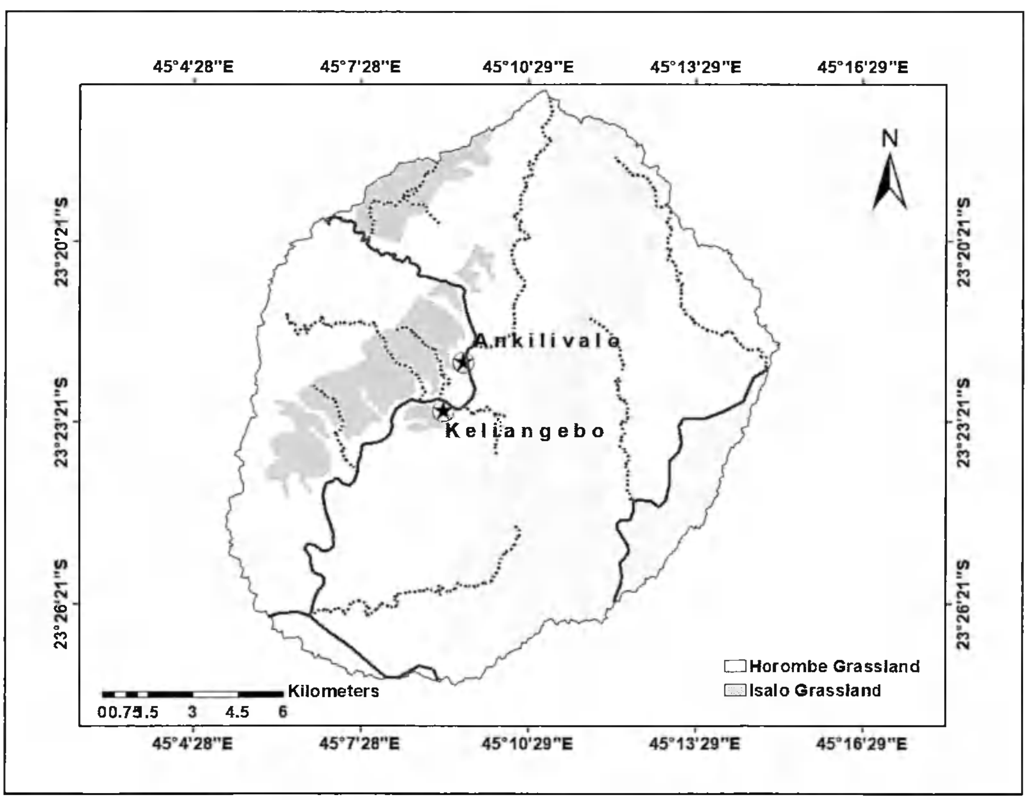

Figure 5.37: Grasslands in the Study Area

To determine the biomass of vegetation types, I used imagery from LANDSAT 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) to generate their Normalized Difference Vegetation Index (hereafter NDVI). Eleven grayscale separate band files were all useful in this analysis (Table 5.7).

Table 5.7: LANDSAT 8 Operational Land Imager and Thermal Infrared Sensor (After https://landsat.usgs.gov/what-are-best-spectral-bands-use-my-study)

Band	**Wavelength**	**Useful for mapping**
Band 1 – Coastal Aerosol	0.435 - 0.451	Coastal and aerosol studies
Band 2 – Blue	0.452 - 0.512	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 3 - Green	0.533 - 0.590	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - Red	0.636 - 0.673	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.851 - 0.879	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.566 - 1.651	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.107 - 2.294	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.503 - 0.676	15-meter resolution, sharper image definition
Band 9 – Cirrus	1.363 - 1.384	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100-meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.50 - 12.51	100-meter resolution, Improved thermal mapping and estimated soil moisture

I combined the bands and turned them into a single raster dataset to get an analyzable color image. To do so, I used the *Composite Bands* tool in ArcMap (*ArcToolbox > Data Management Tools > Raster > Raster Processing > Composite Bands)*. By default, ArcMap assigns Band 1 to Red channel, Band 2 to Green channel, and Band 3 to Blue channel. This setting makes the appearance of the color image unusual, since in Landsat 8 OLI (see Table 5.7) the Red channel corresponds to Band 4, Green to Band 3, and Blue to Band 2. I thus reassigned these bands to their right channels (i.e. Red = Band_4, Green = Band_3, and Blue = Band_2). To do so, one right clicks the layer, goes to *Properties*, then to the *Symbology* tab, and finally assigns the new colors to the bands.

I used NDVI as a proxy for plant health, on the assumption that healthy plants absorb red and blue light for photosynthesis and reflect green and more near infrared (NIR) light (Hill *et al.* 2014: 184). And vice versa for a stressed vegetation.

To calculate the NDVI, I used the following algorithm:

$$NDVI = \frac{NIR - Red\ Light}{\mathrm{NIR + Red\ Light}}$$

I ran this algorithm in the *Raster Calculator* tool (*ArcToolbox > Spatial Analyst Tools > Map Algebra > Raster Calculator*) using Band_4 to represent the red light and Band_5 to represent NIR light. As the values for the input bands are integer raster, I converted them into floating point raster by using the *Float()* function during the calculation:

$$MSV\ NDVI = \frac{\mathrm{Float(Band\ 5 - Band\ 4)}}{\mathrm{Float(Band\ 5 + Band\ 4)}}$$

The logic behind the algorithm is that: when the NIR reflectance increases, so does both the dividend and the divisor (normalization). When the red light reflectance increases, the dividend decreases and the divisor increases, driving the outcome down to zero or a negative number. The returned values of a NDVI calculation range from 1 to -1. Healthy vegetation has value closer to 1, stressed vegetation closer to 0, and bare lands or other features without vegetation below 0.

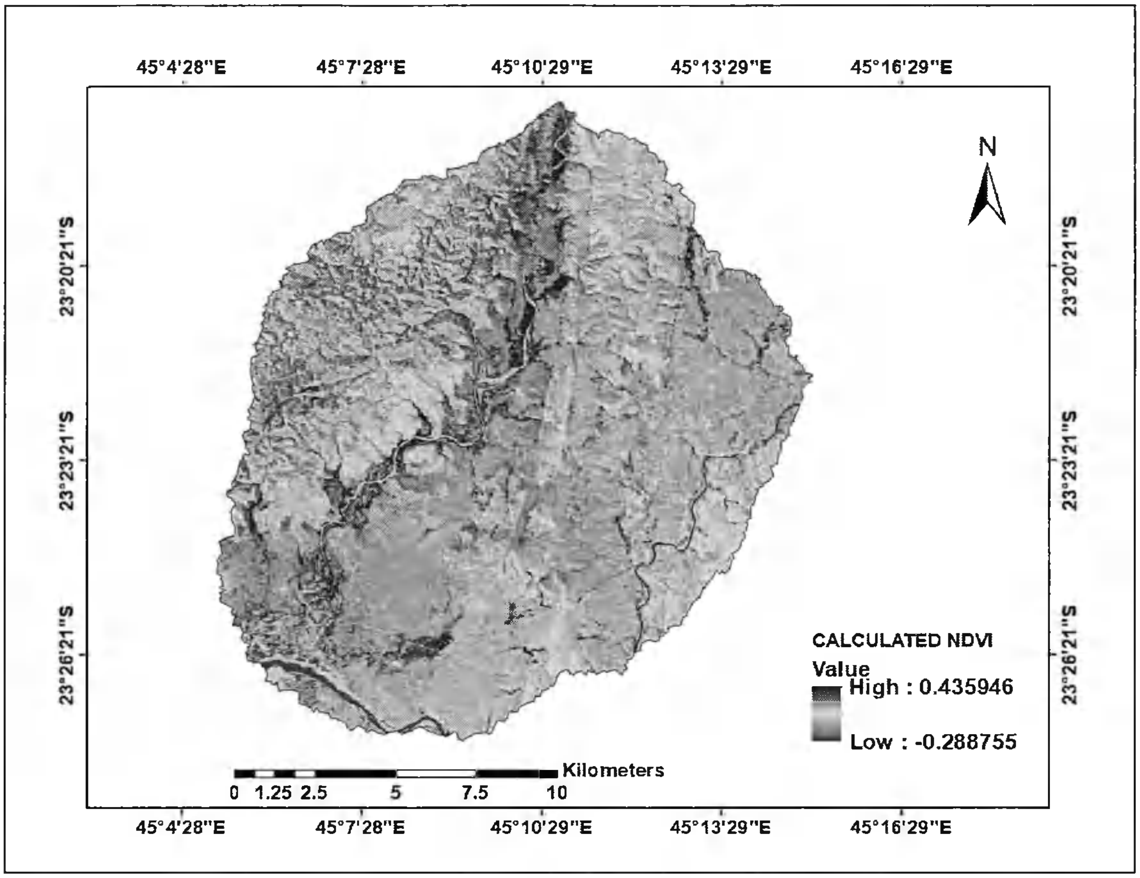

Figure 5.38: Calculated NDVI for the Study Area

NDVI values for the study area range from -0.28 to 0.43. To distinguish vegetation cover from non-vegetation features, I used the *Set Null* tool to exclude all values equal or less than 0 in the NDVI layer (*ArcToolbox* > *Spatial Analyst Tools* > *Conditional* > *Set Null*). This generates a new NDVI layer showing only vegetation cover (Figure 5.39).

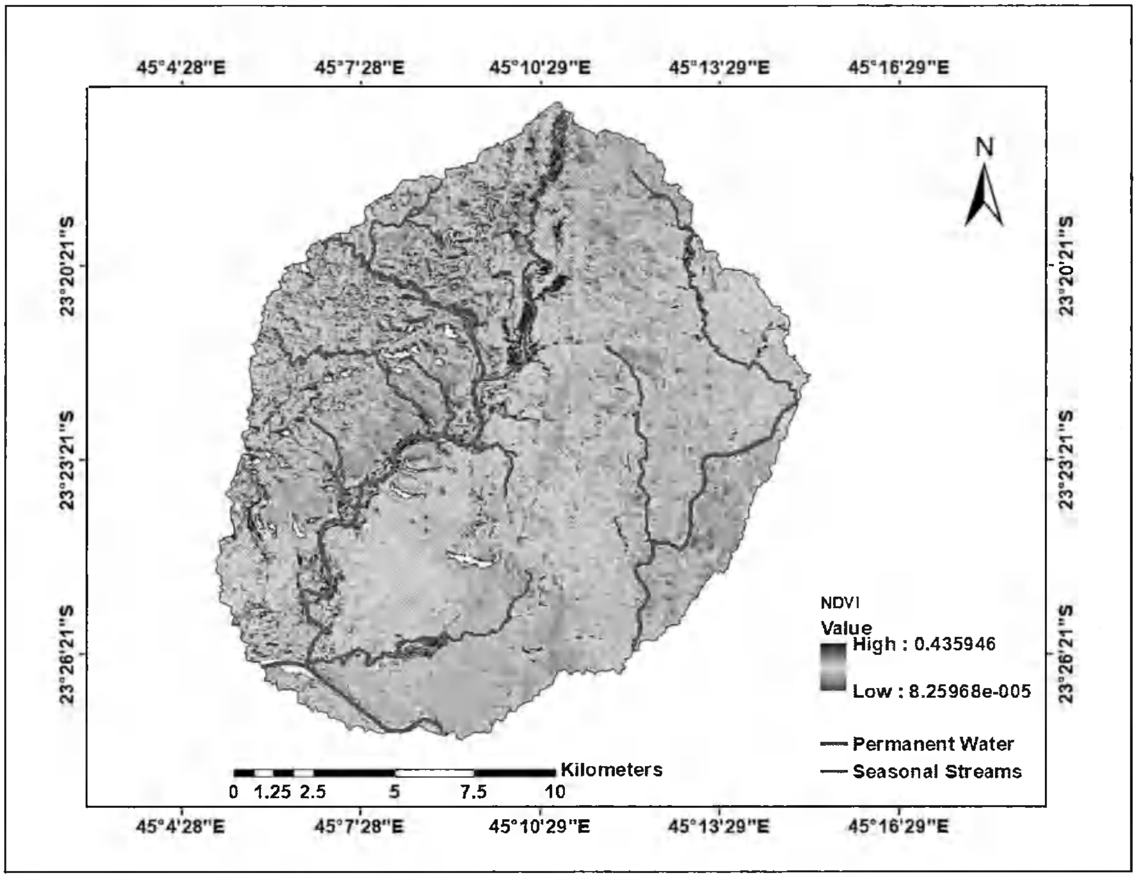

Figure 5.39: NDVI for Vegetation Cover Only

The result shows a higher biomass (abundant vegetation) around the valley and some canyons. These are more likely to represent fields and gallery forests. Lower biomass (sparse vegetation) corresponds to open areas and some hilly locations. These are more likely to represent scrublands and grasslands

This information is important in determining which part of the study area are likely wetter and most suitable for cultivation. Figure 5.38, for example, reflects why modern and ancient occupation sites are more concentrated along the Sakamarekely Valley than the Maloto Valley, even though both places have high flow accumulations.

5.3.5. Site Defensibility Analyses

Differing criteria are used to assess the defensibility of a habitation site (for more details see Bocinsky 2014; Jones 2010; Martindale and Supernants 2009). This study assesses three: visibility, accessibility, and elevation. Visibility calculates viewshed size from a site, while accessibility counts the number of least cost paths accessing the site and degree of slope at its access points. Site elevation compares the height of an archaeological site with its immediate surroundings.

5.3.5.1. Visibility Analysis

Visibility analysis looks at two features, namely lines-of-sight and viewshed (Wheatley and Gillings 2002). Lines-of-sight is the mutual visibility between two points in the landscape, while viewshed is all regions that can be seen from a vantage point (Bocinsky 2014: 165; Jones 2006: 6, 525, 537; Llobera 2003; O'Sullivan and Unwin 2003; Sakaguchi *et al.* 2010: 1175). My site defensibility analysis focused only on viewshed.

Viewshed Analysis

This study analyzes viewsheds, on the assumption that the occupants of a site with larger viewsheds can see enemies approaching and can therefore defend it more easily (Bocinsky 2014: 165; Jones 2010: 3, 6). I first located four vantage points (North, East, South and West) within the site that seemed to have a good command of outlook view (Jones 2006: 527). After recording their GPS coordinates, I generated their viewshed sizes by running the DEM in the *Viewshed* tool in ArcMap (*ArcToolbox > Spatial Analyst Tools > Surface > Viewshed*), and estimating the height of the viewer at 1 m above surface level (see Jones 2010: 6). The sum of viewshed sizes constitutes the site's total viewshed (Connoly and Lake 2006; Jones 2010: 6; Llobera 2003; Verhagen 2018: 18). Viewshed analysis shows a binary result of number 1 (visible cells) and 0 (not visible cells) (Jones 2006: 524; Wheatley and Gillings 2000: 10). But the number of visible cells can also be counted. This is what is called 'viewshed size' in this study. A site with 11,897 visible cells or more (= 5% of the study area) was judged as having a good commanding viewshed.

To avoid edge effect on my viewshed analysis, I used the non-delimited DEM as my input raster, then clipped the output with the delimited one. That is, I only considered the viewshed within my study area. Results of viewshed analysis are detailed in Chapter 7.

5.3.5.2. Accessibility Analysis

The accessibility of a site is a ''measure of ease" of access (Bocinsky 2014: 166; Martindale and Supernant 2009: 195). A site with easy access is judged to be vulnerable to attackers, while a site with difficult access can be considered defensible (Bocinsky 2014: 164; Martindale and Supernant 2009: 195).

Number of Least Cost Path (LCP) Accessing the Site

The number of paths accessing a site is used to assess its defensibility and vulnerability, on the assumption that a defensible site should not be accessible from all directions. A site with many accesses is easily attacked. I generated least cost paths from 8 different directions (North, Northeast, East, Southeast, South, Southwest, West, and Northwest) and counted how many paths reach the site (Cooper 2010: 131; Herzog

2014). Paths ending at the same access point are counted as one access. Results of this analysis are given in Chapter 7.

The degree of Slope at the Site's Access Point(s)

A site with steep slope access is hard to reach, and I estimated the degree of slope at the access points of each site in a further assessment of its defensibility. I placed points along each of the above LCPs accessing a site, and extracted their slope value from the slope layer using the *Extract Values to Points* tool (*ArcToolbox > Spatial Analyst Tools > Extraction > Extract Values to Points*). A slope is scaled from 0 to 90 degrees. I judged a site to be defensible if more than fifty percent of its points of access are greater than 57.79630221 degrees (see Jones 2010: 7; Bocinsky 2014: 165).

5.3.5.3. ***Site Elevation***

Elevation is used to determine whether a site is more defensible than its surroundings, assuming that sites located at higher locations are more defensible than those located at lower places.

I calculated the difference between the elevation of a site and the mean elevation of its surroundings (see De Reu *et al.* 2011: 3438; Gallant and Wilson 2000). To do so, I created a buffer ring of 100-500m radius around the point representing each site using the *Multiple Ring Buffer* tool (*ArcToolbox > Analysis Tools > Proximity > Multiple Ring Buffer*). The size of the buffer ring was chosen to detect small differences in immediate landscape features (see De Reu *et al.* 2011: 3438).

I then generated 250 random points within that buffer (*ArcToolbox > Data Management Tools > Sampling > Create Random Points*), extracted the elevation of each point from a DEM by using the *Extract Values to Points* tool (*ArcToolbox* > *Spatial Analyst Tools* > *Extraction* > *Extract Values to Points*), and calculated their mean elevations (De Reu *et al.* 2011: 3438). I then subtracted the mean elevation from the height of the archaeological site. If the result is positive, the archaeological site is located in a higher place than the buffered area. If the result is negative, the archaeological site is located lower than the buffered area (De Reu *et al.* 2011: 3438).

5.3.5.4.Synthesizing the Site Defensibility

Total site defensibility was assessed with four criteria including (1) viewshed sizes, (2) number of LCPs accessing the site, (3) degree of slope at its accessing point(s), and (4) elevation advantage vis-à-vis the surrounding landscape. I assigned the results of each analysis to 0 (not defensible) or 1 (defensible), and summed all values for each site to generate a total defensibility value. As there are three criteria, the total defensibility is scaled from 0 (not defensible) to 3 (extremely defensible) (Bocinsky 2014: 166; Jones 2006: 527).

Both archaeological sites and random site locations were subject to defensibility analysis to reveal whether archaeological sites were more/less defensible than random sites. Results of defensibility analysis are in Chapter 7.

CHAPTER SIX: FIELD DATA PRESENTATION, ANALYSES AND INTERPRETATION

This chapter presents, analyzes and interprets data recorded during my fieldwork along the Middle Sakamarekely Valley (MSV), in southwest Madagascar. It specifically deals with finds from systematic surveys, intrasite surveys, and excavations.

6.1. Systematic Survey Results

My systematic survey documented a range of sites including isolated finds, shelter sites, and open-air habitation sites along the MSV and in the Isalo Massif (Figure 6.1). *Isolated finds* are non-habitation places where I encountered few archaeological objects, which might be remains of temporary activities of occupants of habitation sites. *Shelter sites* are caves or rock shelters that have archaeological materials on the surface. Cave paintings sites were also considered as shelter sites whether or not they have cultural materials on the surface (Plate 6.1; Plate 6.2); and finally, *habitation sites* are places with scatters of archaeological objects in a relatively wide area, which I therefore deemed dwellings or villages, depending on the scale.

Site catalogs are detailed in Appendix 6.1, and the following sections summarize the two field seasons (2014 and 2015):

6.1.1. Field Season 2014 Systematic Survey

The 2014 survey of 67 grids of 500x500m (Figure 6.1) recorded habitation sites, shelter sites and isolated finds along the MSV and in the Isalo Massif. Finds are listed in Table 6.1.

Table 6.1: Finds during the 2014 Field Survey

#	Grid #	Type of Site	Type of Finds	Locations (in Decimal Degrees)
1	72	Isolated Finds	Scatters of Potsherds	-23.3847; 45.13982
2	73	Isolated Finds	Scatters of Potsherds	-23.38654; 45.1452
3	73	Isolated Finds	Scatters of Potsherds	-23.38595; 45.1464
4	74	Habitation Site	Scatters of Potsherds, Grinding stones	-23.386255; 45.14896
5	85	Shelter Site	Rockshelter, and scatters of potsherds	-23.37977; 45.147655
6	86	Isolated Finds	Scatters of Potsherds	-23.38095; 45.15169
7	98	Isolated Finds	Isolated Potsherds	-23.37695; 45.155025
8	108	Shelter Site	Rock Paintings Site	-23.37446; 45.14155
9	109	Isolated Finds	Imported Ceramic (Longquan Celadon)	-23.37243; 45.14319
10	109	Shelter Site	Rock Paintings Site	-23.371; 45.147
11	111	Habitation Site	Scatters of Potsherds, Faunal Remains	-23.37268; 45.155
12	124	Habitation Site	Scatters of Potsherds	-23.15434; 45.15434
13	135	Isolated Finds	Scatters of Potsherds	-23.363469; 45.154924
14	135	Isolated Finds	Scatters of Potsherds	-23.362413; 45.155001
15	145	Isolated Finds	Scatters of Potsherds	-23.359866; 45.155252
16	146	Isolated Finds	Scatters of Potsherds	-23.36158; 45.15645
17	162	Isolated Finds	Scatters of Potsherds	-23.350263; 45.151347
18	163	Isolated Finds	Scatters of Potsherds	-23.35332; 45.15583
19	163	Isolated Finds	Scatters of Potsherds	-23.352508; 45.154177
20	163	Isolated Finds	Scatters of Potsherds	-23.352636; 45.153121
21	163	Isolated Finds	Scatters of Potsherds	-23.353295; 45.153131
22	163	Isolated Finds	Scatters of Potsherds	-23.353295; 45.153131
23	164	Isolated Finds	Scatters of Potsherds	-23.352461; 45.156261
24	167	Isolated Finds	Scatters of Potsherds	-23.349031; 45.154975
25	173	Shelter Site	Rock Paintings Site,	-23.340858; 45.147658
26	173	Isolated Finds	Scatters of Potsherds	-23.340711; 45.150456

Plate 6.1: Rock Paintings Site in Grid 173 (Season 2014)

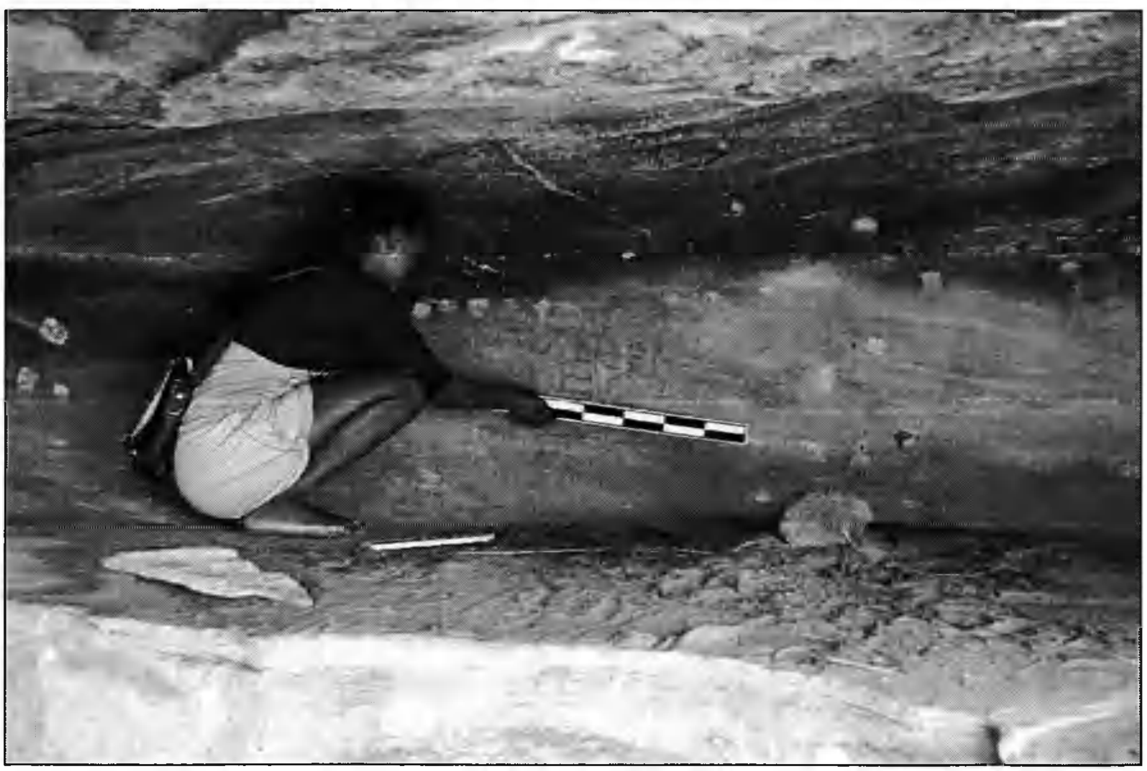

Plate 6.2: Rock Paintings Site in Grid 108 (Season 2014)

The survey suggested that people occupied different parts of the study area at different periods in the past. An imported ceramic – Longquan Celadon encountered at Grid 109 in the Isalo Massif – indicated that the area was occupied during the 13^{th} – 15^{th} centuries CE, and that its occupants had access to trade items (see Radimilahy 1998; Table 6.1). Graphite-coated potsherds decorated with incised lines and triangular impressions from Keliangebo, and isolated finds, suggested that people occupied the MSV during the 16^{th} – 17^{th} centuries CE (Parker Pearson 2010; Rakotoarisoa 1997), while red-slipped plainware potsherds from Ankilivalo and isolated finds indicated that the study area was occupied during the 18^{th} – 19^{th} centuries CE (Henry Wright and Chantal Radimilahy *pers. Comm.*). I observed that the majority of surface materials were concentrated near the Sakamarekely River (Figure 6.1), suggesting that human activities were concentrated in the valley.

The 2014 survey offered opportunities to study socio-ecological interactions through time and space along the MSV, and I decided to continue surveys within the remaining grids in the 2015 field season.

6.1.2. Field Season 2015 Systematic Survey

Surveys in 107 grids along the MSV discovered isolated finds, shelter sites, and habitation sites (Figure 6.1). Finds are listed in Table 6.2.

Table 6.2: Recapitulation of Finds Encountered during the 2015 Field Survey

#	Grid #	Type of Site	Finds	Locations (in Degrees)
1	1	Isolated finds	Scatters of Potsherds	-23.41303; 45.1075
2	1	Isolated finds	Scatters of Potsherds	-23.4151; 45.1104
3	4	Isolated finds	Scatters of Potsherds	-23.41424; 45.1228
4	7	Isolated finds	Scatters of Potsherds	-23.4108; 45.1145
5	9	Isolated finds	Scatters of Potsherds	-23.40826; 45.1238
6	10	Isolated finds	Scatters of Potsherds	-23.41107; 45.12712
7	22	Isolated finds	Scatters of Potsherds	-23.4017; 45.1266
8	22	Isolated finds	Scatters of Potsherds	-23.40286; 45.12491
9	31	Isolated finds	Scatters of Potsherds	-23.39798; 45.1207
10	32	Isolated finds	Scatters of Potsherds	-23.39757; 45.12862
11	33	Isolated finds	Scatters of Potsherds	-23.39614; 45.12993
12	47	Isolated finds	Scatters of Potsherds	-23.39185; 45.13416
13	60	Isolated finds	Scatters of Potsherds	-23.3898; 45.13425
14	62	Isolated finds	Scatters of Potsherds	-23.38762; 45.1453952
15	78	Shelter Site	Rockshelter, and Scatters of Potsherds	-23.38317; 45.16773
16	112	Isolated finds	Scatters of Potsherds	-23.3725; 45.1592

The 2015 survey yielded 16 sites, fewer than in 2014, but the distribution of surface materials corroborated the 2014 conclusion that people concentrated their activities near the Sakamarekely River. Apart from a few rock art sites in the Isalo Massif, the farthest site was only **1,106 m** from the Sakamarekely River (within Grid 78) (see Figure 6.1). The MSV seemed to have been quite densely populated in the past, as at present. Meanwhile, the current occupation of the lower valley is much denser than the MSV, suggesting that a survey of the lower valley might be promising for future research.

I recorded a total of 42 sites during the 2014 and 2015 surveys (Figure 6.1; Table 6.1 and Table 6.2).

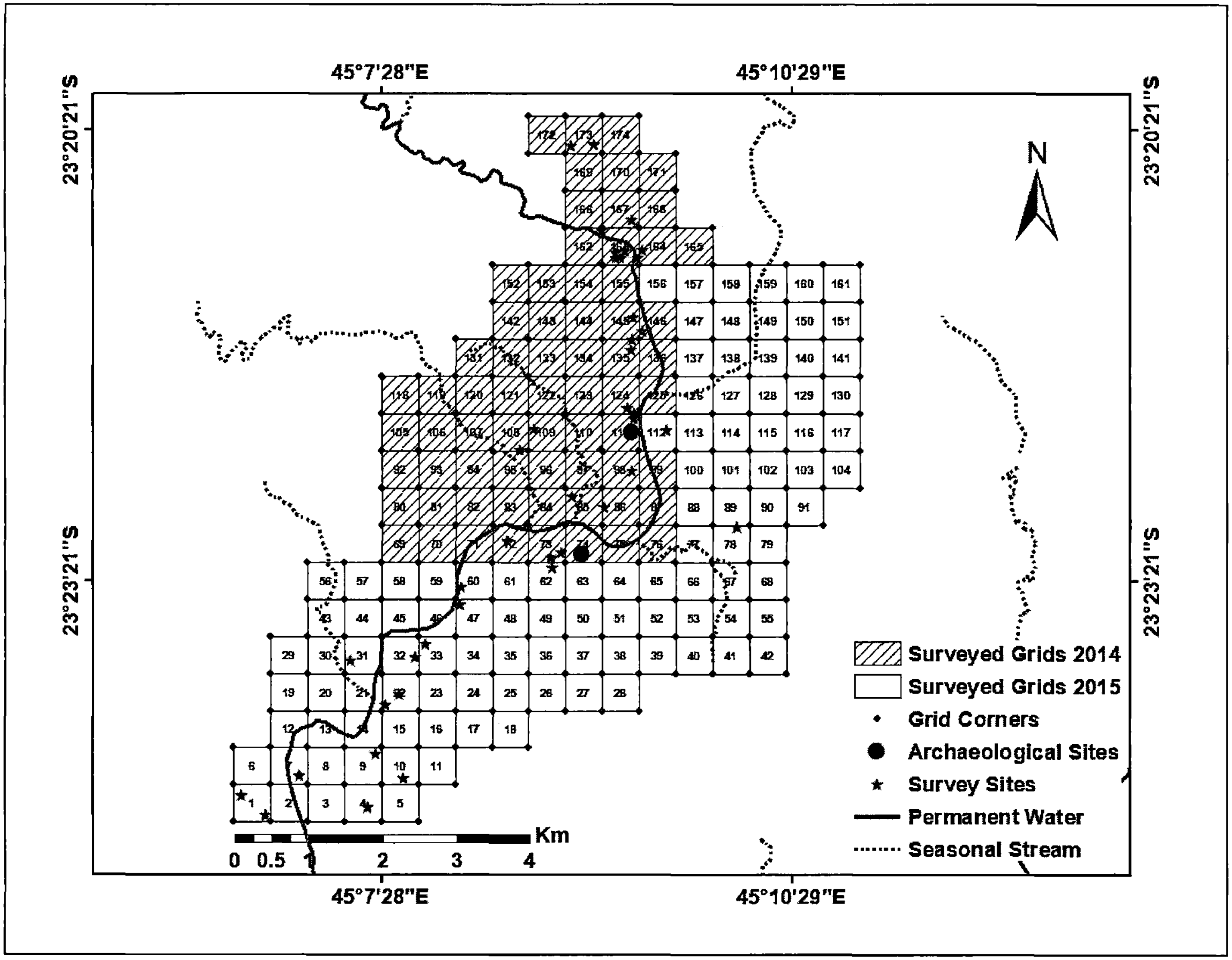

Figure 6.1: Surveyed Grids and Survey Sites

6.2. Intrasite Survey Results

After the systematic surveys, I conducted intrasite surveys at Ankilivalo in 2015, and at Keliangebo in 2016.

6.2.1. Ankilivalo Intrasite Survey

The site of Ankilivalo is located in the foothills above the SMV (Plate 6.3), geographically positioned at -23.37275, 45.15515, and between 277 m and 289 m above sea level.

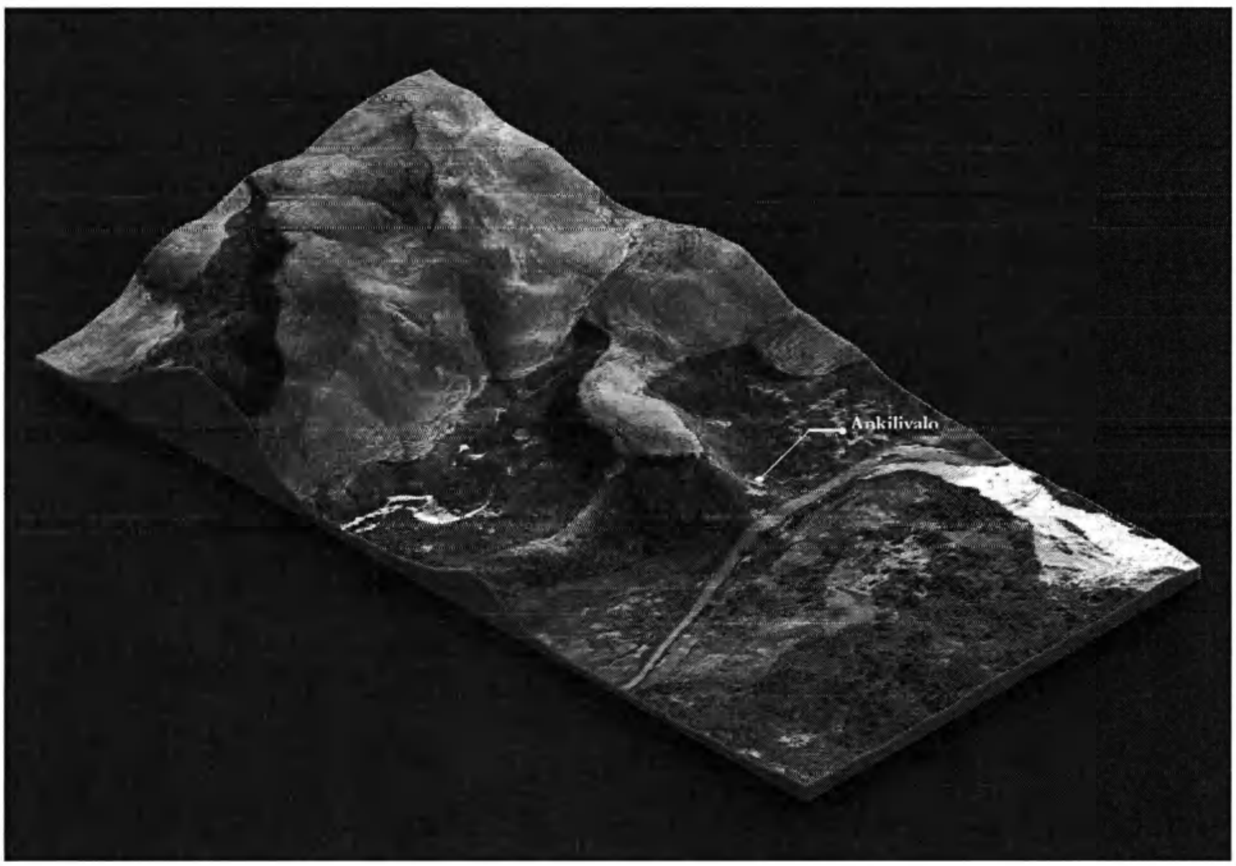

Plate 6.3: The Foothill Site of Ankilivalo and Its Immediate Surroundings

Sherds at Ankilivalo were undecorated and crude, suggesting they were not for artistic or prestige display, and I did not find any imported ceramics at the site. My first impression was that the occupants of Ankilivalo were humble people, who did not own imported materials and sophisticated items, suggesting impoverished community. However, remains of cattle scattered across the site's surface (see Figure 6.2) suggested consumption of a good amount of meat. Based on ethnohistorical records for the last 400 years, commoners rarely consumed meat. Only elites and rich people could afford to slaughter their livestock and eat meat. This leaves room to reconsider the occupants of Ankilivalo as 'sumptuous,' contrary to my first impression. The economic status of the site's occupants is pertinent in that it pertains to how vulnerable or resilient the community were vis-à-vis the unpredictable climate and the insecurity during the 18^{th} – 19^{th} centuries CE. This may play a role in their motivation to respond to the situations.

Within the 43 grids laid out at Ankilivalo (Figure 6.2), I recorded 3017 potsherds, 478 faunal remains, 23 grinding stones, five glass fragments, three ochre fragments, one seashell jewel, and one gunflint (Table 6.3). The spatial distribution of these objects was uneven. They were concentrated in the northwest and northeast, and almost absent in the southern part of the site (see Figure 6.2). My first thought was that materials might have been washed downhill by rainwater, because the terrain at Ankilivalo slopes from south to north (see Figure 6.3). However, my assistant from the Department of Earth Sciences at the University of Toliara observed that soils in the (uphill) southern part of the site differed from those downslopes to the north. The former originated from the exfoliation of adjacent sandstone, and I suspected that this colluvial soil layer buried a cultural layer connected to the soil in the north. To find out, I decided to shovel-test the site before excavating.

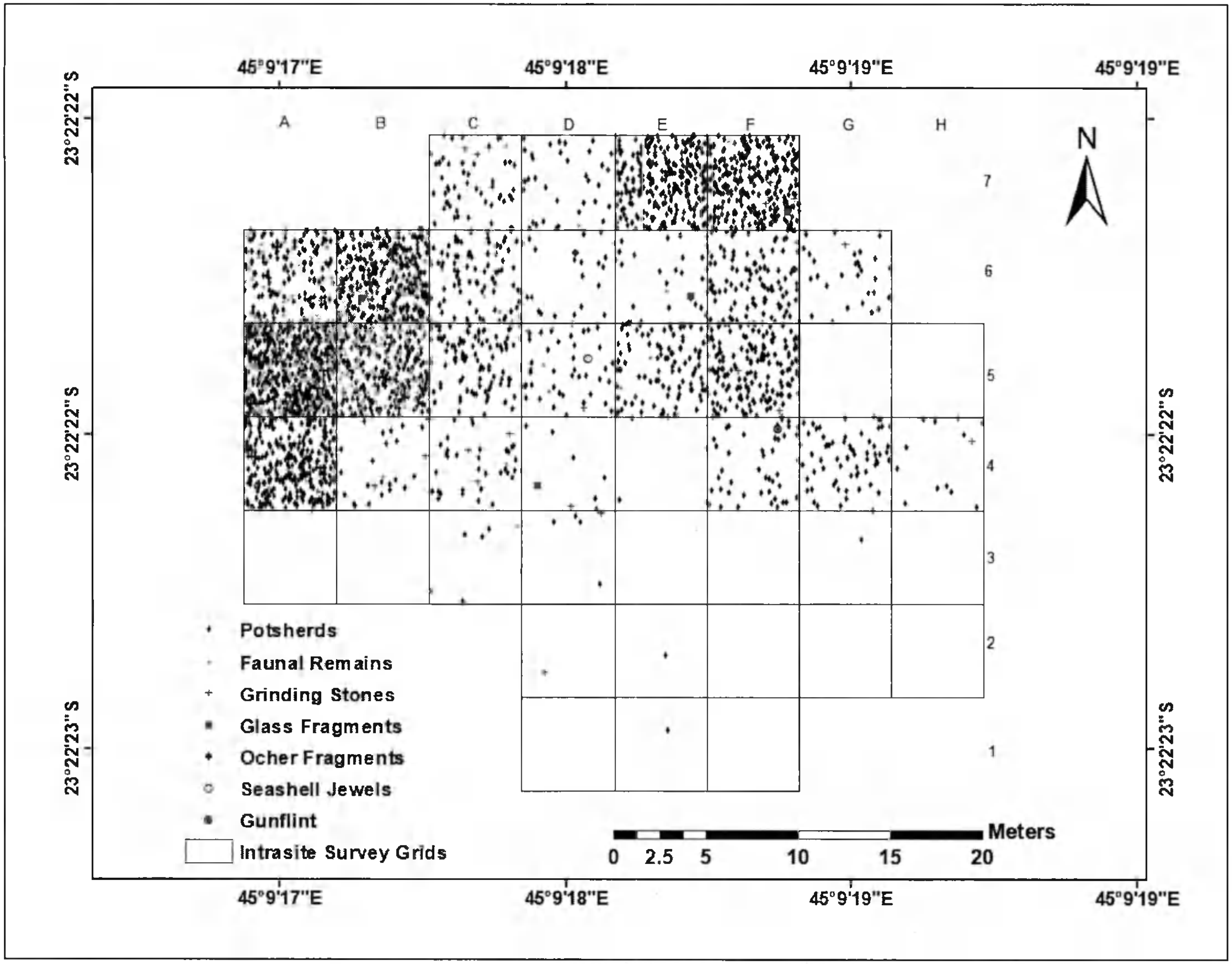

Figure 6.2: Distribution of Surface Materials at Ankilivalo (Field Season 2015)

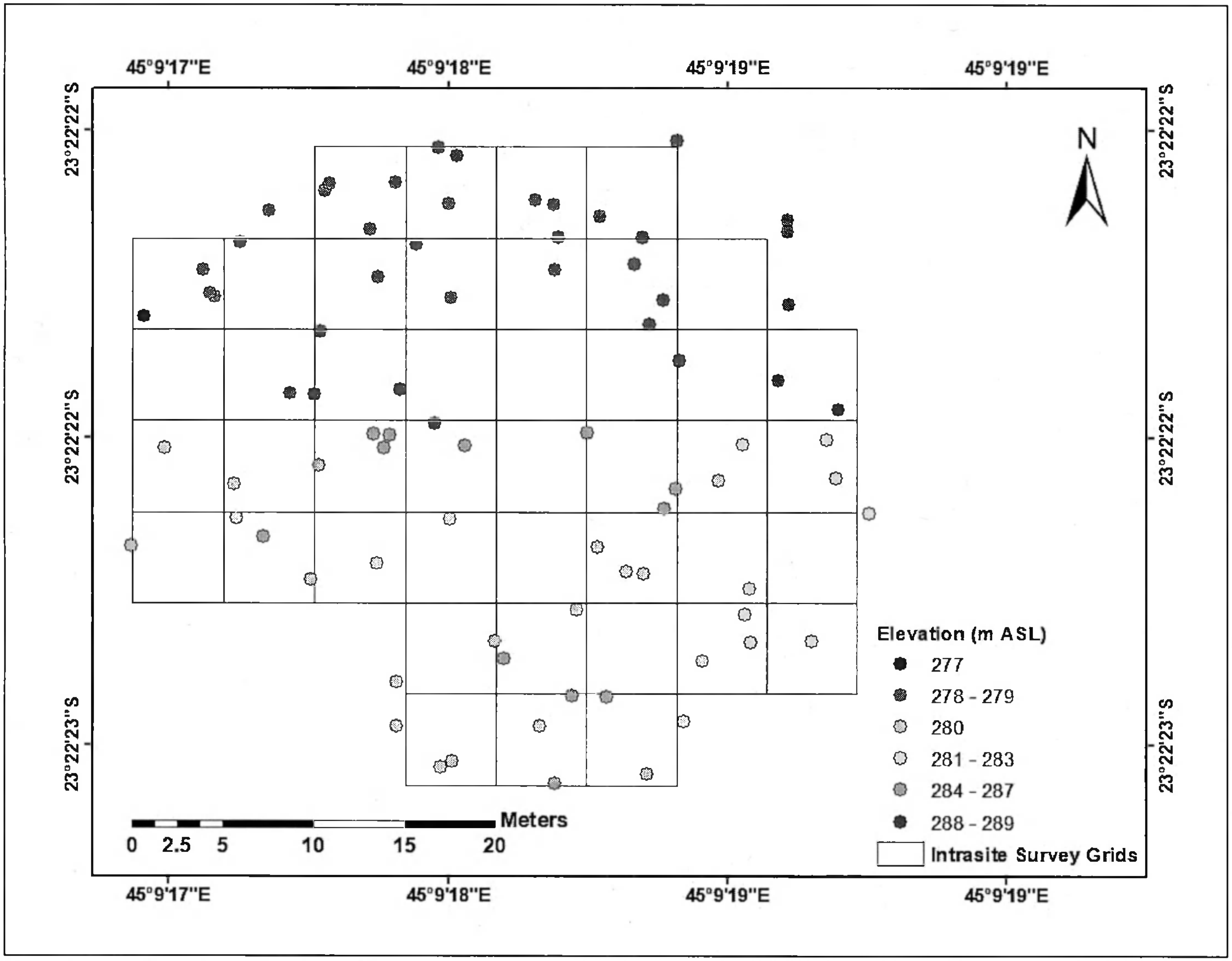

Figure 6.3: Elevation of Points Showing Inclination of Terrain at Ankilivalo

Details of finds from Ankilivalo intrasite survey are summarized in Table 6.3.

Analyses of potsherds from surface collection and excavation are presented in *6.3.5.*

Table 6.3: Material Finds from Systematic Surface Collection at Ankilivalo (Field Season 2015)

Grid #	Potsherds	Faunal Remains	Grinding Stones	Glass Fragments	Ochre Fragments	Seashell Jewels	Gunflint
D1	-	-	-	-	-	-	-
E1	1	-	-	-	-	-	-
F1	-	-	-	-	-	-	-
D2	-	-	1	-	-	-	-
E2	1	-	-	-	-	-	-
F2	-	-	-	-	-	-	-
G2	-	-	-	-	-	-	-
H2	-	-	-	-	-	-	-
A3	-	-	-	-	-	-	-
B3	-	-	-	-	-	-	-
C3	6	1	-	-	-	-	-
D3	4	-	1	-	-	-	-
E3	-	-	-	-	-	-	-
F3	-	-	-	-	-	-	-
G3	1	-	-	-	-	-	-
H3	-	-	-	-	-	-	-
A4	308	15	-	1	-	-	-
B4	22	1	3	-	-	-	-
C4	35	1	3	-	-	-	-
D4	6	-	1	1	-	-	-
E4	2	-	-	-	-	-	-
F4	48	-	-	-	-	-	1
G4	65	-	-	-	-	-	-
H4	13	-	1	-	-	-	-
A5	532	170	1	-	-	-	-
B5	231	144	2	-	-	-	-
C5	102	2	-	-	-	-	-
D5	39	4	2	-	-	1	-
E5	100	5	-	-	-	-	-
F5	170	-	2	-	-	-	-
G5	-	-	-	-	-	-	-
H5	-	-	-	-	-	-	-
A6	143	34	-	-	-	-	-
B6	326	86	-	1	-	-	-
C6	84	5	-	-	-	-	-
D6	20	-	-	-	1	-	-
E6	23	1	-	1	-	-	-
F6	103	1	-	-	1	-	-
G6	30	-	1	-	-	-	-
C7	50	1	2	-	-	-	-
D7	34	1	-	-	-	-	-
E7	253	1	-	-	1	-	-
F7	265	5	3	1	-	-	-

One of the most remarkable objects in the surface collection from Ankilivalo was a circular seashell bead locally known as *Fela* (Plate 6.4 *Left and Center*). Traditionally, this type of bead corresponds to *Alizaoza,* a Malagasy cosmological value associated with sacredness, impurity, and masculinity. It is a distinctive sign for a warrior or a ruler (Mantaux 1970: 196), worn on the forehead for bravery and good luck (see Plate 6.4. *Right*).

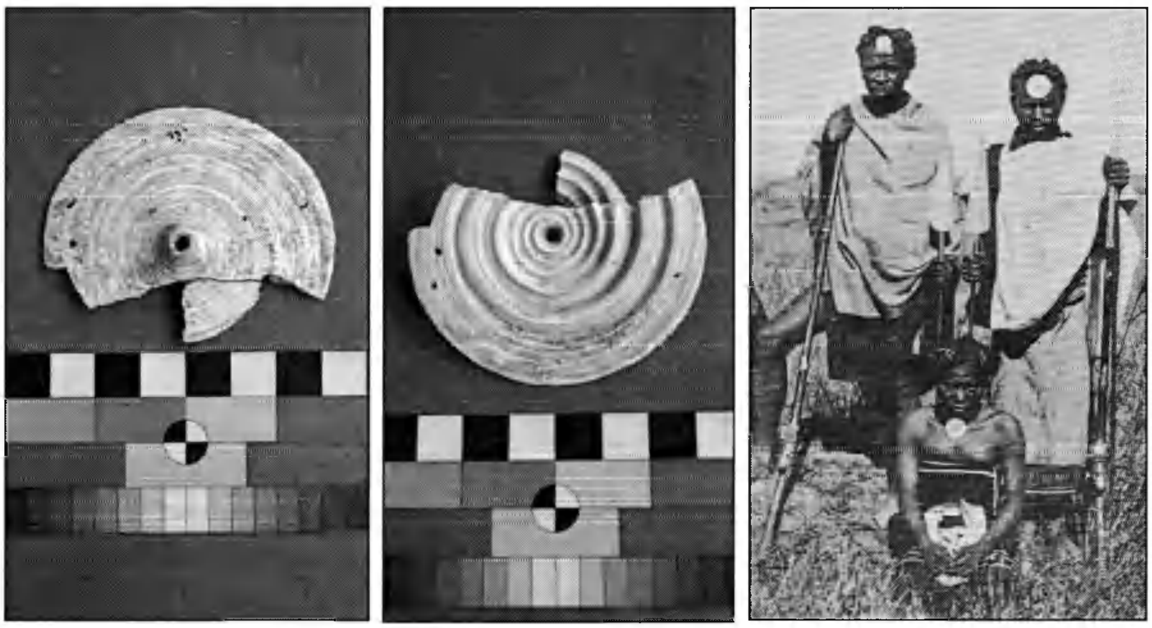

Plate 6.4: (Left and Center) A 'Fela' Recovered from Grid D5 at Ankilivalo (Field Season 2015), and (Right) Bara Warriors Wearing 'Fela' on their Foreheads (Credit: Postcard circa. 1900 in Sarah Fee 2004: 95).

In the 17th century CE, the French General Augustin de Beaulieu described the chief of native warriors in the Onilahy embouchure wearing a *fela*, as follows:

> *Pour ornement, un d'eux, qui paraissait être le chef, avait une plaque d'os ou d'ivoire parfaitement blanc, grande comme un franc, laquelle, étant percée par le milieu, il appliquait justement au milieu du front.* (Grandidier and Grandidier 1904: 338)
>
> As an ornament, one of them, who appeared to be the chief, had a plate of white bone or ivory, as large as a franc, and pierced at its center. He wore it precisely in the middle of his forehead. [My Translation]

Although this ornament was not a weapon, it was certainly warfare paraphernalia and I consider its presence indicative of insecurity and probably a social hierarchy among the inhabitants of Ankilivalo.

I also found a gunflint in the surface collection in Grid F4 (see Table 6.3). This points not only to the insecurity reigning during the occupation of Ankilivalo but also to a connection between the coast and the hinterland. Europeans imported gunflints and flintlock rifles beginning in the 17th century CE (Parker Pearson 2010: 456-459; Radimilahy and Wright 1986). The import of weapons along with the export of slaves (Grandidier and Grandidier 1904) likely exacerbated ongoing conflicts in the southwest. A vulnerable community in such a context would not only seek to acquire weapons but also relocate to a defensible location. Chapter 7 explores this possibility through a site defensibility analysis.

6.2.2. Keliangebo Intrasite Survey

The site of Keliangebo is located on top of a hill (Plate 6.5; Plate 6.6), geographically positioned at -23.386275, 45.14897, between 359 m and 383 m above sea level. I found scatters of decorated and undecorated sherds all over the hilltop (Figure 6.4). The survey revealed that sherds had a variety of rim profiles, including thickened, beveled, thinned and flared. They also had various decorations, including triangular impressions and lines of incisions similar to sherds from Ampasimaiky rock shelter, located 1.7 km northwest of Keliangebo in the Isalo massif (Rasolondrainy 2012). Some sherds were graphite-coated, while others were red-slipped plainware. Access to the site was difficult, but hollows probably made by the occupants of Keliangebo served as steps up the less steep approach from the southeast (Plate 6.7).

Plate 6.5: Keliangebo Site and Its Surrounding Landscape

Plate 6.6: The Hilltop Site of Keliangebo Viewed from the Sakamarekely River Bank.

Plate 6.7: Access to the Keliangebo Site (Adapted from Google Earth 2019)

In the northwest section of the hilltop, I discovered a semi-circular structure made of dry stone (Figure 6.4; Plate 6.8). This was the remains of a dry wall that appeared to have crumbled. I was uncertain of its function. My first thought was that it was a part of a wall defense system. It faced an inaccessible steep escarpment (Plate 6.6), however, making this implausible. Another immediate guess was a cattle pen. However, the steep access made it inaccessible to cattle. This intriguing puzzle led me to select the site for deeper investigation during the 2016 field season.

Plate 6.8: Remains of Collapsed Dry-Stone Wall at Keliangebo (Field Season 2016)

Within the 125 grids laid out at Keliangebo (Figure 6.4), my team collected 2094 potsherds, including 77 rims, 22 necks, 27 shoulders, 1956 body, 17 bases, and 8 spindle whorls. I also recorded 15 faunal remains and 12 grinding stones (Table 6.4 and Table 6.5).

	Rims	**Neck**	**Shoulder**	**Body**	**Base**	**Spindle Whorl**	**TOTAL**
Decorated	34	4	18	495	5	1	543
Undecorated	43	18	9	1461	12	7	1564
Total	**77**	**22**	**27**	**1956**	**17**	**8**	**2102**

Table 6.4: Potsherds from KG Systematic Surface Collection

The distribution of archaeological remains at the site was uneven, with most materials concentrated in the south (Figure 6.4). This might be because the terrain slopes from the northwest towards the south, with a 24 m difference in elevation. Potsherds and other movable materials might have been initially deposited around the dry wall in the northwest and then washed downhill by rainwater.

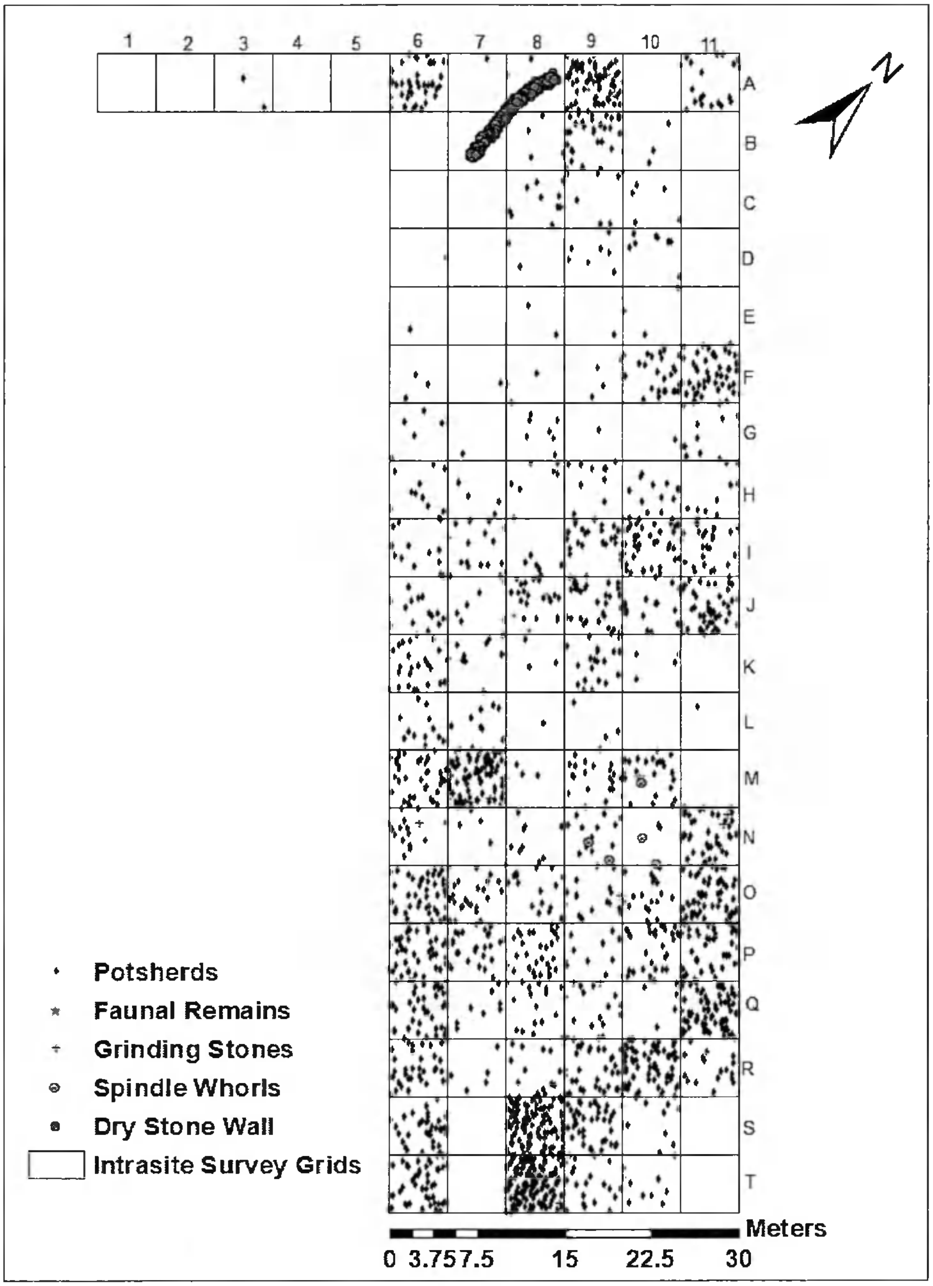

Figure 6.4: Systematic Surface Collection at Keliangebo

Table 6.5: Material Finds Recovered from Systematic Surface Collection at Keliangebo (Field Season 2016)

Grid #	Potsherds	Faunal Remains	Spindle Whorls	Grinding Stones
A1	-	-	-	-
A2	-	-	-	-
A3	2	-	-	-
A4	-	-	-	-
A5	-	-	-	-
A6	42	-	-	-
A7	2	-	-	-
A8	2	-	-	-
A9	67	3	-	-
A10	-	-	-	-
A11	20	-	-	-
B6	-	-	-	-
B7	-	-	-	-
B8	4	-	-	-
B9	34	-	-	-
B10	3	-	-	-
B11	-	-	-	-
C6	-	-	-	-
C7	-	-	-	-
C8	10	-	-	-
C9	7	-	-	-
C10	5	-	-	-
C11	-	-	-	-
D6	1	-	-	-
D7	-	-	-	-
D8	2	-	-	-
D9	7	-	-	-
D10	5	-	-	-
D11	-	-	-	-
E6	1	-	-	-
E7	-	-	-	-
E8	2	-	-	-
E9	1	-	-	-
E10	3	-	-	-
E11	-	-	-	-
F6	3	-	-	-
F7	1	-	-	-
F8	2	-	-	-
F9	5	-	-	-
F10	26	-	-	-
F11	49	-	-	-
G6	6	-	-	-
G7	1	-	-	-
G8	8	-	-	-
G9	1	-	-	-
G10	1	-	-	-
G11	10	-	-	-
H6	11	-	-	-

H7	4	-	-	-
H8	6	-	-	-
H9	11	-	-	-
H10	11	1	-	-
H11	9	-	-	-
I6	12	-	-	-
I7	16	-	-	-
I8	7	-	-	-
I9	25	2	-	-
I10	41	-	-	-
I11	25	-	-	-
J6	15	-	-	-
J7	7	-	-	-
J8	20	3	-	-
J9	32	-	-	-
J10	41	-	-	-
J11	25	-	-	-
K6	25	-	-	-
K7	10	-	-	-
K8	3	2	-	-
K9	21	-	-	-
K10	4	-	-	-
K11	-	-	-	-
L6	12	-	-	-
L7	10	-	-	-
L8	1	-	-	-
L9	3	-	-	-
L10	-	-	-	-
L11	1	-	-	-
M6	38	-	-	-
M7	96	-	-	3
M8	3	-	-	-
M9	21	-	-	-
M10	23	1	1	-
M11	-	-	-	-
N6	15	-	-	1
N7	5	-	-	-
N8	9	-	-	-
N9	14	-	2	-
N10	2	-	2	-
N11	40	-	-	2
O6	43	-	-	-
O7	25	-	-	-
O8	16	-	-	-
O9	16	-	-	1
O10	18	-	-	-
O11	55	-	-	-
P6	41	-	-	-
P7	26	-	-	-
P8	32	-	-	-
P9	11	-	-	-
P10	30	-	-	-
P11	45	-	-	-

Q6	42	2	-	-
Q7	8	-	-	-
Q8	17	-	-	-
Q9	15	-	-	3
Q10	5	-	-	-
Q11	55	-	-	-
R6	32	-	-	-
R7	5	-	-	-
R8	13	-	-	-
R9	33	-	-	-
R10	71	-	-	-
R11	20	-	-	-
S6	35	-	-	-
S7	-	-	-	-
S8	111	-	-	-
S9	40	-	-	-
S10	10	-	-	-
S11	-	-	-	-
T6	45	-	-	-
T7	-	-	-	-
T8	142	1	-	2
T9	23	-	-	-
T10	10	-	-	-
T11	-	-	-	-
TOTAL	**2094**	**15**	**8**	**12**

Since I did not excavate Keliangebo, I tried to obtain a maximum of information about the site's function and its occupants' lifeways from the limited data available from the intrasite survey.

While conducting this survey, it occurred to me that Keliangebo might be a ritual site, due to the distinctiveness of its position, the sophistication of its potsherds (compared to other sites), and the dry wall discussed above. Meanwhile, after finding items that suggested daily activities such as grinding stones and spindle whorls (Plate 6.9), I started also to consider a habitation site as a possibility. The geospatial analysis in Chapter 7 provides additional insight concerning the nature and function of this site.

Plate 6.9: Used and Unfinished Spindle Whorls Recovered from Systematic Surface Collection at Keliangebo (Field Season 2016)

The presence of spindle whorls at Keliangebo offers noteworthy support for comments in documents written in the mid-17th century CE. Spindle whorls have been considered by archaeologists as evidence of local weaving manufacturing. In his 1656 map, Flacourt called the region west of my study area the *Pays des Soies* (i.e. Land of Silks). He stated that

> *Les femmes y font de tres bons et tres forts pagnes de coton et de soie, et d'une autre espece d'ecorce qu'ils appellent "try", qui approche de la douceur de la soie mais ne dure pas tant que le coton.* (Flacourt 1661: 63)
>
> Women make very good and strong fabrics out of cotton and silk, as well as of another species of bark called *try*, which is close to the softness of silk but does not last as long as cotton. [My Translation]

The occupants of Keliangebo might have exploited silk spun by silkworms from the Isalo massif, a practice to this day.

6.2.2.1. Food Remains

I only found 15 faunal remains at Keliangebo during the intrasite survey. My first impression was that the steep terrain helped rainwater wash most ethnobiological traces from the site. However, the systematic survey did not reveal any faunal remains around the foothill at the south side, although I did find potsherds there. I tentatively conclude that the occupants of Keliangebo, unlike those of Ankilivalo, did not consume much meat.

6.2.2.2 Techno-Cultural Remains

I analyzed a sample of 138 potsherds including 49 rims, 4 rim-and-necks, one rim-and-shoulder, one rim-and-body, 2 necks, 25 shoulders, 33 body, 15 bases, and 8 spindle whorls from Keliangebo (Table 6.6). My pottery analysis primarily focused on vessel capacity, stability, accessibility, transportability, and heating effectiveness.

Table 6.6: Potsherd Samples Analyzed from KG Systematic Surface Collection

QUADRAT LABEL	**RIM**		**NECK**		**SHOULDER**		**BODY**		**BASE/LID?**		**SPINDLE WHORL**		**SUB-TOTAL**
	Decor	**Un-decor**	**Décor**	**Un-décor**	**Décor**	**Un-decor**	**Decor**	**Un-decor**	**Decor**	**Un-decor**	**Decor**	**Un-decor**	
KG/A6	2	2 (N)	0	**N**	0	0	1	0	1	0	0	0	06
KG/F6	0	1	0	0	0	0	0	0	0	0	0	0	01
KG/H6	0	1	0	0	0	0	2	0	0	0	0	0	03
KG/J6	1	0	0	0	0	0	0	0	0	0	0	0	01
KG/N6	0	0	0	0	0	0	0	0	0	0	0	2	02
KG/O6	0	0	1	0	1	0	2	0	1	0	0	0	05
KG/P6	1	1 (N)	0	**N**	0	0	2	0	2	0	0	0	06
KG/Q6	1	1	0	0	0	0	2	0	1	0	0	0	05
KG/R6	2	0	0	0	1	0	0	0	0	0	0	0	03
KG/S6	2	0	0	0	1	0	1	0	0	0	0	0	04
KG/T6	2	0	0	0	3	0	2	0	0	0	0	0	07
KG/J7	1	0	0	0	0	0	0	0	0	0	0	0	01
KG/R7	3	2	0	0	0	0	0	0	0	0	0	0	05
KG/F8	1	0	0	0	0	0	0	0	0	0	0	0	01
KG/I8	3	0	0	0	0	0	3	0	1	0	0	0	07
KG/J8	1	0	0	0	0	0	0	0	0	0	0	1	02
KG/R8	0	0	0	0	0	0	5	0	3	0	0	0	08
KG/S8	0	0	0	0	3	0	0	0	0	0	0	0	03
KG/T8	1(N)	0	**N**	0	1	0	0	1	0	0	0	0	03
KG/A9	5	0	0	0	1	0	1	0	0	0	0	0	07
KG/B9	0	0	0	0	0	0	3	1	1	0	0	0	05
KG/H9	2	1 (S)	0	0	0	S	2	0	0	0	2	1	08
KG/I9	1	0	1	0	1	0	0	0	0	0	0	0	03
KG/L9	0	0	0	0	2	0	0	0	1	0	0	0	03

KG/O9	2	0	0	0	1	0	0	0	0	0	0	0	03
KG/P9	0	0	0	0	2	0	0	0	0	0	0	0	02
KG/R9	5	0	0	0	1	0	1	0	2	0	0	0	09
KG/S9	1	1	0	0	0	0	0	0	0	0	0	0	02
KG/T9	0	0	0	0	0	0	1	0	0	0	0	0	01
KG/F10	0	2	0	0	1	0	0	0	1	0	0	0	04
KG/H10	1	0	0	0	0	0	0	0	0	0	0	0	01
KG/J10	1 (B)	0	0	0	0	0	B	0	0	0	0	0	01
KG/C11	1	0	0	0	0	0	0	0	0	0	0	1	02
KG/G11	0	0	0	0	1	0	0	0	0	0	0	0	01
KG/H11	0	0	0	0	2	0	1	0	0	0	0	0	03
KG/I11	0	0	0	0	0	0	1	0	0	0	0	1	02
KG/J11	1	0	0	0	0	0	1	0	0	0	0	0	02
KG/O11	1	1 (N)	0	**N**	3	0	0	0	0	1	0	0	06
TOTAL	**42**	**13**	**2+1N**	**3N**	**25**	**S**	**31+B**	**2**	**14**	**1**	**2**	**6**	**138**

N: *Neck*; **S:** *Shoulder*; **B:** *Body*

Among the 55 rim sherds, I recorded a maximum diameter of 35 cm and a minimum diameter of 12 cm (Figure 6.5; Table 6.7). The mean diameter is 23.38 cm with a standard deviation of ± 5.5. Thirty of 55 rims (54.5 %) had diameters equal or larger than the mean.

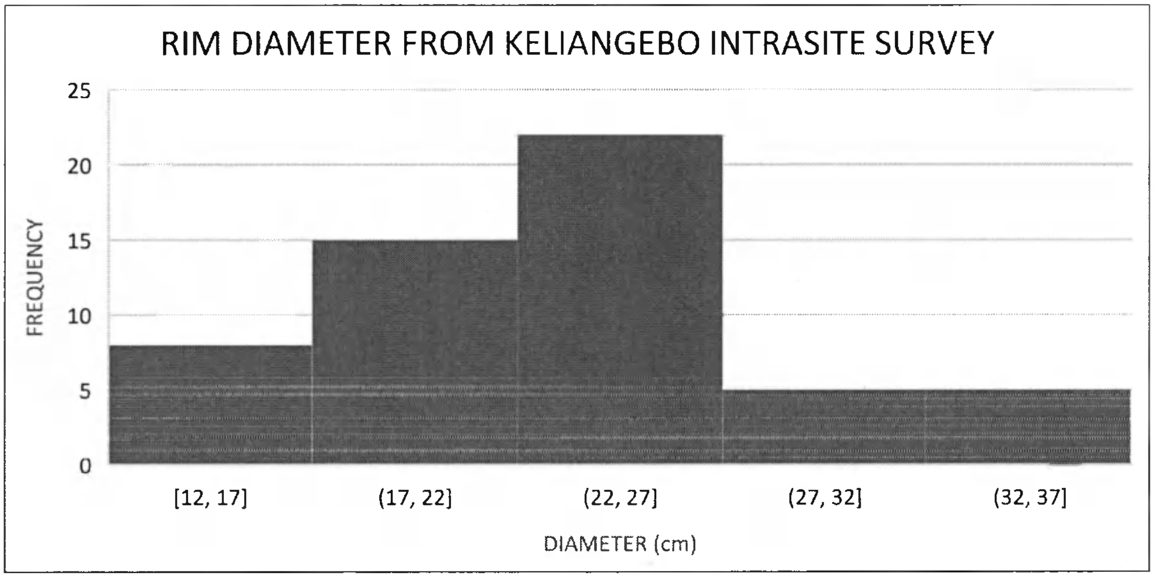

Figure 6.5: Histogram of the Rim Diameter from KG Surface Collection

The capacity of vessels from Keliangebo was thus relatively small, and they were likely household utensils (see Rice 1987: 236). None had the capacity of 'long-term storage' jars (Rice 2015: 413-414), suggesting the site inhabitants did not store water for long periods or other materials such as calabashes were used. This might be due to the site's proximity to the Sakamarekely river. Proximity analysis in reference to permanent water sources in Chapter 7 will address this question.

Table 6.7: Analyzed Rims from KG Systematic Surface Collection

Grid	SL	Dm	Orf	LT	LRT	H	W	RV	RS	LM	ST	SP	SC	PD	DS	CP	TP	Tp	FC
A6	**KG_A6_S1**	25	7	10.2	11.9	66.81	56.9	E	P	F	B	N	RSB	ND	ND	DB	C	S	R
A6	**KG_A6_S2**	25	4	11.5	8.07	45.26	54.2	I	Th	F	B	N	GBB	RE	RIB	DB	CF	S	R
A6	**KG_A6_S3**	14	8	4.85	8.25	23.73	36.9	S	T	R	B	N	GBB	RE	RIE	B	CF	S	R
A6	**KG_A6_S4**	25	3	5.75	4.58	17.95	26.4	E	P	B	B	N	GBB	ND	ND	B	F	S	R
F6	**KG_F6_S1**	20	6	10.1	6.57	43.72	45.4	I	Th	F	B	N	RSB	ND	ND	DB	CF	S	R
H6	**KG_H6_S1**	27	12	10.1	10	66.33	98.1	E	P	F	B	N	RSB	ND	ND	DB	C	S	R
J6	**KG_J6_S1**	33	1.5	13	8.57	42.67	29.7	E	Th	F	B	N	GBB	RE	BIGLE	B	CF	S	R
P6	**KG_P6_S1**	30	7	16.9	9.67	46.4	62.9	E	Th	B	B	N	GBB	RE	RIB	DB	CF	S	R
P6	**KG_P6_S2**	20	11	9.32	8.66	43.34	73.3	E	P	U	B	N	RSB	ND	ND	DB	CF	S	R
Q6	**KG_Q6_S1**	20	7	10.7	8.43	31.37	45.1	S	Th	R	B	N	GBB	SE	IL	DB	CF	S	R
Q6	**KG_Q6_S2**	20	7	10.5	9.3	41.73	48.1	S	P	U	B	N	RSB	ND	ND	DB	CF	S	R
R6	**KG_R6_S1**	20	6	11.6	10.6	27.18	37.5	I	Th	F	B	N	GBB	RE	RIB	DB	CF	S	R
R6	**KG_R6_S2**	15	3	7.51	5.94	22.17	20.7	S	P	R	B	N	GBB	RE	RIB	B	CF	S	R
S6	**KG_S6_S1**	23	4	8.3	5.62	26.46	31.4	E	Th	R	B	N	GBB	RE	IL; RIE	B	CF	S	R
S6	**KG_S6_S2**	15	8	7.89	5.31	23.93	36.7	S	P	R	B	N	GBB	RE	RIB	B	CF	S	R
T6	**KG_T6_S1**	33	6	7.76	6.61	53.16	59.7	I	P	U	B	N	RSE; GBI	RE	PLRIB	DB	CF	S	R
T6	**KG_T6_S2**	18	4	8.56	7.26	36.95	30.9	E	P	A	B	N	GBB	RE	PLRIE; IGI	Br	F	S	R
J7	**KG_J7_S1**	26	10	7.7	7.5	42.58	82.8	S	P	U	B	N	GBB	RE	PLRIE; G	DB	F	S	R
R7	**KG_R7_S1**	26	3	11.7	11.6	37.26	26.7	S	P	R	B	N	GBB	RE	FRC	RB	F	S	O
R7	**KG_R7_S2**	25	5	9.72	9.18	34.5	41.5	S	P	U	B	N	GBE	RE	RIE; PLRIE	Bl	CF	S	R
R7	**KG_R7_S3**	35	4	11.5	10.6	25	47.2	S	P	B	B	N	GBE	RE	PLRIE	Br	F	S	R
R7	**KG_R7_S4**	20	9	13.6	8.46	46.61	53.5	I	Th	R	B	N	RSB	ND	ND	DB	C	S	R

R7	**KG_R7_S5**	16	4	6.38	8.66	35.38	27.8	I	T	A	B	N	RSB	ND	ND	B	CF	S	R
F8	**KG_F8_S1**	25	14	7.85	7.4	45.46	105	S	P	U	B	N	GBB	RE	PLRIE; G	DB	F	S	R
I8	**KG_I8_S1**	31	6	15.2	9.12	47.9	62.4	E	Th	F	B	N	GBB	RE	RIB	DB	CF	S	R
I8	**KG_I8_S2**	30	3	15.3	8.72	44.19	35.9	E	Th	B	B	N	GBB	RE	RIB	DB	CF	S	R
I8	**KG_I8_S3**	19	5	8.99	6.32	36.4	31.8	E	Th	U	B	N	GBB	RE	RIB	DB	CF	S	R
J8	**KG_J8_S1**	23	5	7.5	7.52	37.3	36.6	S	P	U	B	N	GBB	RE	PLRIB	Br	C	S	R
T8	**KG_T8_S1**	26	15	8.12	10.2	68.29	120	E	T	F	B	N	RSB	SE	CL	DB	C	S	R
A9	**KG_A9_S1**	25	9	8.68	6.12	42.84	66.7	E	Th	A	B	N	GBE	RE	BIGLB	DB	CF	S	R
A9	**KG_A9_S2**	22	6	11.6	9.63	24.68	40.1	I	P	F	B	N	GBB	RE	RII	B	CF	S	R
A9	**KG_A9_S3**	27	3	13.6	11.5	26.4	32.7	I	Th	B	B	N	GBB	RE	PLRIB	DB	CF	S	R
A9	**KG_A9_S4**	20	4	7.92	8.09	22.73	24.4	S	P	R	B	N	GBB	RE	PLRIB	DB	CF	S	R
A9	**KG_A9_S5**	25	6	7.96	7.29	24.09	50	I	P	F	B	N	GBB	RE	RII	DB	CF	S	R
H9	**KG_H9_S1**	25	10	9.8	8.49	49.33	77.8	I	P	U	B	N	GBB	RE	RIE; IGB	RB	CF	S	O
H9	**KG_H9_S2**	12	15	6.15	6.45	55.03	53.1	I	P	R	B	N	RSB	ND	ND	B	CF	S	R
H9	**KG_H9_S3**	23	8	9.18	8.33	37.42	57.4	S	P	R	B	N	GBB	RE	RIE	DB	CF	S	R
I9	**KG_I9_S1**	28	5	13.8	12.1	41.16	54.2	E	Th	F	B	N	GBB	RE	FRC; BIGLE	DB	CF	S	R
O9	**KG_O9_S1**	25	8	12.1	8.3	50.64	60	E	Th	U	B	N	GBB	RE	PLRIB; IGB	Br	CF	S	R
O9	**KG_O9_S2**	23	3	16.3	11.7	21.11	27.6	E	Th	F	B	N	GBB	RE	RIE	DB	CF	S	R
R9	**KG_R9_S1**	20	10	10.9	7.74	46.31	64.3	I	Th	F	B	N	GBB	RE	RIB	DB	CF	S	R
R9	**KG_R9_S2**	20	7	11.6	8.04	44.31	44.2	I	Th	F	B	N	GBB	RE	RIB	DB	CF	S	R
R9	**KG_R9_S3**	25	2	10.2	7.86	22.96	52.8	I	P	U	B	N	GBB	RE	RIE; IGB	RB	CF	S	O
R9	**KG_R9_S4**	27	5	14	8.48	32.69	32.7	E	Th	F	B	N	GBB	RE	RIB	DB	CF	S	R
R9	**KG_R9_S6**	20	5	9.84	10.3	36.39	33.1	E	P	A	B	N	GBB	RE	RIB	DB	CF	S	R
S9	**KG_S9_S1**	15	6	8.11	7.92	37.76	29.2	E	P	R	B	N	GBB	RE	IGB	B	CF	S	R
S9	**KG_S9_S2**	16	9	8.91	8.49	46.5	50.9	E	P	U	B	N	RSB	ND	ND	DB	CF	S	R

F10	**KG_F10_S1**	16	13	7.51	7.8	49.12	65.3	E	P	R	B	N	RSB	ND	ND	DB	C	S	R
F10	**KG_F10_S2**	24	8	11.7	11.2	31.19	57.4	S	P	F	B	N	GBB	RE	RIE	DB	F	S	R
H10	**KG_H10_S1**	27	7	14.3	11.4	23.89	57.1	E	Th	F	B	N	RSE	L; RE	FRC; BIGLE	DB	F	S	R
J10	**KG_J10_S1**	34	8	8.39	7.95	42.67	81.6	E	P	F	B	N	RSB	RE	FRC; BIGLE	G	F	S	R
C11	**KG_C11_S1**	19	6	6.81	9.5	35.49	35.4	S	T	U	B	N	RSB	RE	FRC; PLRIE	Br	F	S	R
J11	**KG_J11_S1**	33	5	13.1	9.26	41.54	52.1	E	Th	F	B	N	GBB	RE	BIGLE	B	CF	S	R
O11	**KG_O11_S1**	30	10	15.8	9.53	46.89	91.8	E	Th	B	B	N	GBB	RE	RIB	DB	CF	S	R
O11	**KG_O11_S2**	20	17	8.65	9	69.31	102	E	P	R	B	N	RSB	NE	CL	B	C	S	R

SL: Sherd Label; **Dm:** Diameter; **Orf:** Orifice percentage; **LT:** Lip Thickness; **LRT:** Lower Rim Thickness; **H:** Height; **W:** Width; **RV:** Rim Verticality -> *Everted* (**E**); *Inverted* (**I**); *Straight* (**S**)

RS: Rim Wall Shape -> *Thickened* (**Th**); *Parallel* (**P**); *Tapered* (**T**)

LP: Lip Morphology -> *Angular* (**A**); *Beveled* (**B**); *Flattened* (**F**); *Rounded* (**R**); *U-shaped* (**U**)

ST: Surface Treatment -> *Burnished* (**B**); *Patterned* (**P**); *Smoothed* (**S**)

SP: Surface Patterning -> *No Patterning* (**N**)

SC: Surface Coating -> *Red Slipped on Both Walls* (**RSB**); *Red Slipped on the Exterior Wall* (**RSE**); *Red Slipped on the Interior Wall* (**RSI**); *Graphite Burnished on Both Walls* (**GBB**); *Graphite Burnished on the Exterior Wall* (**GBE**); *Graphite Burnished on the Interior Wall* (**GBI**)

PD: Place of Decoration -> *On the Lip* (**L**); *On the Exterior of the Rim* (**RE**); *On the Exterior of the Neck* (**NE**); *On the Exterior of the Shoulder* (**SE**); *No Decoration* (**ND**)

DS: Decoration Motif Style -> *Combing Lines* (**CL**); *False Relief Chevron* (**FRC**); *Guillauche* (**G**); *Incised Line* (**IL**); *Impressions in Geometric Forms on both walls* (**IGB**); *Impressions in Geometric Forms on the Interior Wall* (**IGI**); *Row of Impression on Both Side* (**RIB**); *Row of Impression on the Exterior* (**RIE**); *Row of Impression on the Interior* (**RII**); *Parallel lines of impression row on both wall* (**PLRIB**); *Parallel lines of impression row on the exterior wall* (**PLRIE**); *Band of Impression and Geometric Lines on both walls* (**BIGLB**); *Band of Impression and Geometric Lines on the Exterior Wall* (**BIGLE**); *Parallel Lines and Row of Impression on Both Walls* (**PLRIB**); *Parallel Lines and Row of Impression on the Exterior Wall* (**PLRIE**); *No Decoration* (**ND**)

PC: Paste Color -> *Black* (**Bl**); *Dark Brown* (**DB**); *Brown* (**Br**); *Red Brown* (**RB**); *Red* (**R**); *Gray* (**G**)

PT: Paste Texture -> *Coarse* (**C**); *Coarse Fine* (**CF**); *Fine* (**F**)

Tp: Tempers -> *Sand* (**S**); *Organic* (**O**)

FC: Firing Condition -> *Reduced* (**R**); *Oxidized* (**O**)

Among the 17 bases recovered from KG, 15 were flat, while 2 were rounded (Table 6.8). The maximum thickness recorded was 13.07 mm, while the minimum was 7 mm. These results indicate that most vessels from KG stayed put on a flat ground.

It should be noted, however, that some bases may turn out to be lids. The placement of elaborate decorations on their exterior walls suggests the intent of potters to exhibit the beauty of the vessel while covered. But this is just one possible explanation, since the bases of plates or bowls also might display their aesthetic appearance when not served at the vessel stack.

Table 6.8: Bases Analyzed from KG Systematic Surface Collection

Grid	SL	Th	BM	ST	SP	SC	PD	DS	PC	PT	Tp	FC	O
A6	KG_A6_S5	13.07	F	BB	NP	NBB	BE	RIE	DB	CF	S	R	B
O6	KG_O6_S2	12.09	F	BB	NP	NBB	BE	RIE	DB	CF	S	R	B
O6	KG_O6_S6	10.45	F	BB	NP	NBB	BdE; BE	RIE; FRC	RB	CF	S	O	C
P6	KG_P6_S3	12.97	F	BB	NP	NBB	BE	RIE	DB	CF	S	R	B
P6	KG_P6_S6	8.43	F	BB	NP	NBB	BE	RIE	Bl	CF	S	R	B
Q6	KG_Q6_S3	10.57	F	BB	NP	NBB	BE	RIE	Bl	CF	S	R	B
I8	KG_I8_S5	8.7	R	BB	NP	NBB	BE	PLRIE; BIGLE	Bl	F	S	R	St
I8	KG_I8_S6	10.54	R	BB	NP	NBB	BE	FRC; PLRIE	DB	CF	S	R	C
R8	KG_R8_S6	11.72	F	BB	NP	NBB	BE	RIE	Bl	CF	S	R	B
R8	KG_R8_S8	10.51	F	BB	NP	NBB	ND	RIE	DB	F	S	R	B
B9	KG_B9_S3	10.34	F	BB	NP	NBB	BE	RIE	Br	CF	S	R	B
L9	KG_L9_S3	10.48	F	BB	NP	RSB	BE	RIE	Br	CF	S	R	B
R9	KG_R9_S7	7.62	F	BB	NP	NBB	BE	RIE	DB	F	S	R	B
R9	KG_R9_S9	7	F	BB	NP	NBB	BdE	RIE	Bl	CF	S	R	B
R9	KG_R9_S10	8.56	F	BB	NP	NBB	BdE	RIE	DB	CF	S	R	B
F10	KG_F10_S4	9.26	F	BB	NP	NBB	BdE	PLRIE	Bl	CF	S	R	B
O11	KG_O11_S3	9.32	F	BB	NP	plain	ND	ND	Br	CF	S	R	B

SL: Sherd Label

BM: Base Morphology -> *Flat* (**F**); *Rounded* (**R**)

ST: Surface Treatment -> *Burnished on both Walls* (**BB**); *Patterned* (**P**); *Smoothed* (**S**)

SP: Surface Patterning -> *Patterned* (**P**); *Not Patterned* (**NP**)

SC: Surface Coating -> *Red Slipped on Both Walls* (**RSB**); *Red Slipped on the Exterior Wall* (**RSE**); *Red Slipped on the Interior Wall* (**RSI**); *Graphite Burnished on Both Walls* (**GBB**); *Graphite Burnished on the Exterior Wall* (**GBE**); *Graphite Burnished on the Interior Wall* (**GBI**)

PD: Place of Decoration -> *On the Exterior of the Base* (BE); *On the Exterior of the Body* (**BdE**); *On the interior of the base* (**BI**); *No Decoration* (**ND**)

DS: Decoration Motif Style -> *False Relief Chevron* (**FRC**); *Row of Impression on Both Side* (**RIB**); *Row of Impression on the Exterior* (**RIE**); *Parallel lines of impression row on the exterior wall* (**PLRIE**); *Band of Impression and Geometric Lines on the Exterior Wall* (**BIGLE**); *Parallel Lines and Row of Impression on the Exterior Wall* (**PLRIE**); *No Decoration* (**ND**)

PC: Paste Color -> *Black* (**Bl**); *Dark Brown* (**DB**); *Brown* (**Br**); *Red Brown* (**RB**); *Red* (**R**); *Other* (**O**)

PT: Paste Texture -> *Coarse* (**C**); *Coarse Fine* (**CF**); *Fine* (**F**)

Tp: Tempers -> *Sand* (**S**); *Organic* (**O**)

FC: Firing Condition -> *Reduced* (**R**); *Oxidized* (**O**)

The shape of the vessels represented by the 55 rims, 33 body and 15 bases could not ultimately be determined using Chami's general vessel form model for East Africa (see Chami 1994: 78). Thanks to the expertise of Drs. Henry Wright and Chantal Radimilahy, however, it was possible to identify the forms for some potsherds based on specific decoration styles on specific parts of the vessel. The majority of the rims and bases were from serving bowls.

Among the sherds identified using the Chami (1994) *vessel form model* were 2 necks and 4 rim-and-necks from restricted jars, 25 shoulders and the rim-and-shoulder from restricted vessels (jar or bowl), and a rim-body from an unrestricted bowl.

Most rims were thickened everted or parallel rims with flattened or rounded lips (Figure 6.7; Table 6.9), suggesting their contents could be reached easily. The presence of 22 necks recorded from the KG surface collection nevertheless implied that the occupants of the site used at least a few restricted jars to store liquids (probably water).

Table 6.9: Rim Verticality, Rim Wall Shape, and Lip Morphology from KG

	Everted			Straight			Inverted			TOTAL
	Thick	Paral	Taper	Thick	Paral	Taper	Thick	Paral	Taper	
Flattened	7	3	1	0	1	0	5	2	0	**19**
Rounded	1	3	0	1	5	1	1	1	0	**13**
U-shaped	2	2	0	0	5	1	0	3	0	**13**
Angular	1	2	0	0	0	0	0	0	1	**4**
Beveled	3	1	0	0	1	0	1	0	0	**6**
TOTAL	**14**	**11**	**1**	**1**	**12**	**2**	**7**	**6**	**1**	**55**

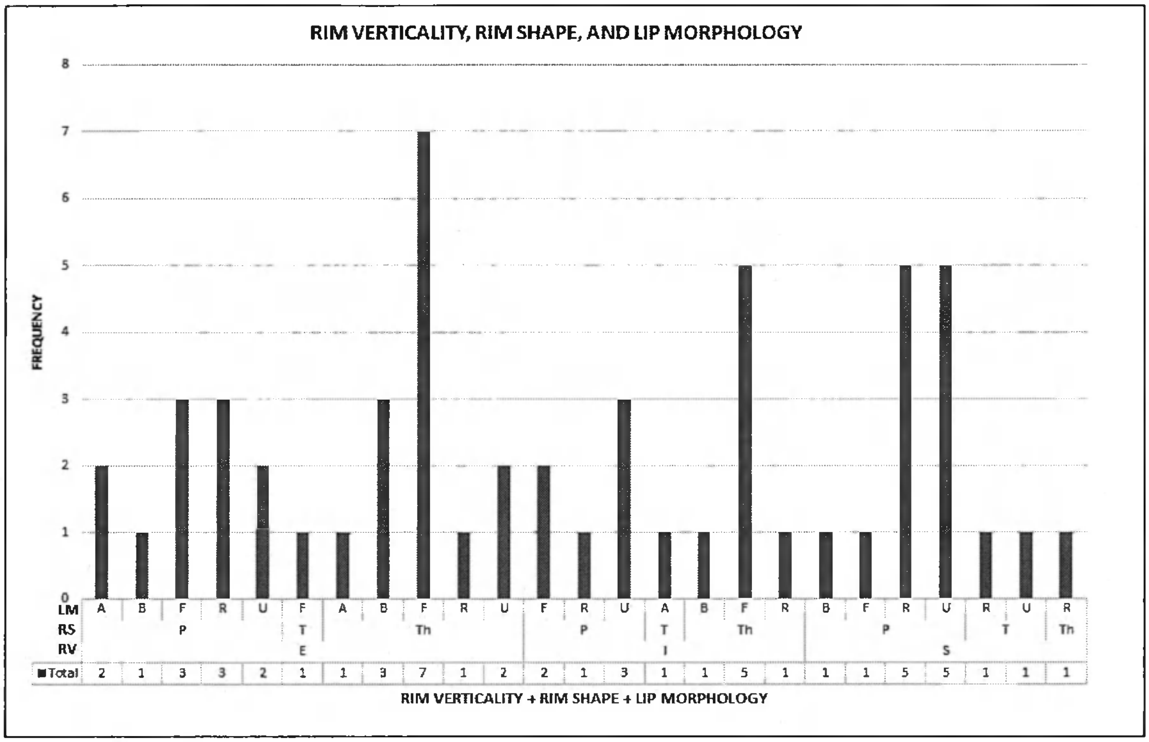

Figure 6.7: Verticality, Shape, and Lip Morphology of Rims Analyzed from KG

LM: Lip Morphology -> *Angular* (**A**); *Beveled* (**B**); *Flattened* (**F**); *Rounded* (**R**); *U-shaped* (**U**)
RS: Rim Wall Shape -> *Thickened* (**Th**); *Parallel* (**P**); *Tapered* (**T**)
RV: Rim Verticality -> *Everted* (**E**); *Inverted* (**I**); *Straight* (**S**)

The majority of the vessels were quite small (Figure 6.5), suggesting that they were not heavy and could have been transported for long distances. The rarity of necks (n = 22 out of 2102), however, suggests that the contents of most vessels spilled easily. It occurred to me that some undrilled, small disc potsherds were stoppers for restricted jars (see Plate 6.8), but they turned out to be much smaller than the minimum diameter of the rims or necks recorded. Furthermore, only one sherd had a patterning on its exterior surface (Figure 6.8), suggesting that the graspability of vessels was very limited.

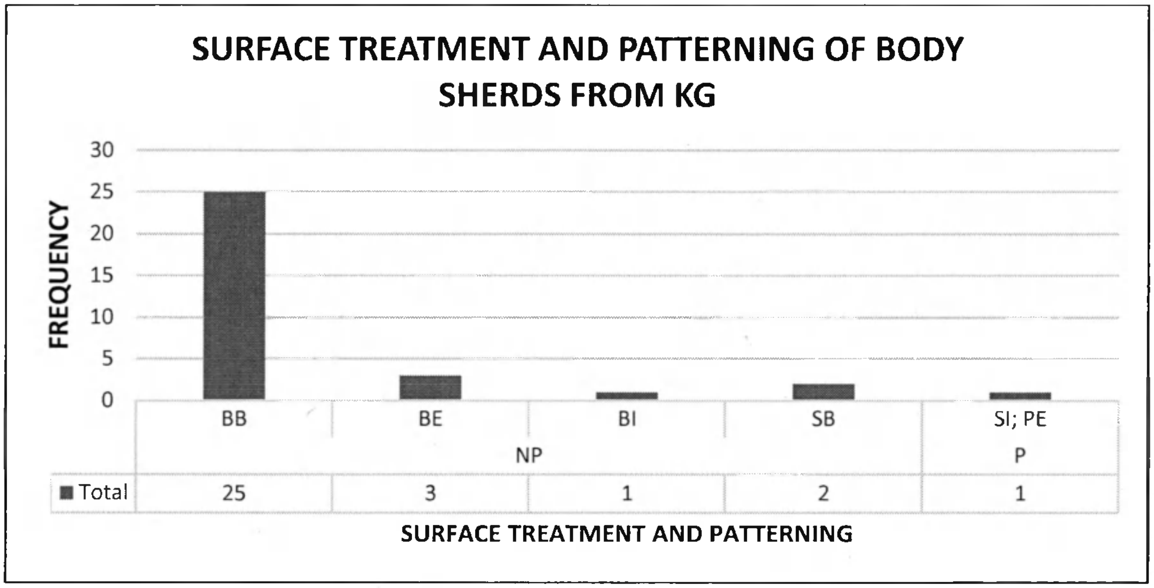

Figure 6.8: Graspability of Sherds from Keliangebo

ST: Surface Treatment -> *Burnished inside and out* (**BB**); *Burnished on the exterior wall* (**BE**); *Burnished on the interior wall* (**BI**); *Smoothed on the interieur wall* (**SI**); *Smoothed on both walls* (**SB**); *Patterned on the exterior wall* (**PE**)

SP: Surface Patterning -> *Patterned* (**P**); *No Patterning* (**NP**)

I started by examining the thickness of vessel bases and bodies. Among the 17 bases, thickness ranged from 13.07 mm to 7 mm (mean 10.09 mm, SD ± 1.74; Figure 6.9; Table 6.8).

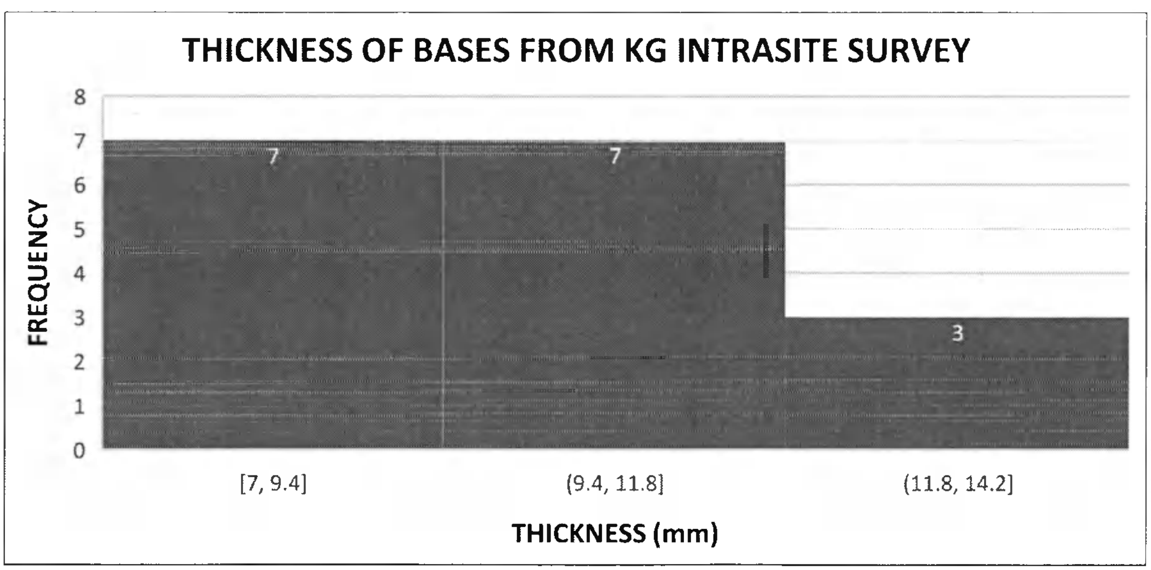

Figure 6.9: Thickness of Bases from KG Surface Collection

Among the 33 body sherds, thickness ranged from 11.9 mm - 4.44 mm (mean=8.42 mm, SD ± 1.46; see Figure 6.10; Table 6.10). These measurements indicate that heat could easily move through vessel walls.

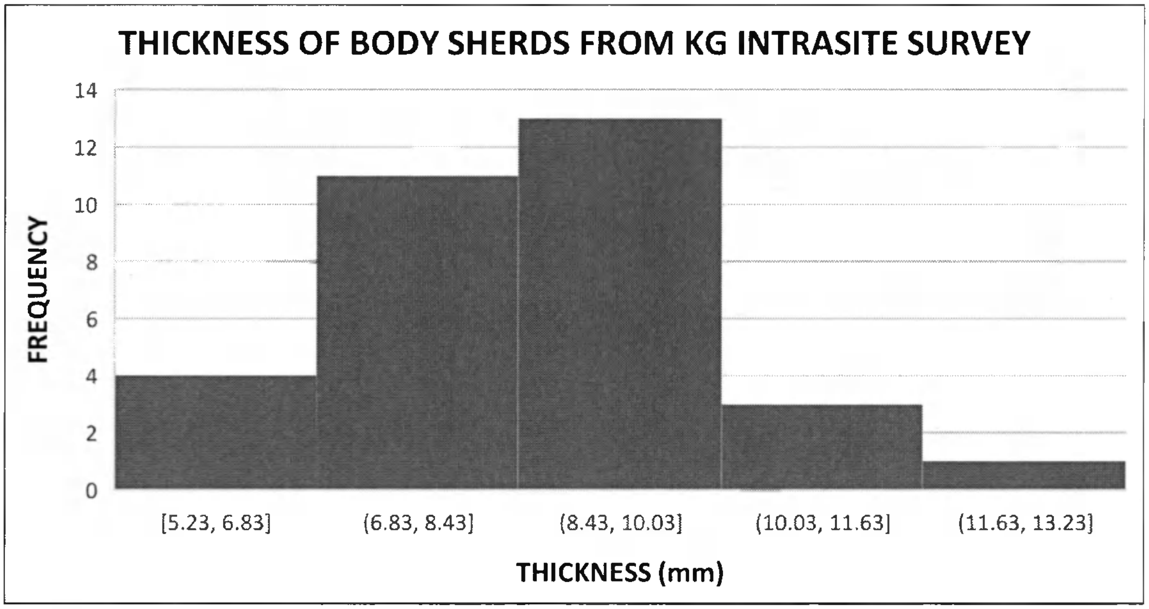

Figure 6.10: Thickness of Body Sherds from KG Surface Collection

Analysis of the vessel paste texture showed that in most cases it was of fine and coarse-fine texture (Figure 6.11; Table 6.10), suggesting low porosity. Low porosity decreases the thermal shock resistance of a vessel (Skibo 2013: 40). I also observed that the potters had added mineral tempers (sand, quartz, and feldspar) and fired the vessels at a reduced atmosphere, which would have added some permeability to the vessel's paste (Skibo 2013: 40). However, the dominance of burnishing and slipping techniques (see Figure 6.11) applied to the vessels' surface must have closed pores on the vessel's wall (Chami 1994: 84; Skibo 2013: 40), thereby limiting their thermal shock resistance. Less shock-resistant vessels are more conducive for serving than for cooking food (Rice 1987: 238).

Table 6.10: Body Sherds Analyzed from KG Surface Collection

Grid	SL	UT	LT	H	W	ST	SP	SC	PD	DS	PC	PT	Tp	FC
A6	**KG_A6_S6**	10.45	7.33	23.25	32.4	BB	NP	GBB	BE	RIE; BILRIE	DB	C	S	R
O6	**KG_O6_S1**	10.34	7.4	41.92	38.6	BB	NP	GBB	BE	FRC	RB	F	S	O
O6	**KG_O6_S4**	7.52	7.17	26.49	28.65	BB	NP	RSB	BE	WCL	Br	CF	S	R
O6	**KG_O6_S5**	8.54	6.88	25.92	40.84	BB	NP	RSB	BE	RIE	Br	C	S	R
P6	**KG_P6_S5**	9.92	9.01	34.84	42.48	BB	NP	GBB	BE	PLRIB	Bl	CF	S	R
Q6	**KG_Q6_S4**	6.51	5.96	31.07	40.12	BB	NP	RSB	BE	RIE	Br	CF	S	R
Q6	**KG_Q6_S5**	11.9	6.84	25.68	38.12	BB	NP	RSE; PI	BE	RIE	Br	C	S	R
S6	**KG_S6_S3**	9.6	6.7	24.32	39.49	BB	NP	GBE	BE	BIGLE	DB	CF	S	R
T6	**KG_T6_S7**	8.44	7.49	57.3	53.77	BB	NP	GBB	BE	PLRIB; BIGLE	Bl	CF	S	R
I8	**KG_I8_S7**	5.46	5.32	31.76	33.63	BB	NP	GBB	BE	FRC	DB	F	S	R
P8	**KG_P8_S1**	8.47	5.82	43.62	55.63	SB	NP	RSB	BE	WCL	DB	CF	S	R
Q8	**KG_Q8_S3**	7.71	7.59	24.79	32.02	BB	NP	GBB	BE	IL	DB	F	S	R
R8	**KG_R8_S4**	7.93	6.88	30.2	37.91	SB	NP	RSB	BE	WCL	Br	CF	S	R
R8	**KG_R8_S7**	10.4	6.45	45.06	37	BI	NP	GBI	BE	RIE	DB	F	S	R
A9	**KG_A9_S7**	7.4	6.91	42.45	46.21	BB	NP	GBB	BE	RIE; BIGLE	DB	F	S	R
B9	**KG_B9_S2**	7.32	6.15	41.55	58.77	SI; PE	P	RSB	ND	ND	Bl	CF	S	R
B9	**KG_B9_S4**	5.23	4.44	27.36	41.08	BB	NP	RSB	BE	BIGLE	Br	F	S	R
B9	**KG_B9_S5**	9.15	7.26	25.94	47.59	BB	NP	GBB	BE	PLRIB; BILRIE	RB	C	S	O
H9	**KG_H9_S7**	8.23	5.97	36.67	26.84	BB	NP	GBB	BE	IL; PLRIE; BIGLI	RB	F	S	O
H9	**KG_H9_S8**	9.83	7.9	39.63	34.53	BB	NP	GBB	BE	PLRIB	Bl	CF	S	R
O9	**KG_O9_S4**	9.17	8.15	27.39	37.26	BE	NP	GBB	BE	RIE	Bl	C	S	R
P9	**KG_P9_S2**	8.91	4.59	31.3	33.55	BB	NP	GBB	BE	FRC; PLRIE	Br	F	S	R
R9	**KG_R9_S8**	9.23	7.58	26.12	30.98	BB	NP	GBB	BE	RIE	Bl	F	S	R

T9	**KG_T9_S1**	9.47	8.23	40.06	44.88	BB	NP	GBB	BE	FRC; BILRIE	RB	F	S	O
H11	**KG_H11_S1**	8.59	6.91	44.16	24.45	BB	NP	RSB	BE	PLRIB	RB	CF	S	O
H11	**KG_H11_S2**	7.95	7.07	28.72	40.71	BB	NP	GBB	BE	BIGLE; BILRIE	DB	F	S	R
H11	**KG_H11_S3**	7.36	7.26	48.49	33.76	BB	NP	GBB	BE	PLRIB; BIGLB	Bl	CF	S	R
I11	**KG_I11_S2**	7.73	6.26	29.33	24.1	BB	NP	GBB	BE	RIE	DB	F	S	R
J11	**KG_J11_S2**	6.29	6.05	43.69	71.56	BE	NP	GBE	BE	FRC	Br	F	S	R
O11	**KG_O11_S5**	7.99	6.14	41.46	39.63	BB	NP	GBB	BE	RIE	DB	CF	S	R
O11	**KG_O11_S6**	7.62	5.24	42.01	42.08	BB	NP	GBB	BE	RIE	DB	F	S	R
O11	**KG_O11_S7**	8.88	5.59	34.29	39.16	BE	NP	GBB	BB	RIE; BILRIE	DB	CF	S	R

SL: Sherd Label; **UT:** Upper thickness; **LT:** Lower thickness; **H:** Height; **W:** Width

ST: Surface Treatment -> Burnished on both Walls (**BB**); Burnished on the Interior Wall (**BI**); Patterned (**P**); Smoothed on the exterior wall (**SE**); Smoothed on both walls (**SB**); Smoothed on the interieur wall (**SI**); Patterned on the exterior wall (**PE**)

SP: Surface Patterning -> Patterned (**P**); Not Patterned (**NP**)

SC: Surface Coating -> Red Slipped on Both Walls (**RSB**); Red Slipped on the Exterior Wall (**RSE**); Red Slipped on the Interior Wall (**RSI**); Graphite Burnished on Both Walls (**GBB**); Graphite Burnished on the Exterior Wall (**GBE**); Graphite Burnished on the Interior Wall (**GBI**); Plain on the interior wall (**PI**)

PD: Place of Decoration -> On the Exterior of the body (BE); On both wall of the body (BB); No Decoration (**ND**)

DS: Decoration Motif Style -> Band of incised lines (**BIL**); Wavy Combing Lines (**WCL**); False Relief Chevron (**FRC**); Row of Impression on Both Side (**RIB**); Row of Impression on the Exterior (**RIE**); Parallel lines of impression row on the exterior wall (**PLRIE**); Band of Impression and Geometric Lines on the Exterior Wall (**BIGLE**); Band of Impression and Geometric Lines on the interior wall (**BIGLI**); Band of Impression and Geometric Lines on both walls (**BIGLB**); Band of incised lines and rows of impression (**BILRIE**); Parallel Lines and Row of Impression on the Exterior Wall (**PLRIE**); No Decoration (**ND**)

PC: Paste Color -> Black (**Bl**); Dark Brown (**DB**); Brown (**Br**); Red Brown (**RB**); Red (**R**); Other (**O**)

PT: Paste Texture -> Coarse (**C**); Coarse Fine (**CF**); Fine (**F**)

Tp: Tempers -> Sand (**S**); Organic (**O**)

FC: Firing Condition -> Reduced (**R**); Oxidized (**O**); Mixed (**M**)

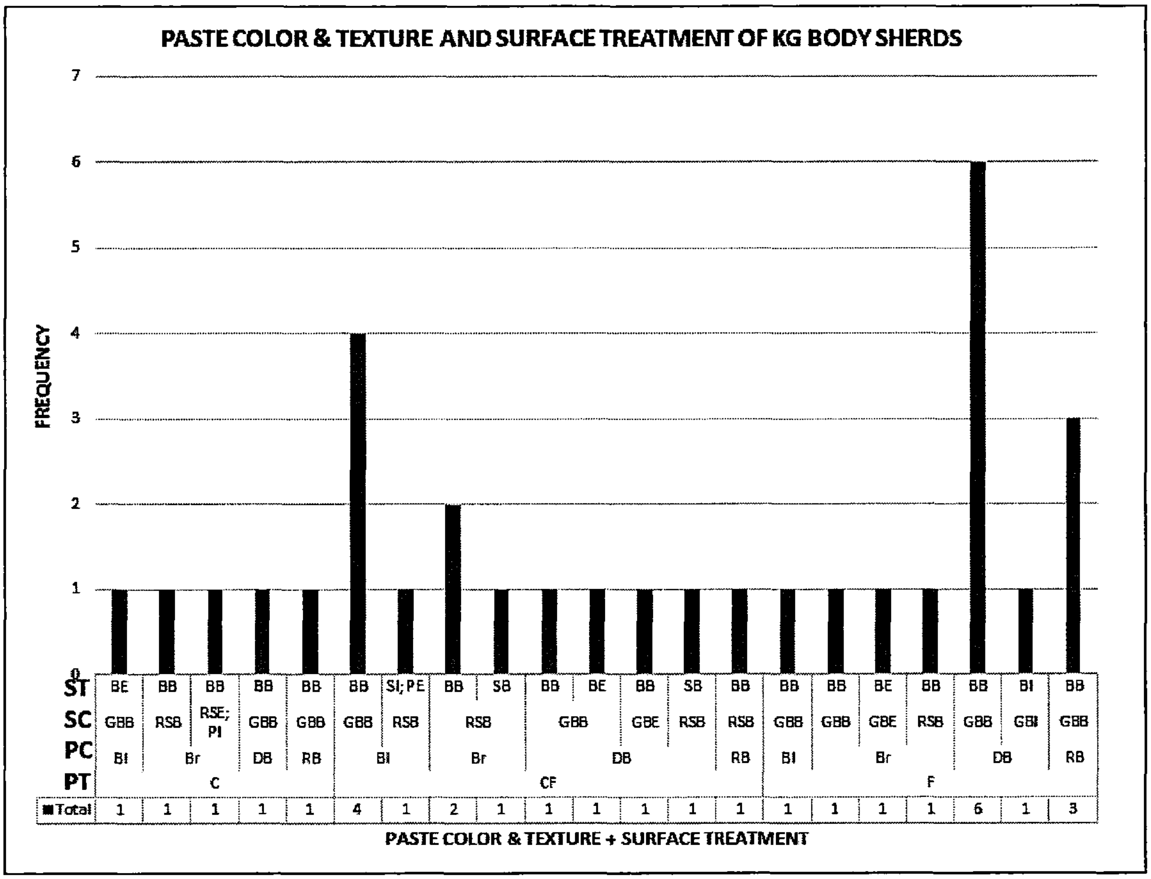

Figure 6.11: Heating Effectiveness of Body Sherds from KG Based on Paste Texture & Color, and Surface Treatment & Patterning

ST: *Surface Treatment -> Burnished on both walls* (**BB**); *Burnished on the Interior Wall* (**BI**); *Burnished on the Exterior Wall* (**BE**); *Smoothed on the interieur wall* (**SI**); *Patterned on the exterior wall* (**PE**)

SC: *Surface Coating -> Red Slipped on Both Walls* (**RSB**); *Red Slipped on the Exterior Wall* (**RSE**); *Red Slipped on the Interior Wall* (**RSI**); *Plain on both walls* (**PB**)

PC: *Paste Color -> Black* (**Bl**); *Dark Brown* (**DB**); *Brown* (**Br**); *Red Brown* (**RB**)

PT: *Paste Texture -> Coarse* (**C**); *Coarse Fine* (**CF**)

I also observed a correlation between the graphite-burnishing and darker paste color on the one hand, and the red-slipping and lighter paste color on the other (Figure 6.11). At first, I thought the application of graphite to the surface constrained potters to fire their pot at a low temperature, for fear that the graphite would melt. However, Etienne de Flacourt noted that graphite was rubbed on vessels only after they had been fired.

> "*Les potiers et potières s'adonnent à choisir, pétrir et preparer la terre, à la fabrique des villangues, sines, pots, plats, vases qu'ils cuisent avec un feu de broussailles; après les avoir frottés avec une terre noire ressemblant à de l'antimoine, deviennent clairs et reluisants comme s'ils étaient vernis.*" (Flacourt 1661: 74).
>
> Potters, male and female, devoted themselves to choosing, kneading and preparing the soil, to make *villangues* [vilagne = pot], *sines* [siny = jar], pots, dishes, and vases which they baked in brushwood fire; after they have been rubbed with black soil resembling antimony, they become clear and shining as if they were varnished.

If Flacourt was correct, then the reduced firing techniques might have been intended for reasons not having to do with graphite. If graphite-burnished pottery was made locally along the MSV, potters would have had to acquire graphite ore from somewhere else. The nearest graphite deposit is located 40 km south of the Onilahy (Besairie et al. 1951: 29; Guyot 2002: 39).

The small capacity of vessels indicates that they could have been used for different purposes, except for long-term storage (see Rice 2015: 413-414). The abundance of unrestricted vessels with thin walls suggests they were more likely for cooking or serving than for processing (Rice 1987: 238; Skibo 2013: 30-32; Smith 1985: 305). According to Flacourt (1661: 74), they were pots, jar, dishes, and vases. The stability of vessels suggests they could be used without being held or attached/leaned against a support. High spill-ability and lack of graspability suggest that they were not for transport, at least not over long distances. Although they were suitable for heating, their thermal shock resistance was limited. In a nutshell, the KG assemblage was dominated by open bowls that would have been used for serving, and probably for cooking. More studies of sooting and carbonization are needed to determine whether they were used for cooking.

6.2.2.3. Dating Keliangebo

Dating was based on comparative analyses of a diagnostic pottery tradition known elsewhere in Madagascar. The shapes and motifs (impressed triangles and incised lines of different geometric designs) of the graphite-burnished pottery predominantly found at the site were the key. These decorations have been encountered at many sites in Madagascar (Figure 6.12). In the central highlands, they have been reported at Antanambe, Fiekena, and Ankatso (Arnaud 1970; Wright 2005: 42-49). Thermoluminescence dates at Antanambe go back to 15th - 16th centuries CE (Wright 2005: 42). A similar tradition was present at Antsentsindrano, Antsahabe, and Vohimasina further south, in the Vakinankaratra region of the central highlands, and was absolutely dated to the late 14th to early 16th centuries CE (Crossland 2001: 116; Raharijaona 1986; Wright 2005: 48). The same graphite-burnished pottery vessels have been absolute-dated to 15th – 17th centuries CE along the east coast (Griffin 2009: 104) and in the southwest (Douglass 2016; Verin 1971), to 16th-17th centuries CE in the southeast (Rakotoarisoa 1998: 89-91) and deep south (Parker Pearson 2010: 262-267), and to 15th – 16th centuries CE on the west coast (Wright *in preparation*). Consistent dating of 15th – 17th centuries CE is evident across southern Madagascar, and it is reasonable to assume that Keliangebo was occupied during this period. This assumption should be tested with absolute dating methods in future.

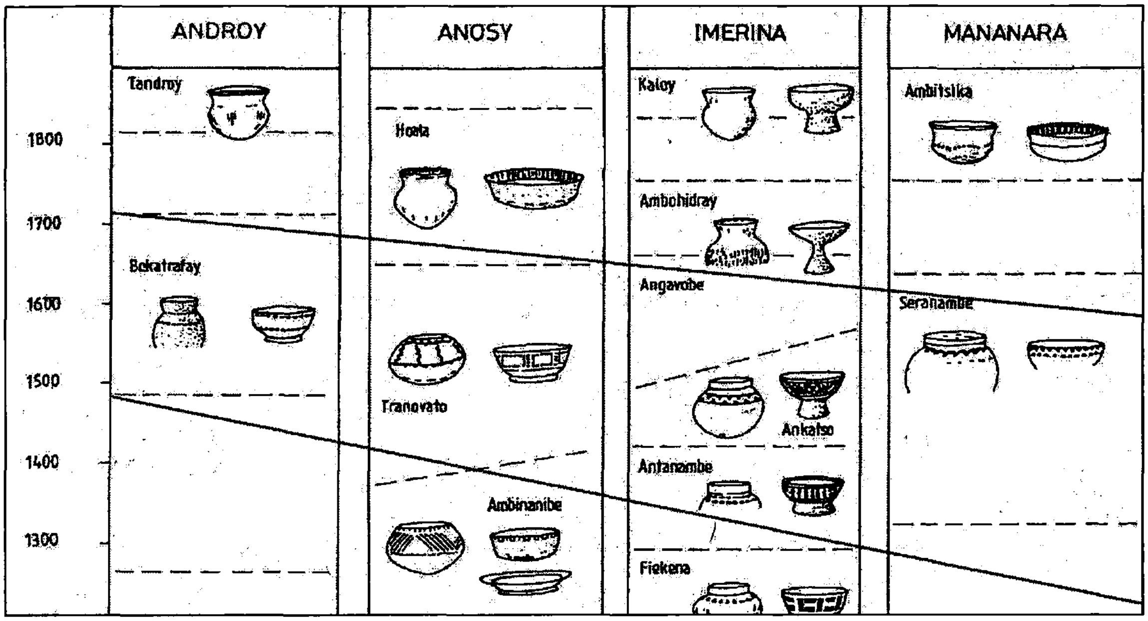

Figure 6.12: Graphite-Burnished Pottery Decorated with Impressed Triangles and Incised Lines from Different Parts of Madagascar (After Rakotoarisoa 1998: 134)

6.3. Excavation Results for the Ankilivalo Site

I excavated three units of different sizes and shapes at Ankilivalo (Figure 6.13). The choices for placing excavation units are discussed in *5.2.3.* Figure 6.13 shows their locations in relation to the intrasite survey grids, shovel test pits, and distribution of surface materials.

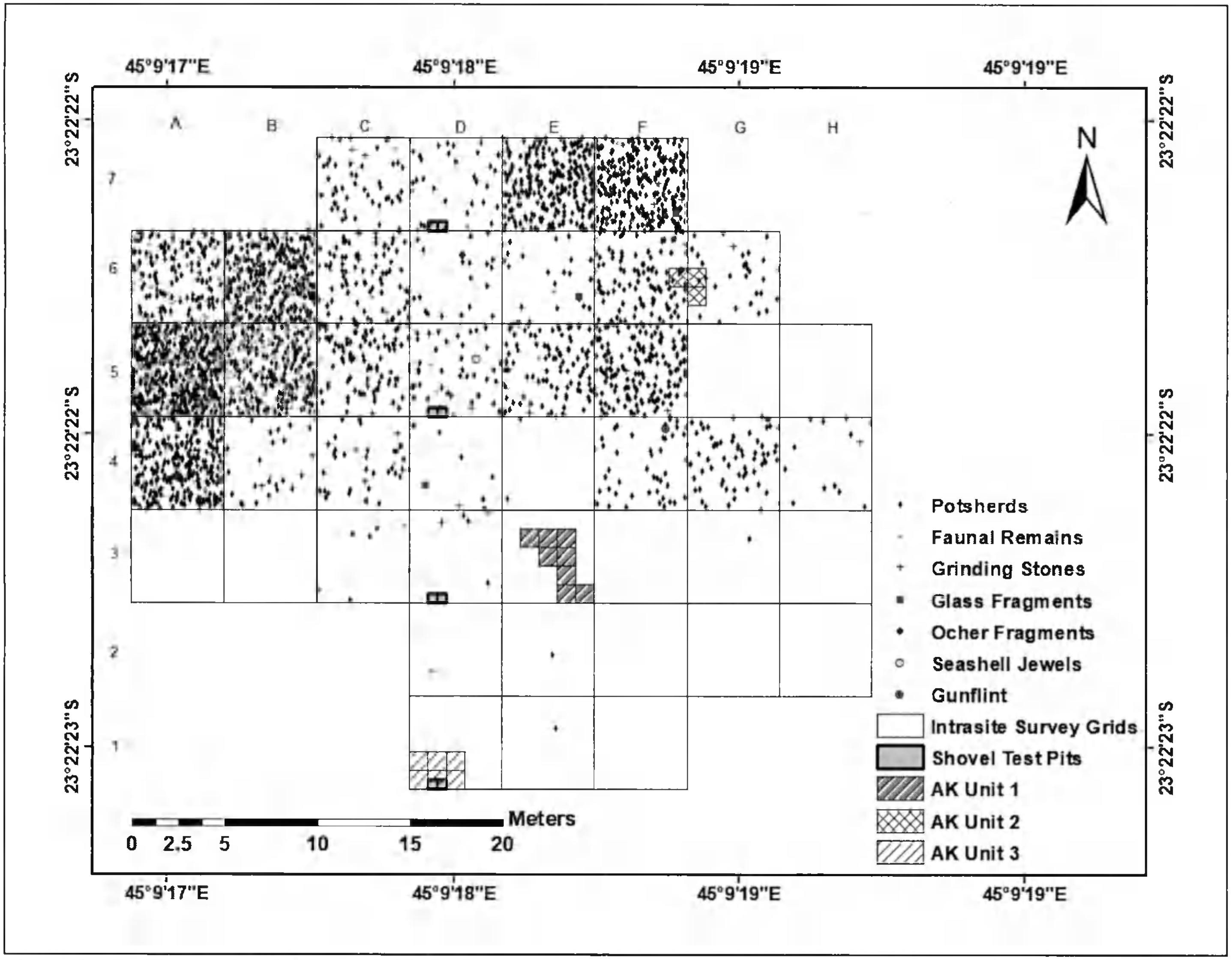

Figure 6.13: Excavation Units and Their Contexts at Ankilivalo

6.3.1. Excavation Unit 1

The number of layers within sub-units of Excavation Unit 1 was inconsistent. I stopped excavating at 70 cm deep from the sub-datum 0 leveled line across all sub-units, however, because this was where a sandy soil that looked like river sand was encountered.

Five soil colors and textures occurred consistently across the adjacent sub-units SU1 and SU2 (see Figure 6.14). Only the first two layers yielded archaeological materials, including potsherds, faunal remains, a gunflint and a fishing hook (Table 6.12).

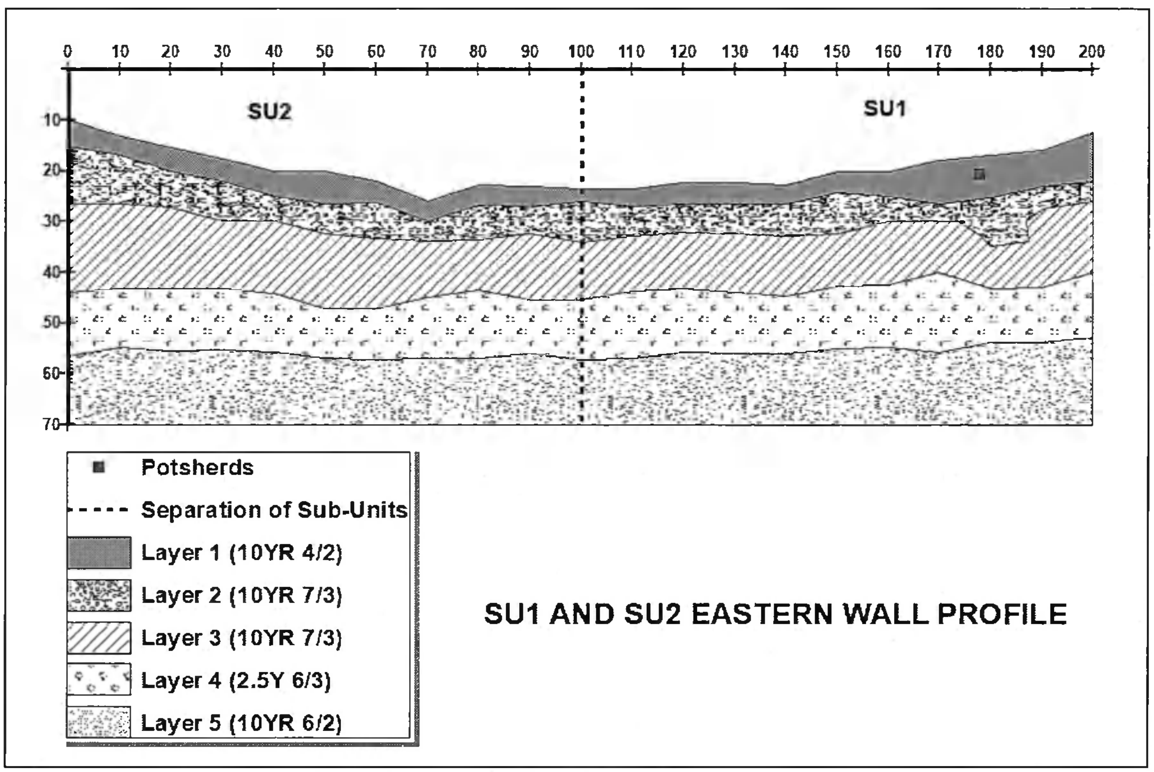

Figure 6.14: Eastern Wall Profiles of SU1-SU2

Table 6.11: Recapitulation of Finds Recovered from AK Excavation Unit 1 SU1 and SU2

Level	Opening Depth (cm)	Closing Depth (cm)	Soil Colors and Textures	Pt	Fn	Lt	Mtl	C
Layer 1	NW: 14 NE: 10 SE: 10 SW: 10 C: 11	NW: 16 NE: 15 SE: 22 SW: 20 C: 18	Dark Grayish Brown (10YR 4/2) Medium Sand (1/4 – 1/2 mm)	110	5	1	1	163
Layer 2	NW: 16 NE: 15 SE: 22 SW: 20 C: 18	NW: 26 NE: 27 SE: 26 SW: 25 C: 27	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	13	8	0	0	30
Layer 3	NW: 26 NE: 27 SE: 26 SW: 25 C: 27	NW: 44 NE: 43 SE: 40 SW: 39 C: 42	Very Pale Brown (10YR 7/3) Fine Sand (1/8 – 1/4 mm)	0	0	0	0	0
Layer 4	NW: 44 NE: 43 SE: 40 SW: 39 C: 42	NW: 55 NE: 56 SE: 52 SW: 54 C: 53	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 -1/2 mm)	0	0	0	0	0
Layer 5	NW: 55 NE: 56 SE: 52 SW: 54 C: 53	NW: 70 NE: 70 SE: 70 SW: 70 C: 70	Light Brownish Gray (10YR 6/2) Fine Sand (1/8 – 1/4 mm)	0	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic materials (here a gunflint)*; **Mtl** = *Metal (here a fishing hook)*; **C** = *Charcoal fragments.*

In addition, I discovered five circular features of dark, yellowish brown (10YR 3/4) medium sand (1/4 – 1/2 mm). Four were aligned from southeast to northwest (Figure 6.15). While the layer was hard overall, requiring much energy to dig with a trowel, it was easy to remove these features with a spoon. I accordingly posited that they were postholes, but the absence of cultural materials within the third and fourth layers made my assumption implausible. To make sure they were not postholes, I opened six other sub-units to look for extensions of these features.

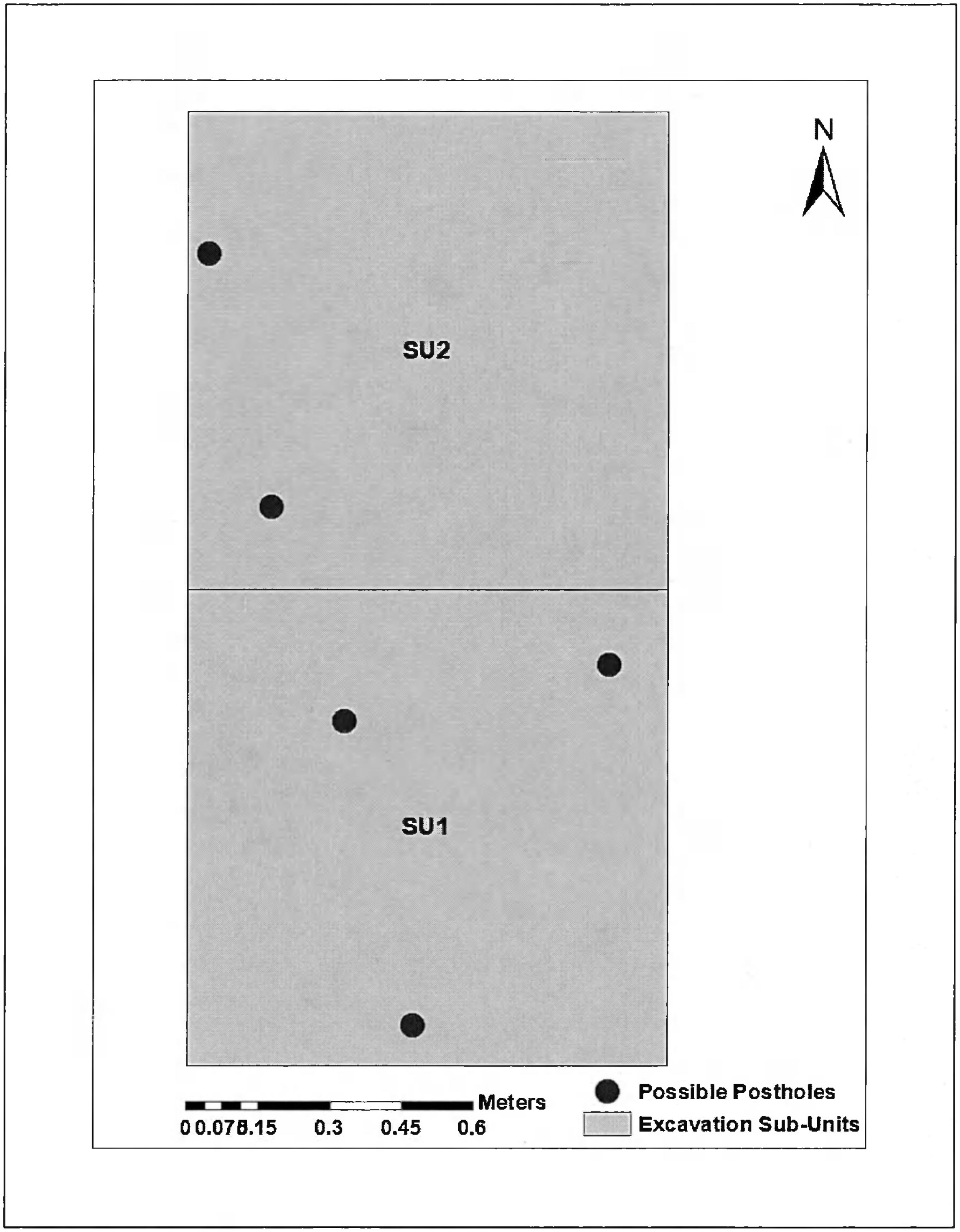

Figure 6.15: Five Possible Postholes Encountered at AK Excavation Unit 1 SU1 and SU2, Level 4

In the northern part of Excavation Unit 1, three soil colors and textures were found consistently in the three adjacent sub-units (SU3, SU5, and SU7) (Figure 6.16). Only the first layer yielded cultural materials (Tables 6.12, 6.13 and 6.14).

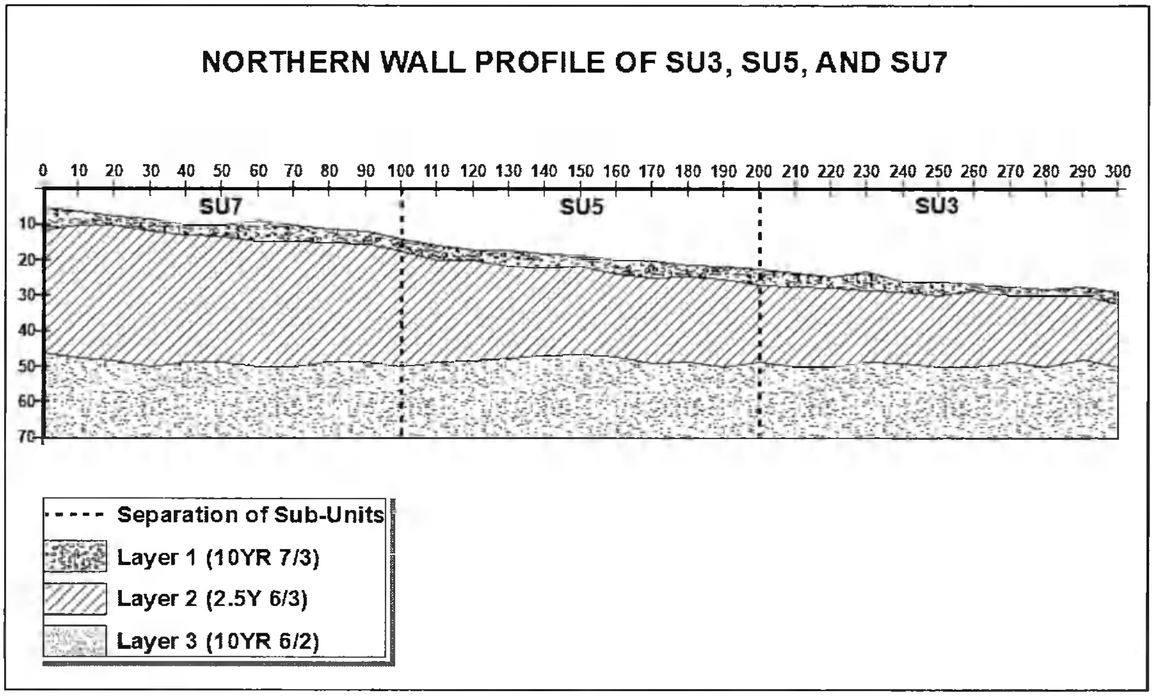

Figure 6.16: Northern Wall Profile for SU3, SU5, and SU7

Table 6.12: Recapitulation of Finds Recovered from Excavation Unit 1 Sub-Unit 3

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Potsherds	Faunal Remains
Level 1	NW: 22 NE: 29 SE: 10 SW: 14 C: 19	NW: 27 NE: 32 SE: 26 SW: 27 C: 28	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	4	2
Level 2	NW: 27 NE: 32 SE: 26 SW: 27 C: 28	NW: 48 NE: 50 SE: 56 SW: 55 C: 53	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 – 1/2 mm)	0	0
Level 3	NW: 48 NE: 50 SE: 56 SW: 55 C: 53	NW: 70 NE: 70 SE: 70 SW: 70 C: 70	Light Yellowish Gray (10YR 6/2) Medium Sand (1/4 -1/2 mm)	0	0

Table 6.13: Recapitulation of Finds Recovered from Excavation Unit 1 Sub-Unit 5

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Potsherds	Faunal Remains
Level 1	NW: 13 NE: 22 SE: 14 SW: 12 C: 17	NW: 17 NE: 27 SE: 27 SW: 22 C: 25	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	4	2
Level 2	NW: 17 NE: 27 SE: 27 SW: 22 C: 25	NW: 50 NE: 48 SE: 55 SW: 46 C: 50	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 – 1/2 mm)	0	0
Level 3	NW: 50 NE: 48 SE: 55 SW: 46 C: 50	NW: 70 NE: 70 SE: 70 SW: 70 C: 70	Light Yellowish Gray (10YR 6/2) Medium Sand (1/4 -1/2 mm)	0	0

Table 6.14: Recapitulation of Finds Recovered from Excavation Unit 1 Sub-Unit 7

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	Lt	Mtl	C
Level 1	NW: 5 NE: 13 SE: 12 SW: 4 C: 10	NW: 11 NE: 17 SE: 22 SW: 12 C: 19	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	14	0	2	1	4
Level 2	NW: 11 NE: 17 SE: 22 SW: 12 C: 19	NW: 46 NE: 50 SE: 46 SW: 48 C: 47	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 – 1/2 mm)	0	0	0	0	0
Level 3	NW: 46 NE: 50 SE: 46 SW: 48 C: 47	NW: 70 NE: 70 SE: 70 SW: 70 C: 70	Light Yellowish Gray (10YR 6/2) Medium Sand (1/4 -1/2 mm)	0	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic materials*; **Mtl** = *Metal Pieces*; **C** = *Charcoal fragments*.

In the southern part of Excavation Unit 1, I recorded four soil colors and textures within three adjacent sub-units (SU4, SU6 and SU8) (Figure 6.17, and Figure 6.18). Finds are summarized in Tables 6.15, 6.16, and 6.17.

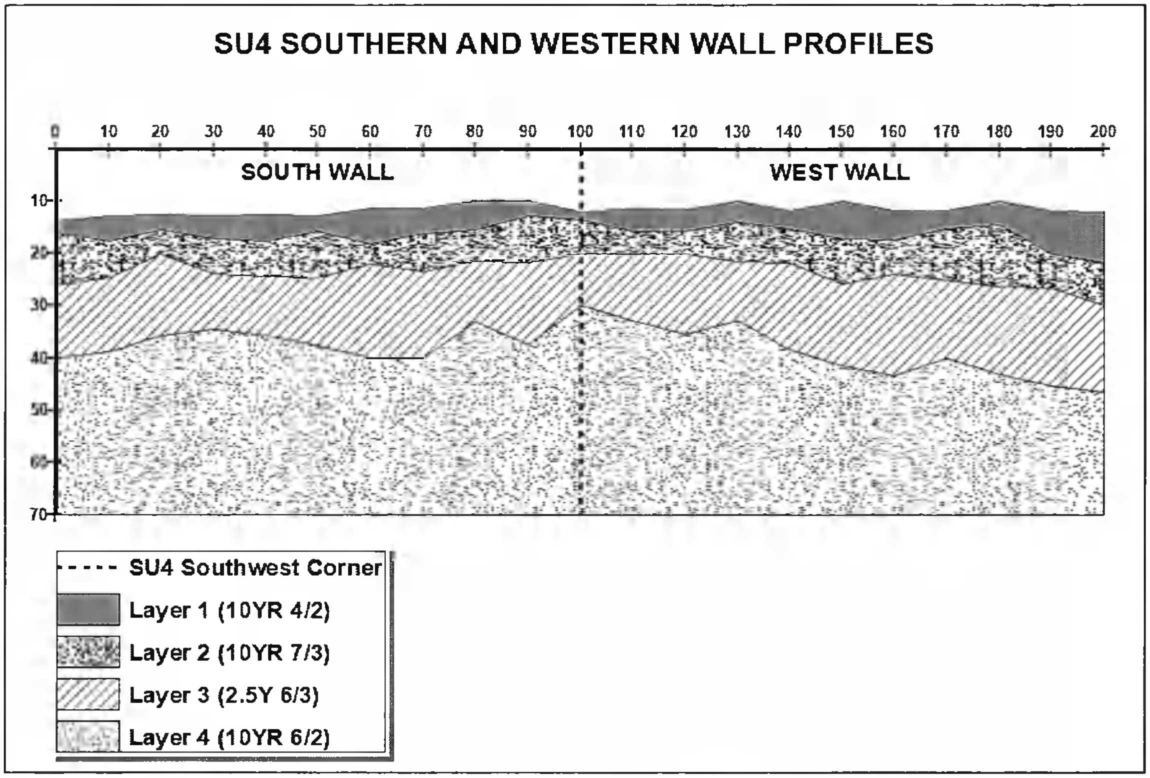

Figure 6.17: Sub-Unit 4 Southern and Western Wall Profiles

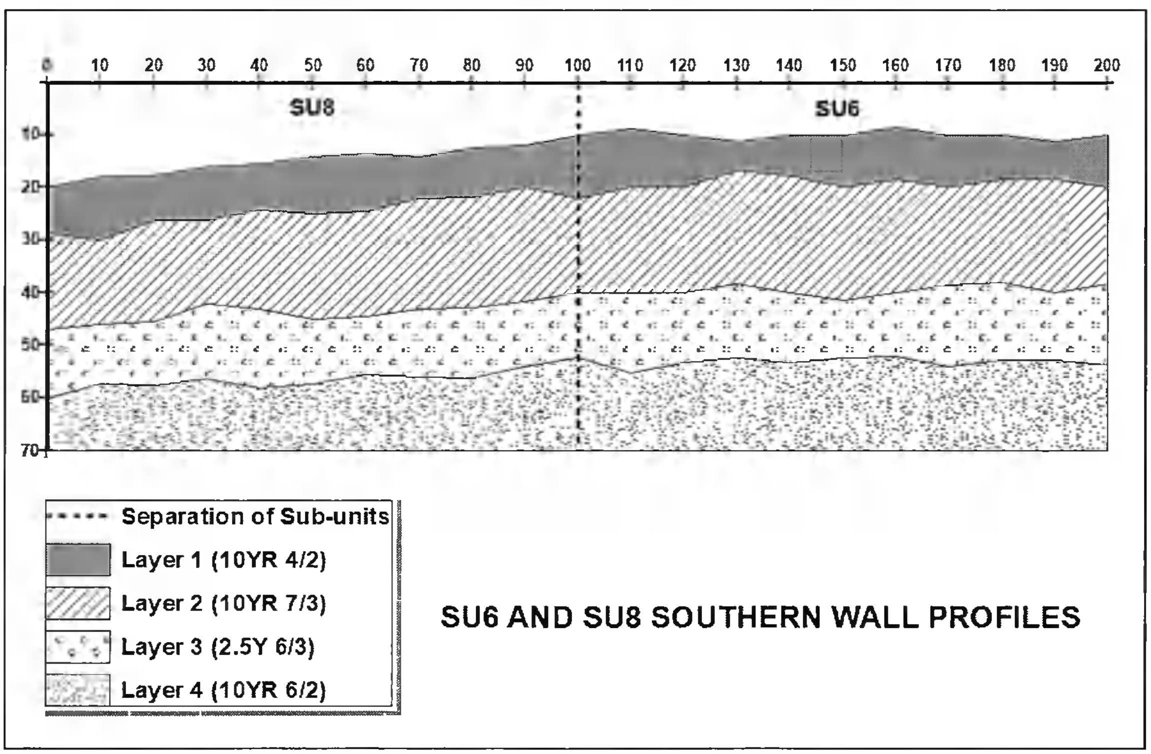

Figure 6.18: SU6 and SU8 Southern Wall Profiles

Table 6.15: Recapitulation of Finds Recovered from AK Excavation Unit 1 Sub-Unit 4

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	Gls	C
Level 1	NW: 12 NE: 14 SE: 14 SW: 14 C: 13	NW: 22 NE: 27 SE: 16 SW: 15 C: 18	Dark Grayish Brown (10YR 4/2) Medium Sand (1/4 – 1/2 mm)	59	6	1	8
Level 2	NW: 22 NE: 27 SE: 16 SW: 15 C: 18	NW: 30 NE: 34 SE: 26 SW: 20 C: 27	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0	0
Level 3	NW: 30 NE: 34 SE: 26 SW: 20 C: 27	NW: 46 NE: 55 SE: 40 SW: 29 C: 39	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 -1/2 mm)	0	0	0	0
Level 4	NW: 46 NE: 55 SE: 40 SW: 29 C: 39	NW: 70 NE: 70 SE: 70 SW: 70 C: 70	Light Brownish Gray (10YR 6/2) Fine Sand (1/8 – 1/4 mm)	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Gls** = *Glass fragments*; **C** = *Charcoal fragments*.

Table 6.16: Recapitulation of Finds Recovered from Excavation Unit 1 Sub-Unit 6

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	Mtl	C
Level 1	NW: 10 NE: 10 SE: 10 SW: 10 C: 10	NW: 20 NE: 22 SE: 22 SW: 20 C: 20	Dark Grayish Brown (10YR 4/2) Medium Sand (1/4 – 1/2 mm)	9	3	1	1
Level 2	NW: 20 NE: 22 SE: 22 SW: 20 C: 20	NW: 39 NE: 40 SE: 40 SW: 38 C: 41	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0	0
Level 3	NW: 39 NE: 40 SE: 40 SW: 38 C: 41	NW: 54 NE: 52 SE: 52 SW: 53 C: 52	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 -1/2 mm)	0	0	0	0
Level 4	NW: 54 NE: 52 SE: 52 SW: 53 C: 52	NW: 70 NE: 70 SE: 70 SW: 70 C: 70	Light Brownish Gray (10YR 6/2) Fine Sand (1/8 – 1/4 mm)	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Mtl** = *Metal fragments*; **C** = *Charcoal fragments*.

Table 6.17: Recapitulation of Finds Recovered from Excavation Unit 1 Sub-Unit 8

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Potsherds	Charcoal Fragments
Level 1	NW: 10 NE: 17 SE: 20 SW: 10 C: 14	NW: 22 NE: 26 SE: 29 SW: 22 C: 25	Dark Grayish Brown (10YR 4/2) Medium Sand (1/4 – 1/2 mm)	2	1
Level 2	NW: 22 NE: 26 SE: 29 SW: 22 C: 25	NW: 40 NE: 46 SE: 48 SW: 40 C: 44	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0
Level 3	NW: 40 NE: 46 SE: 48 SW: 40 C: 44	NW: 52 NE: 54 SE: 60 SW: 52 C: 58	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 -1/2 mm)	0	0
Level 4	NW: 52 NE: 54 SE: 60 SW: 52 C: 58	NW: 70 NE: 70 SE: 70 SW: 70 C: 70	Light Brownish Gray (10YR 6/2) Fine Sand (1/8 – 1/4 mm)	0	0

In total, Excavation Unit 1 yielded 215 potsherds, 26 faunal remains, three stone objects, three metal objects, one glass fragments, and 207 pieces of charcoal (Table 6.18).

Table 6.18: Recapitulation of Finds Recovered from Excavation Unit 1

Sub-Units	Potsherds	Faunal Remains	Stone Objects	Metal Object	Glass Fragments	Charcoals
SU1-SU2	123	13	01	01	00	193
SU3	04	02	00	00	00	00
SU4	59	06	00	00	01	08
SU5	04	02	00	00	00	00
SU6	09	03	00	01	00	01
SU7	14	00	02	01	00	04
SU8	02	00	00	00	00	01
Total	**215**	**26**	**03**	**03**	**01**	**207**

6.3.2. Excavation Unit 2

Five soil colors and textures were consistently encountered in the three sub-units (Figure 6.19), and I observed a few disturbances between layers.

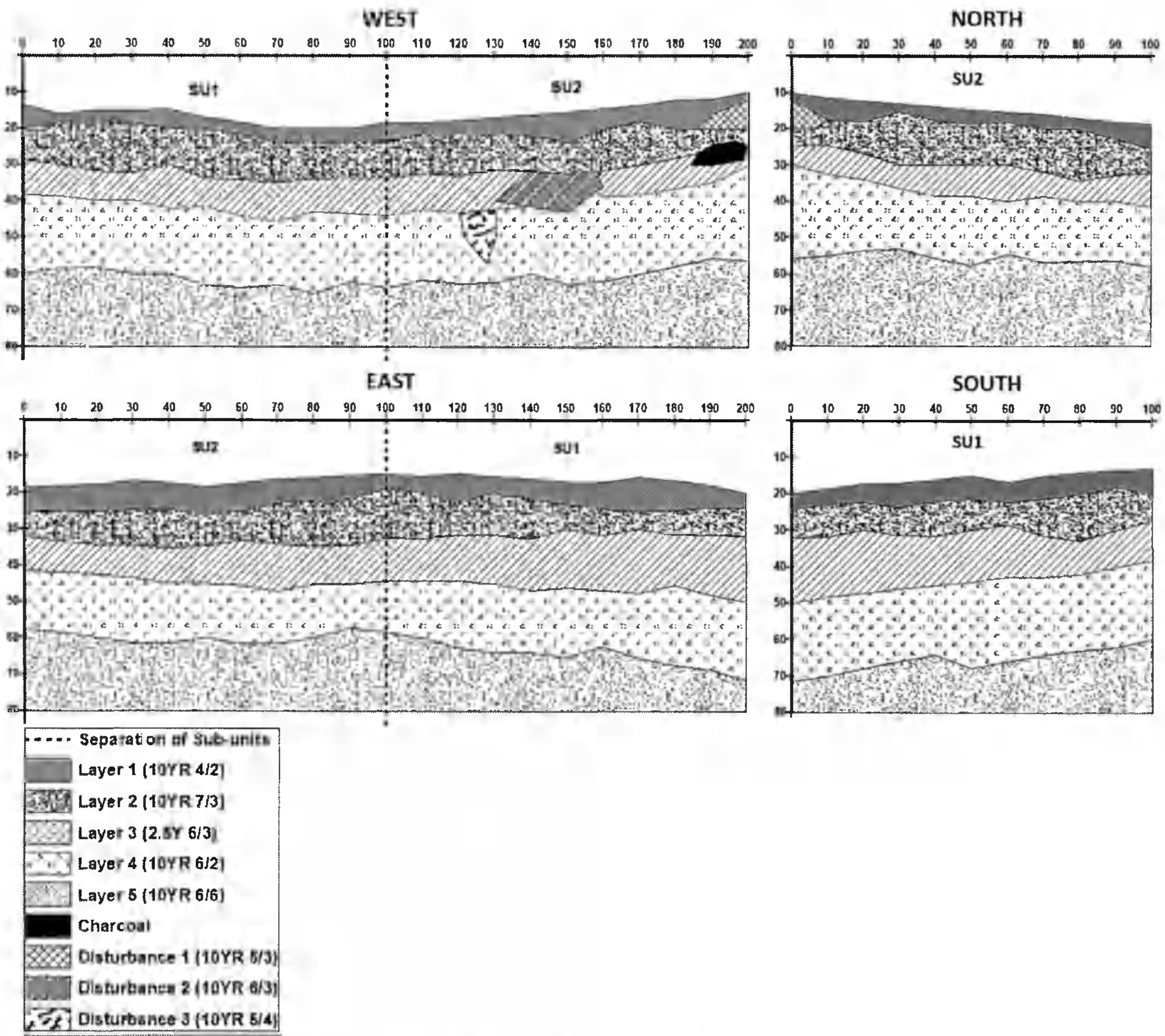

Figure 6.19: Western Wall Profiles of Excavation Unit 2 SU1 and SU2

Most finds were recovered from the first layer. A few archaeological objects were also found in the second layer of SU1 (see Tables 6.19, 6.20, and 6.21).

Table 6.19: Recapitulation of Finds Recovered from Excavation Unit 2 Sub-Unit 1

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	Lt	Gls	C
Level 1	NW: 17 NE: 15 SE: 20 SW: 13 C:	NW: 22 NE: 19 SE: 24 SW: 20 C: 21	Dark Grayish Brown (10YR 4/2) Medium Sand (1/4 – 1/2 mm)	109	19	1	1	7
Level 2	NW: 22 NE: 19 SE: 24 SW: 20 C: 21	NW: 33 NE: 32 SE: 32 SW: 28 C: 35	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	3	4	0	0	29
Level 3	NW: 33 NE: 32 SE: 32 SW: 28 C: 35	NW: 43 NE: 44 SE: 50 SW: 38 C: 41	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 -1/2 mm)	0	0	0	0	0
Level 4	NW: 43 NE: 44 SE: 50 SW: 38 C: 41	NW: 62 NE: 59 SE: 71 SW: 60 C: 63	Light Brownish Gray (10YR 6/2) Medium Sand (1/4 – 1/2 mm)	0	0	0	0	0
Level 5	NW: 62 NE: 59 SE: 71 SW: 60 C: 63	NW: 80 NE: 80 SE: 80 SW: 80 C: 80	Brownish Yellow (10YR 6/6) Fine Sand (1/8 – 1/4 mm)	0	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic objects*; **Gls** = *Glass fragments*; **C** = *Charcoal fragments*.

Table 6.20: Recapitulation of Finds Recovered from Excavation Unit 2 Sub-Unit 2

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Lt	Gls	Mtl
Level 1	NW: 10 NE: 19 SE: 15 SW: 17 C: 15	NW: 12 NE: 25 SE: 19 SW: 22 C: 23	Dark Grayish Brown (10YR 4/2) Medium Sand (1/4 – 1/2 mm)	1	1	1	1
Level 2	NW: 20 NE: 25 SE: 19 SW: 22 C: 23	NW: 24 NE: 32 SE: 32 SW: 33 C: 32	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0	0
Level 3	NW: 24 NE: 32 SE: 32 SW: 33 C: 32	NW: 30 NE: 41 SE: 44 SW: 43 C: 40	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 -1/2 mm)	0	0	0	0
Level 4	NW: 30 NE: 41 SE: 44 SW: 43 C: 40	NW: 57 NE: 58 SE: 59 SW: 62 C: 62	Light Brownish Gray (10YR 6/2) Medium Sand (1/4 – 1/2 mm)	0	0	0	0
Level 5	NW: 57 NE: 58 SE: 59 SW: 62 C: 62	NW: 80 NE: 80 SE: 80 SW: 80 C: 80	Brownish Yellow (10YR 6/6) Fine Sand (1/8 – 1/4 mm)	0	0	0	0

Pt = *Potsherds*; **Lt** = *Lithic objects*; **Gls** = *Glass fragments*; **Mtl** = *Metal fragments*.

Table 6.21: Recapitulation of Finds Recovered from Excavation Unit 2 Sub-Unit 3

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	Lt
Level 1	NW: 8 NE: 10 SE: 17 SW: 9 C: 15	NW: 10 NE: 12 SE: 22 SW: 15 C: 19	Dark Grayish Brown (10YR 4/2) Medium Sand (1/4 – 1/2 mm)	10	1	1
Level 2	NW: 10 NE: 12 SE: 22 SW: 15 C: 19	NW: 20 NE: 24 SE: 34 SW: 26 C: 30	Very Pale Brown (10YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0
Level 3	NW: 20 NE: 24 SE: 34 SW: 26 C: 30	NW: 29 NE: 30 SE: 43 SW: 32 C: 36	Light Yellowish Brown (2.5Y 6/3) Medium Sand (1/4 -1/2 mm)	0	0	0
Level 4	NW: 29 NE: 30 SE: 43 SW: 32 C: 36	NW: 53 NE: 57 SE: 62 SW: 51 C: 58	Light Brownish Gray (10YR 6/2) Medium Sand (1/4 – 1/2 mm)	0	0	0
Level 5	NW: 53 NE: 57 SE: 62 SW: 51 C: 58	NW: 80 NE: 80 SE: 80 SW: 80 C: 80	Brownish Yellow (10YR 6/6) Fine Sand (1/8 – 1/4 mm)	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic objects*

In total, Excavation Unit 2 yielded 123 potsherds, 24 faunal remains, three stone objects, three glass fragments, one metal object (unknown), and seven pieces of charcoals (Table 6.22).

Table 6.22: Recapitulation of Finds Recovered from Excavation Unit 2

Sub-Units	Potsherds	Faunal Remains	Charcoals	Stone Objects	Metal Object	Glass Fragments
SU1	112	23	07	01	00	01
SU2	01	00	00	01	01	01
SU3	10	01	00	01	00	01
Total	**123**	**24**	**07**	**03**	**01**	**03**

6.3.3. Excavation Unit 3

I recorded six soil colors and textures across the six sub-units of Unit 3 (see Figure 6.20). They were mainly colluvial deposits washed down from the adjacent hill. Unit 3 revealed a deep stratigraphy sealing a fifth layer rich in potsherds and animal bones. I stopped excavating at 110 cm deep from the sub-datum 0 leveled line. Tables 6.23 - 6.28 summarize finds in each layer.

Table 6.23: Recapitulation of Finds Recovered from Excavation Unit 3 Sub-Unit 1

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	Lt	Plt	C
Level 1	NW: 19 NE: 21 SE: 15 SW: 10 C: 18	NW: 40 NE: 42 SE: 41 SW: 36 C: 40	Dark Yellowish Brown (10 YR 4/4) Medium Sand (1/4 -1/2 mm)	0	0	0	0	0
Level 2	NW: 40 NE: 42 SE: 41 SW: 36 C: 40	NW: 46 NE: 48 SE: 49 SW: 41 C: 47	Light Yellowish Brown (2.5 YR 6/3) Fine Sand (1/8 -1/4 mm)	0	0	0	0	0
Level 3	NW: 46 NE: 48 SE: 49 SW: 41 C: 47	NW: 63 NE: 66 SE: 64 SW: 59 C: 62	Pale Brown (10YR 6/3) Medium Sand (1/4 – 1/2mm)	0	0	0	0	0
Level 4	NW: 63 NE: 66 SE: 64 SW: 59 C: 62	NW: 74 NE: 77 SE: 76 SW: 73 C: 76	Grayish Brown (10 YR 5/2) Medium Sand (1/4 - 1/2 mm)	0	0	0	0	0
Level 5	NW: 74 NE: 77 SE: 76 SW: 73 C: 76	NW: 89 NE: 93 SE: 93 SW: 87 C: 91	Dark Grayish Brown (10 YR 4/2) Medium Sand (1/4 -1/2 mm)	7	106	0	1	57
Level 6	NW: 89 NE: 93 SE: 93 SW: 87 C: 91	NW: 110 NE: 110 SE: 110 SW: 110 C: 110	Very Pale Brown (10 YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic objects*; **Plt** = *Plant Remains*; **C** = *Charcoal fragments*.

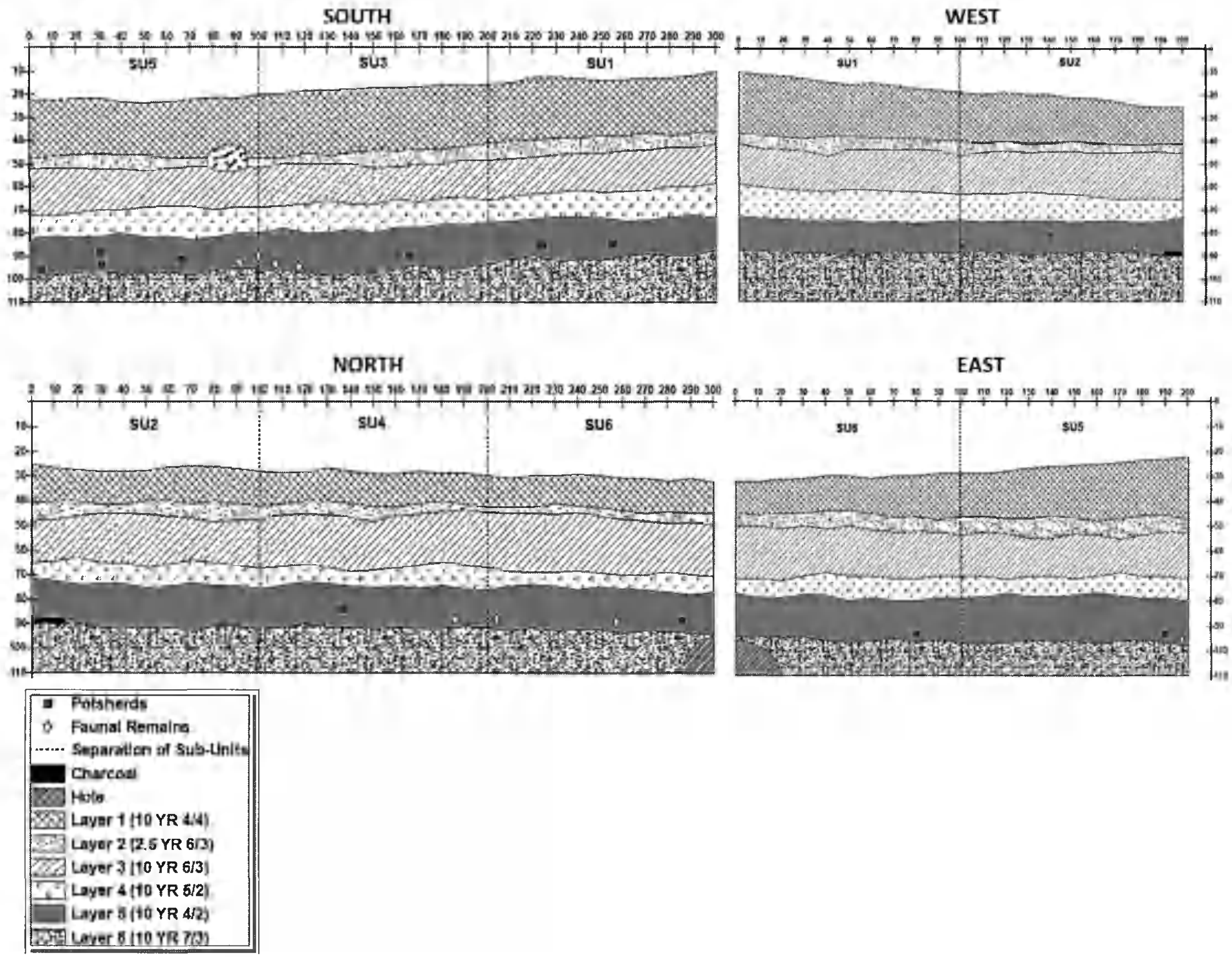

Figure 6.20: AK Excavation Unit 3 Wall Profiles

Table 6.24: Recapitulation of Finds Recovered from Excavation Unit 3 Sub-Unit 2

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	C
Level 1	NW: 25 NE: 28 SE: 21 SW: 19 C: 25	NW: 41 NE: 42 SE: 42 SW: 40 C: 41	Dark Yellowish Brown (10 YR 4/4) Medium Sand (1/4 -1/2 mm)	0	0	0
Level 2	NW: 41 NE: 42 SE: 42 SW: 40 C: 41	NW: 47 NE: 47 SE: 48 SW: 46 C: 47	Light Yellowish Brown (2.5 YR 6/3) Fine Sand (1/8 -1/4 mm)	0	0	0
Level 3	NW: 47 NE: 47 SE: 48 SW: 46 C: 47	NW: 65 NE: 67 SE: 66 SW: 63 C: 66	Pale Brown (10YR 6/3) Medium Sand (1/4 – 1/2mm)	0	0	0
Level 4	NW: 65 NE: 67 SE: 66 SW: 63 C: 66	NW: 73 NE: 76 SE: 77 SW: 74 C: 75	Grayish Brown (10 YR 5/2) Medium Sand (1/4 -1/2 mm)	0	0	0
Level 5	NW: 73 NE: 76 SE: 77 SW: 74 C: 75	NW: 90 NE: 92 SE: 93 SW: 89 C: 91	Dark Grayish Brown (10 YR 4/2) Medium Sand (1/4 -1/2 mm)	2	7	231
Level 6	NW: 90 NE: 92 SE: 93 SW: 89 C: 91	NW: 110 NE: 110 SE: 110 SW: 110 C: 110	Very Pale Brown (10 YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **C** = *Charcoal fragments.*

Table 6.25: Recapitulation of Finds Recovered from Excavation Unit 3 Sub-Unit 3

Level	**Opening Depth**	**Closing Depth**	**Soil Colors and Textures**	**Pt**	**Fn**	**Lt**	**Plt**	**C**
Level 1	NW: 21 NE: 28 SE: 20 SW: 15 C: 24	NW: 42 NE: 45 SE: 47 SW: 41 C: 45	Dark Yellowish Brown (10 YR 4/4) Medium Sand (1/4 - 1/2 mm)	0	0	0	0	0
Level 2	NW: 42 NE: 45 SE: 47 SW: 41 C: 45	NW: 48 NE: 50 SE: 49 SW: 49 C: 49	Light Yellowish Brown (2.5 YR 6/3) Fine Sand (1/8 -1/4 mm)	0	0	0	0	0
Level 3	NW: 48 NE: 50 SE: 49 SW: 49 C: 49	NW: 66 NE: 69 SE: 69 SW: 64 C: 68	Pale Brown (10YR 6/3) Medium Sand (1/4 – 1/2mm)	0	0	0	0	0
Level 4	NW: 66 NE: 69 SE: 69 SW: 64 C: 68	NW: 77 NE: 75 SE: 80 SW: 76 C: 76	Grayish Brown (10 YR 5/2) Medium Sand (1/4 -1/2 mm)	0	0	0	0	0
Level 5	NW: 77 NE: 75 SE: 80 SW: 76 C: 76	NW: 93 NE: 96 SE: 95 SW: 93 C: 94	Dark Grayish Brown (10 YR 4/2) Medium Sand (1/4 -1/2 mm)	42	86	1	2	203
Level 6	NW: 93 NE: 96 SE: 95 SW: 93 C: 94	NW: 110 NE: 110 SE: 110 SW: 110 C: 110	Very Pale Brown (10 YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic objects*; **Plt** = *Plant Remains*; **C** = *Charcoal fragments*

Table 6.26: Recapitulation of Finds Recovered from Excavation Unit 3 Sub-Unit 4

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	C
Level 1	NW: 28 NE: 30 SE: 28 SW: 21 C:27	NW: 42 NE: 43 SE: 45 SW: 42 C: 43	Dark Yellowish Brown (10 YR 4/4) Medium Sand (1/4 -1/2 mm)	0	0	0
Level 2	NW: 42 NE: 43 SE: 45 SW: 42 C: 43	NW: 47 NE: 47 SE: 50 SW: 48 C: 49	Light Yellowish Brown (2.5 YR 6/3) Fine Sand (1/8 -1/4 mm)	0	0	0
Level 3	NW: 47 NE: 47 SE: 50 SW: 48 C: 49	NW: 67 NE: 68 SE: 69 SW: 66 C: 68	Pale Brown (10YR 6/3) Medium Sand (1/4 – 1/2mm)	0	0	0
Level 4	NW: 67 NE: 68 SE: 69 SW: 66 C: 68	NW: 76 NE: 76 SE: 75 SW: 77 C: 76	Grayish Brown (10 YR 5/2) Medium Sand (1/4 -1/2 mm)	0	0	0
Level 5	NW: 76 NE: 76 SE: 75 SW: 77 C: 76	NW: 92 NE: 92 SE: 96 SW: 93 C: 94	Dark Grayish Brown (10 YR 4/2) Medium Sand (1/4 -1/2 mm)	17	21	43
Level 6	NW: 92 NE: 92 SE: 96 SW: 93 C: 94	NW: 110 NE: 110 SE: 110 SW: 110 C: 110	Very Pale Brown (10 YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **C** = *Charcoal fragments.*

Table 6.27: Recapitulation of Finds Recovered from Excavation Unit 3 Sub-Unit 5

Level	Opening Depth	Closing Depth	Soil Colors and Textures	Pt	Fn	Lt	C
Level 1	NW: 28 NE: 29 SE: 22 SW: 20 C:26	NW: 45 NE: 46 SE: 48 SW: 47 C: 47	Dark Yellowish Brown (10 YR 4/4) Medium Sand (1/4 -1/2 mm)	0	0	0	0
Level 2	NW: 45 NE: 46 SE: 48 SW: 47 C: 47	NW: 50 NE: 52 SE: 52 SW: 49 C:51	Light Yellowish Brown (2.5 YR 6/3) Fine Sand (1/8 -1/4 mm)	0	0	0	0
Level 3	NW: 50 NE: 52 SE: 52 SW: 49 C:51	NW: 69 NE: 70 SE: 72 SW: 69 C: 71	Pale Brown (10YR 6/3) Medium Sand (1/4 – 1/2mm)	0	0	0	0
Level 4	NW: 69 NE: 70 SE: 72 SW: 69 C: 71	NW: 75 NE: 76 SE: 81 SW: 80 C: 77	Grayish Brown (10 YR 5/2) Medium Sand (1/4 -1/2 mm)	0	0	0	0
Level 5	NW: 75 NE: 76 SE: 81 SW: 80 C: 77	NW: 96 NE: 97 SE: 99 SW: 95 C: 97	Dark Grayish Brown (10 YR 4/2) Medium Sand (1/4 -1/2 mm)	19	165	1	254
Level 6	NW: 96 NE: 97 SE: 99 SW: 95 C: 97	NW: 110 NE: 110 SE: 110 SW: 110 C: 110	Very Pale Brown (10 YR 7/3) Medium Sand (1/4 – 1/2 mm)	0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic objects*; **C** = *Charcoal fragments.*

<u>Table 6.28:</u> Recapitulation of Finds Recovered from Excavation Unit 3 Sub-Unit 6

Level	**Opening Depth**	**Closing Depth**	**Soil Colors and Textures**	**Pt**	**Fn**	**Mtl**	**C**
Level 1	NW: 30 NE: 32 SE: 29 SW: 28 C: 30	NW: 43 NE: 45 SE: 46 SW: 45 C: 44	Dark Yellowish Brown (10 YR 4/4) Medium Sand (1/4 -1/2 mm)	0	0	0	0
Level 2	NW: 43 NE: 45 SE: 46 SW: 45 C: 44	NW: 47 NE: 50 SE: 52 SW: 50 C: 49	Light Yellowish Brown (2.5 YR 6/3) Fine Sand (1/8 -1/4 mm)	0	0	0	0
Level 3	NW: 47 NE: 50 SE: 52 SW: 50 C: 49	NW: 68 NE: 71 SE: 70 SW: 69 C: 70	Pale Brown (10YR 6/3) Medium Sand (1/4 – 1/2mm)	0	0	0	0
Level 4	NW: 68 NE: 71 SE: 70 SW: 69 C: 70	NW: 76 NE: 77 SE: 76 SW: 75 C: 76	Grayish Brown (10 YR 5/2) Medium Sand (1/4 - 1/2 mm)	0	0		0
Level 5	NW: 76 NE: 77 SE: 76 SW: 75 C: 76	NW: 92 NE: 94 SE: 97 SW: 96 C: 95	Dark Grayish Brown (10 YR 4/2) Medium Sand (1/4 -1/2 mm)	39	84	1	174
Level 6	NW: 92 NE: 94 SE: 97 SW: 96 C: 96	NW: 110 NE: 110 SE: 110 SW: 110 C: 110		0	0	0	0

Pt = *Potsherds*; **Fn** = *Faunal remains*; **Lt** = *Lithic objects*; **Plt** = *Plant Remains*; **C** = *Charcoal fragments*

In total, Excavation Unit 3 yielded 126 potsherds, 485 faunal remains, three burnt seeds, two grinding stones, and 962 pieces of charcoal (Table 6.29).

<u>Table 6.29:</u> Recapitulation of Finds Recovered from Excavation Unit 3

Subunit	**Sherds**	**Faunal remains**	**Burnt Seeds**	**Stone Objects**	**Charcoals**
SU1	7	106	1	0	57
SU2	2	7	0	0	231
SU3	42	86	2	1	203
SU4	17	21	0	0	43
SU5	19	165	0	1	254
SU6	39	84	0	0	174
Total	**126**	**469**	**3**	**2**	**962**

6.3.4. Ethnobiological Traces

6.3.4.1. Plant Remains

I uncovered two charred seed of *sakoa* (*Spondias dulcis*) from layer 5 of Excavation Unit 3 sub-unit 1. This endemic tree species grows in the wild in the southwest, especially in the Horombe Plateau (see Chapter 3). Although the fruit is edible, it is not clear whether the occupants of Ankilivalo ate it.

I uncovered a seemingly charred maize seed from Excavation Unit 3 sub-unit 3, layer 5. Maize seems to be a relatively recent introduction to Madagascar. None was recovered from Mahilaka before the 15th centuries CE (Radimilahy, 1998), and Flacourt (1661) made no mention of maize in his list of foods "*Les aliments*". Specifically, for the southwest, there is no archaeobotanical evidence of maize whatsoever. An oral tradition collected by Jacques Faublée (1942: 164) mentioned maize fields along with sweet potatoes and rice fields during the Bara kingdom period (approximately 19th century CE). The Bara-Vinda people, occupants of the MSV today, recognize three varieties of maize: an "old" variety/species they call *tsako foty* (white maize) or *ndravala*, a recent European introduction locally known as *tsakom-bazaha* (foreign maize), and *tsakomena* (red maize) (Faublée 1942: 172).

The presence of introduced crops such as maize at Ankilivalo suggests that cultivators broadened the repertoire of their crops in response to unpredictable growing conditions. The short period between planting and harvest for maize (less than four months) likely made it more viable than plants with a longer growing season and therefore higher risk of crop failure (see Table 6.30).

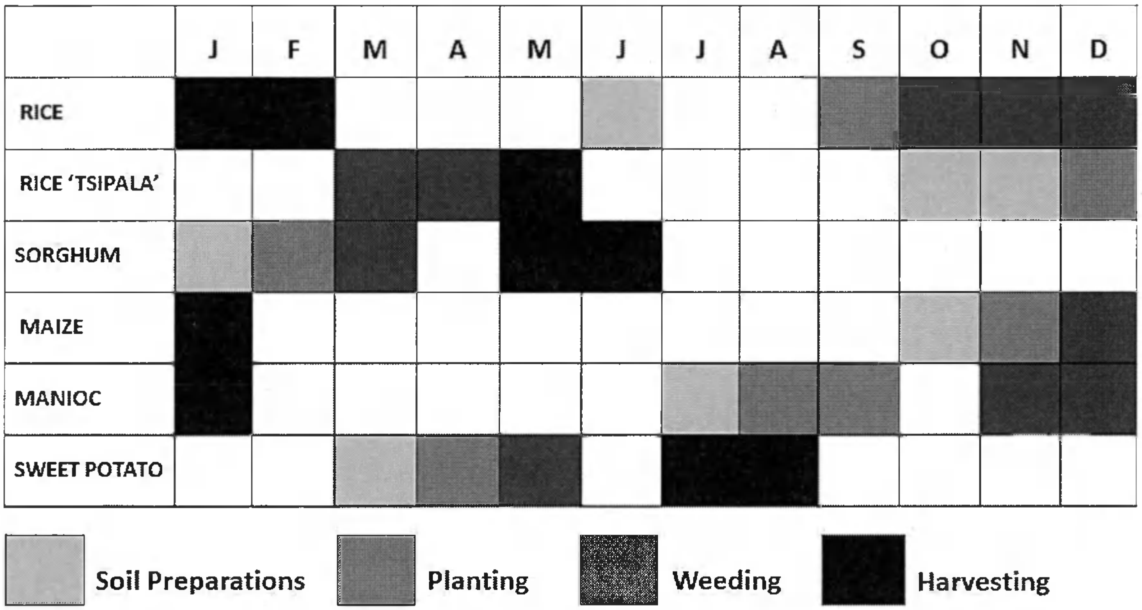

Table 6.30: Current Agricultural Calendar in the Middle Sakamarekely Valley

6.3.4.2. Faunal Remains

The faunal analysis conducted by Dr. Richard Redding at the Archaeozoological Lab of the Kelsey Museum of Archaeology, University of Michigan yielded the following results:

… "A total of 469 bone fragments were examined, weighing 919.3 grams. The following are a summary of the taxa:

Reptiles:

Two shaft fragments from small reptiles (or perhaps amphibians) the size of a small lizard or frog have been recorded, but cannot be further specified.

Birds:

Three limb fragments of birds are present. Two are shaft fragments about which little can be said. One is a fragment of a shaft of a tibia-metatarsus, perhaps of a duck.

Mammals: Tenrecidae.

A distal fragment of a mandible with teeth is unquestionably a relatively large tenrec, probably *Tenrec ecaudatus*, the common tailless tenrec. There is also a cranial fragment, probably a tenrec. Some of the otherwise unidentified small mammal bone could also be from the tenrec. This opossum-like animal, famous for its high reproduction rate, can be found throughout Madagascar. It was hunted as early as the 11th century CE (Rasamuel 1984) and is still widely hunted today. The two identified elements, however, do not exhibit either cut marks or burning, and could be accidental inclusions in the Unit 3 deposit.

Mammals: Bovidae: Cows.

The most commonly identified taxon from Ankilivalo is *Bos sp.* Most elements of the cow are represented, indicating that these animals were butchered on the site. The identified elements comprised 16 teeth or tooth fragments and 25 other elements. Also, there were 116 unidentified 'large mammal' bones. There was no other mammal of this size in Madagascar before the introduction of horses in the 19th century CE, the now extinct pigmy hippopotamus having much heavier bones. Also, the number of identified *Bos* elements and the number of large mammal elements in the six blocks show a positive correlation (Table 6.31).

There are no cranial or maxillary bones of *Bos,* though there are a few maxillary teeth. In contrast, mandibular teeth and bone fragments are common. Often in Madagascar today, the skulls of cows are ritually displayed in public places or near tombs, without their mandibles and often missing most of their maxillary teeth. Thus, skulls would rarely be discarded with ordinary refuse.

Both general observation and the few measurements I made indicate the Ankilivalo cows were relatively small and gracile, compared to the reference specimens (Egyptian cows) at Kelsey Lab. Unfortunately, the sample does not contain any of the few elements that allow us to say whether these were *Bos taurus,* or *Bos indicus,* or a cross between the two. The cattle seen in the area today are small animals with marked humps.

About 23% of the combined *Bos* and large mammal elements were uniformly burned, indicating direct discard into the fire.

The only bone tool found was cut from a large mammal limb shaft. We have the roughly rectangular basal or proximal end of the tool, and a narrower shaft, but not the working end. If it was pointed it could have been used as an awl. It is also possible that it was used as a pin to hold a shawl in place.

Mammals: Caprinae: Sheep and Goats.

Elements of *Ovis* or *Capra* comprise two teeth or tooth fragments and 22 other elements, slightly less than those of *Bos*. In addition, there were 116 'medium mammal' bones. There were other mammals of this size in Madagascar – dogs and pigs for example – but none of these are attested at Ankilivalo. None of the elements that would allow specification of *Ovis* versus *Capra* were found. Both are known from other sites in southwestern Madagascar and both are seen in herds today. All elements of the sheep or goat are represented, indicating the animals were butchered on the site. However, no elements have cut marks. About 34% of the combined sheep/goat and medium mammal elements were burned, indicating even more roasting of cuts of sheep/goat with bone attached, than is indicated for cows.

Table 6.31: Ankilivalo, Unit 3, Layer 5, Middle Sakamarekely Valley, SW Madagascar.

	Bos + Large Mammal		*Ovis/Capra* + Medium Mammal	
Block	No. Un-burnt Elements	No. Burnt Elements	No. Un-burnt Elements	No. Burnt Elements
SU 1	3	20	20	13
SU 3	31	2	12	7
SU 4	4	1	8	4
SU 5	67	11	37	21
SU 6	13	1	16	2
Total	**118**	**35**	**93**	**47**

In spite of the seemingly large number of bones from Unit 3, this is not a large sample and it has been damaged by carnivores or scavengers. There are many analytical procedures which we might like to use, but which it would be foolhardy to attempt because of the following:

First, we do not have enough elements to use any of the techniques to estimate the number of animals butchered, such as MNI ("Minimum Number of Individuals" based on the most common right or left element of each age class of each taxa). Whatever its problems, we used the NISP ("Number of Identified Specimens",) the count of the identified elements.

Second, we do not have enough elements with known dates of fusion to estimate the age at which animals in a given taxa are butchered and to help us construct mortality curves. This would facilitate discussion of strategies of herd exploitation.

Third, we do not have enough measured elements to assess the size and possible sex of the animals in any taxon.

Fourth, there are none of the diagnostic elements which enable archaeo-zoologists to assess the presence of *Ovis* versus *Capra* or of varieties of *Bos*.

This analysis provides a basic understanding of animal exploitation in the upper Onilahy region. The bone from each subunit vary in total count and weight, species frequency, and degree of burning. Reptiles, birds and small mammals may have been hunted, but made little contribution to the diet. The herding of domestic animals was far more important, with cows the dominant source of protein for the people who discarded their food debris at Ankilivalo Unit 3. In addition, the possible special treatment of cow skulls may indicate the social importance of wealth in cattle." ...

Interpretation of the Faunal Analysis Results

I observed that Excavation Unit 3 yielded more faunal remains (n = 469) than the other two units (n = 24 and 26 respectively). At first, I thought that this discrepancy was an indication of social inequality. That is, bones from Unit 1 and Unit 2 might have been discarded by poorer families who ate little meat, while those of Unit 3 came from a privileged family who consumed more meat. However, drawing on the cosmological arrangement and indications of ethnohistorical data from the last 400 years, the location of Unit 3 (southwest corner of the site) corresponded with *Alimiza,* cosmologically signifying impurity and profanity (see Figure 2.1), and where the refuse of a village would be placed (see Chapter 2). The abundant faunal remains in Unit 3 might, thus, represent a village refuse area rather than social inequality between households. Most bones had been chewed by scavengers (likely dogs), moreover, as would be expected at a refuse area (Reitz and Wing 2008: 120).

Although no diagnostic elements in the faunal assemblage were found to distinguish *Ovis* versus *Capra*, ethnohistorical data suggest that the medium-sized mammal remains were of sheep. Documents of the 17th-18th centuries CE mentioned only sheep and cattle in the southwest (Grandidier and Grandidier 1903; 1904) and, according to oral history, goat meat was (and still is) taboo for people of this area except the Zafimagnely, the royal family who arrived in the MSV in the 19th century CE (Faublée 1947: 291-310; and see Chapter 4).

It is noteworthy that no fish bones were found during surveys and excavations, despite the presence of a metallic fishing hook in Unit 1 (Table 6.12) and the river's proximity. This might be due to sampling and recovery techniques, or consumption practices that did not allow fish remains to survive (Engelbrecht 2003: 15-16).

Last but not least, fresh water snails (*Helicophanta vesicalis* or *Pila cecillei*) were found but there is no indication whether they were consumed or not.

6.3.4.3. Isotopic Analysis of Specimens

I sent two excavated specimens from the Ankilivalo site to Penn State University Isotopic Lab for isotopic analysis and AMS measurements. The first specimen (TR1) was a phalanx, forelimb, fused (adult) *Bos* weighing 21.7g, from Unit 3, Subunit 3. The second (TR2) was a phalanx, fused (adult) *Bos* weighing 18.7g from Unit 3 Subunit 5.

Bulk stable carbon and nitrogen isotope values were estimated from collagens extracted from the bones (Table 6.32):

Table 6.32: Stable Isotopic Data (Source: Penn State University Isotopic Lab, January 2018)

Sample ID	**Weight**	**$\delta^{15}N_{AIR}$**	**$\delta^{13}C_{VPDB}$**	**%N**	**%C**	**C:N**	**%C/12/%N/14**
TR1	1.600	**7.2**	-8.6	9.9	27.2	2.8	3.22
TR2	0.930	**7.2**	-11.0	9.5	25.9	2.7	3.18

Values for the cattle samples from Ankilivalo were similar to those of extant mammal browsers elsewhere in the southwest (see Crowley *et al.* 2012: 3599). That is, they fed on shrubs, leaves of trees within reach, and woody materials. This suggests that people herded their livestock more in the valley than on the open grasslands. Ethnohistorical data indicates that people typically kept their livestock in the valley only during a lean season or period of drought (Faublée 1953: 33, 39; Rakotomanana 2002: 14). This suggests that the occupants of Ankilivalo experienced periods of low precipitation, probably associated with the Late Maunder Minimum in the beginning of the 18th century CE (see Zinke *et al.* 2004).

6.3.5. Techno-Cultural Remains

6.3.5.1. Grinding Stones

Grinding stones were found across all three excavation units at Ankilivalo. Grinding stones are often associated with the processing of edible wild and domesticated plants (Nathan 2017: 198). Further study of use wear is needed to determine the kinds of plants processed on these stones.

6.3.5.2. Pottery Analysis at Ankilivalo

This section presents vessel function analysis of potsherds from intrasite surveys and excavations at Ankilivalo.

Vessels from AK were of small capacity, and could have been used for various purposes but not for long-term storage (see Rice 2015: 413-414). For instance, the rim diameters from the systematic surface collection ranged from 4 – 32 cm (mean=18.3 cm, SD ± 5.8; Figure 6.18, 6.21; Table 6.33), while those from Excavation Unit 3 ranged from 10 – 23 cm (mean=15 cm, SD ± 4.17; Figure 6.22; Table 6.34).

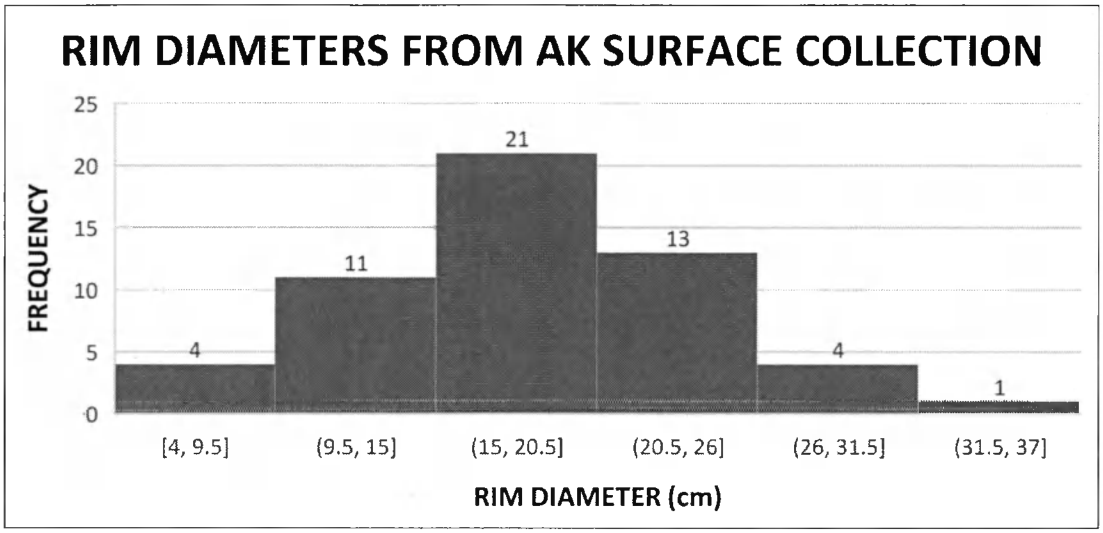

Figure 6.21: Rim Diameter of Sherds from AK Surface Collection

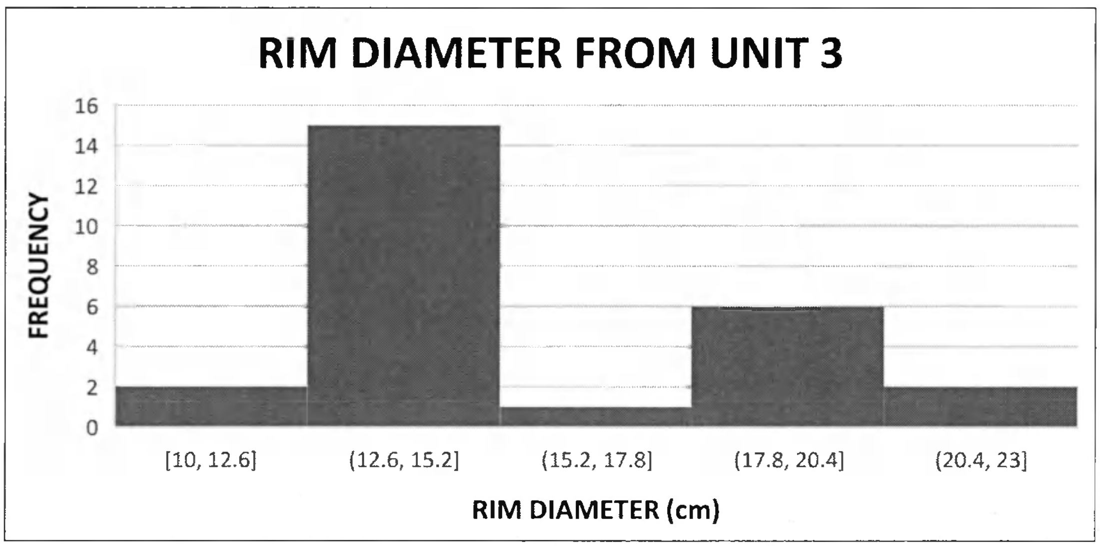

Figure 6.22: Histogram of Rim Diameters of Sherds from AK Excavation Unit 3

Table 6.33: Rims Analyzed from AK Systematic Surface Collection

SU#	Sherds Label	Dm	O	LT	LR	H	W	RV	RS	LM	ST	SP	SC	PD	DS	PC	PT	Tp	FC
SU2	**AK_U3_SU2_L5_R1**	18	5	7	7	28	5	S	P	F	BB	NP	PB	ND	ND	Br	C	S	R
SU2	**AK_U3_SU2_L5_R2**	17	3	7	6	20	5	S	P	F	BB	NP	PB	ND	ND	Br	C	S	R
SU3	**AK_U3_SU3_L5_R1**	13	5	8.6	6.4	24.5	22.8	I	Th	F	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R2**	14	3	7.5	5.4	20.5	14	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R3**	10	2	5	4.3	18.4	9.7	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R4**	13	5	7.2	6.2	14	17.8	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R5**	14	4	6		21	54	S	T	U	BB	NP	PB	ND	ND	Br	C	S	R
SU4	**AK_U3_SU4_L5_R1**	15	4	5.5	4.7	15.9	23.1	E	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU4	**AK_U3_SU4_L5_R2**	15	4	6.1	4.3	19.3	8	E	T	F	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU5	**AK_U3_SU5_L5_R1**	14	6	8.3	6	48.3	38.9	I	Th	F	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU5	**AK_U3_SU5_L5_R2**	13	4	7.7	5.2	22.1	34.3	E	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU5	**AK_U3_SU5_L5_R3**	19	6	7	7	32	6	S	P	R	BB	NP	PB	ND	ND	B	C	S	R
SU5	**AK_U3_SU5_L5_R4**	21	4	6	6	30.5	5	S	P	F	BB	NP	PB	ND	ND	B	C	S	R
SU5	**AK_U3_SU5_L5_R5**	15	5	6	6	25	5	S	P	R	BB	NP	PB	ND	ND	B	C	S	R
SU5	**AK_U3_SU5_L5_R6**	23	5	6	6	29.5	7	S	P	R	BB	NP	PB	ND	ND	Br	C	S	R
SU5	**AK_U3_SU5_L5_R7**	15	3	7	7	19	6.5	S	P	R	BB	NP	PB	ND	ND	B	C	S	R
SU6	**AK_U3_SU6_L5_R1**	13	2	6.2	5	21.3	12.4	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU6	**AK_U3_SU6_L5_R2**	14	3	6	4.3	14.9	16.7	I	T	R	SE BI	NP	RSB	ND	ND	Br	CF	S	R
SU6	**AK_U3_SU6_L5_R3**	14	3	7.1	5.5	16.7	17.7	E	Th	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R
SU6	**AK_U3_SU6_L5_R4**	12	3	4.5	3.8	13.1	14.5	S	P	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R
SU6	**AK_U3_SU6_L5_R5**	19	3	4.5	3.7	13.3	16.6	E	P	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R
SU6	**AK_U3_SU6_L5_R6**	18	4	7.8	3.6	25.5	15	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU6	**AK_U3_SU6_L5_R7**	14	4	5.5	4.3	15.8	18	S	T	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R
SU6	**AK_U3_SU6_L5_R8**	13	3	6.3	3.	31.6	20.3	E	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R

SU6	**AK_U3_SU6_L5_R9**	19	5	6	5.4	19.1	29.9	S	P	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU6	**AK_U3_SU6_L5_R10**	18	3	7	5.2	17.4	16.8	I	T	R	SE BI	NP	RSB	ND	ND	Br	CF	S	R

Table 6.34: Rims Analyzed from Excavation Unit 3

SU#	**Sherds Label**	**Dm**	**O**	**LT**	**LT**	**H**	**W**	**RV**	**RS**	**LP**	**ST**	**SP**	**SC**	**PD**	**DS**	**PC**	**PT**	**Tp**	**FC**
SU2	**AK_U3_SU2_L5_R1**	14	3	6	7	28	5	S	P	F	BB	NP	PB	ND	ND	Br	C	S	R
SU2	**AK_U3_SU2_L5_R2**	15	3	7	6	20	5	S	P	F	BB	NP	PB	ND	ND	Br	C	S	R
SU3	**AK_U3_SU3_L5_R1**	13	5	8.61	6.45	24.5	22.8	I	Th	F	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R2**	14	3	7.52	5.43	20.49	14	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R3**	10	2	5.03	4.33	18.38	9.76	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R4**	13	5	7.22	6.26	14.01	17.8	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU3	**AK_U3_SU3_L5_R5**	17	3	6		21	54	S	T	U	BB	NP	PB	ND	ND	Br	C	S	R
SU4	**AK_U3_SU4_L5_R1**	15	4	5.54	4.76	15.98	23.1	E	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU4	**AK_U3_SU4_L5_R2**	18	6	6.11	4.33	19.33	8.06	E	T	F	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU5	**AK_U3_SU5_L5_R1**	14	6	8.33	6.01	48.34	38.9	I	Th	F	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU5	**AK_U3_SU5_L5_R2**	13	4	7.74	5.18	22.14	34.3	E	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU5	**AK_U3_SU5_L5_R3**	16	4	7	7	32	6	S	P	R	BB	NP	PB	ND	ND	B	C	S	R
SU5	**AK_U3_SU5_L5_R4**	21	4	6	6	30.5	5	S	P	F	BB	NP	PB	ND	ND	B	C	S	R
SU5	**AK_U3_SU5_L5_R5**	14	6	7	6	25	5	S	P	R	BB	NP	PB	ND	ND	B	C	S	R
SU5	**AK_U3_SU5_L5_R6**	23	3	7	6	29.5	7	S	P	R	BB	NP	PB	ND	ND	Br	C	S	R
SU5	**AK_U3_SU5_L5_R7**	13	4	7	7	19	6.5	S	P	R	BB	NP	PB	ND	ND	B	C	S	R
SU6	**AK_U3_SU6_L5_R1**	13	2	6.2	4.96	21.34	12.4	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU6	**AK_U3_SU6_L5_R2**	14	3	6.08	4.3	14.95	16.7	I	T	R	SE BI	NP	RSB	ND	ND	Br	CF	S	R
SU6	**AK_U3_SU6_L5_R3**	14	3	7.11	5.57	16.69	17.7	E	Th	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R
SU6	**AK_U3_SU6_L5_R4**	12	3	4.56	3.85	13.12	14.5	S	P	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R

SU6	**AK_U3_SU6_L5_R5**	17	3	4.47	3.76	13.32	16.6	E	P	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R
SU6	**AK_U3_SU6_L5_R6**	17	3	7.86	3.64	25.56	15	I	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU6	**AK_U3_SU6_L5_R7**	14	4	5.55	4.29	15.83	18	S	T	R	SE BI	NP	RSB	ND	ND	DB	CF	S	R
SU6	**AK_U3_SU6_L5_R8**	13	3	6.29	3.04	31.57	20.3	E	T	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU6	**AK_U3_SU6_L5_R9**	19	5	6.06	5.38	19.09	29.9	S	P	R	SE BI	NP	RSB	ND	ND	B	CF	S	R
SU6	**AK_U3_SU6_L5_R10**	19	6	7.07	5.17	17.45	16.8	I	T	R	SE BI	NP	RSB	ND	ND	Br	CF	S	R

Dm: Diameter; **O:** Orifice percentage; **LT:** Lip Thickness; **LR:** Lower Rim Thickness; **H:** Height; **W:** Width.

RV: Rim Verticality -> Everted (**E**); Inverted (**I**); Straight (**S**)
RS: Rim Wall Shape -> Thickened (**Th**); Parallel (**P**); Tapered (**T**)
LM: Lip Morphology -> Angular (**A**); Beveled (**B**); Flattened (**F**); Rounded (**R**); U-shaped (**U**)

ST: Surface Treatment -> Burnished (**B**); Patterned (**P**); Smoothed (**S**)

SP: Surface Patterning -> Patterned (**P**); Not Patterned (**NP**)

SC: Surface Coating -> Red Slipped on Both Walls (**RSB**); Red Slipped on the Exterior Wall (**RSE**); Red Slipped on the Interior Wall (**RSI**); Graphite Burnished on Both Walls (**GBB**); Graphite Burnished on the Exterior Wall (**GBE**); Graphite Burnished on the Interior Wall (**GBI**)

PD: Place of Decoration -> On the Lip (**L**); On the Exterior of the Rim (**RE**); On the Exterior of the Neck (**NE**); On the Exterior of the Shoulder (**SE**); No Decoration (**ND**)

DS: Decoration Motif Style -> Combing Lines (**CL**); False Relief Chevron (**FRC**); Guilloche (**G**); Incised Line (**IL**); Impressions in Geometric Forms on both walls (**IGB**); Impressions in Geometric Forms on the Interior Wall (**IGI**); Row of Impression on Both Side (**RIB**); Row of Impression on the Exterior (**RIE**); Row of Impression on the Interior (**RII**); Parallel lines of impression row on both wall (**PLRIB**); Parallel lines of impression row on the exterior wall (**PLRIE**); Band of Impression and Geometric Lines on both walls (**BIGLB**); Band of Impression and Geometric Lines on the Exterior Wall (**BIGLE**); Parallel Lines and Row of Impression on Both Walls (**PLRIB**); Parallel Lines and Row of Impression on the Exterior Wall (**PLRIE**); No Decoration (**ND**)

PC: Paste Color -> Black (**Bl**); Dark Brown (**DB**); Brown (**Br**); Red Brown (**RB**); Red (**R**); Other (**O**)
PT: Paste Texture -> Coarse (**C**); Coarse Fine (**CF**); Fine (**F**)
Tp: Tempers -> Sand (**S**); Organic (**O**)
FC: Firing Condition -> Reduced (**R**); Oxidized (**O**)

I could not examine the stability of the vessels from AK, due to the virtual absence of bases in the assemblage. One flat base was recovered in the surface collection, and none at all during excavations.

The accessibility of vessels from AK suggests that they were used for cooking, serving or processing. The majority of rims from the surface collection were everted or straight parallel flattened rims (Figure 6.23; Table 6.35), suggesting that their contents could be reached easily. Among the rims from Excavation Unit 3, straight and inverted rims, tapered and parallel rim walls, and rounded lips were the dominant forms (Figure 6.24; Table 6.36), suggesting the presence of both restricted and unrestricted vessels.

Table 6.35: Rim Verticality, Rim Shape, and Lip Morphology from AK Surface Collection

	Everted			Straight			Inverted			TOTAL
	Thick.	Paral.	Taper.	Thick.	Paral.	Taper.	Thick.	Paral.	Taper.	
Flattened	2	16	0	1	17	5	0	1	0	**42**
Rounded	0	3	0	0	1	4	1	0	0	**9**
U-shaped	1	0	1	0	0	0	1	0	0	**3**
TOTAL	**3**	**19**	**1**	**1**	**18**	**9**	**2**	**1**	**0**	**54**

Table 6.36: Rim Verticality, Rim Shape, and Lip Morphology from Excavation Unit 3

	Everted			Straight			Inverted			TOTAL
	Thick.	Paral.	Taper.	Thick.	Paral.	Taper.	Thick.	Paral.	Taper.	
Flattened	0	0	1	0	3	0	2	0	0	**6**
Rounded	1	1	3	0	6	1	0	0	7	**19**
U-shaped	0	0	0	0	0	1	0	0	0	**1**
TOTAL	**1**	**1**	**4**	**0**	**9**	**2**	**2**	**0**	**7**	**26**

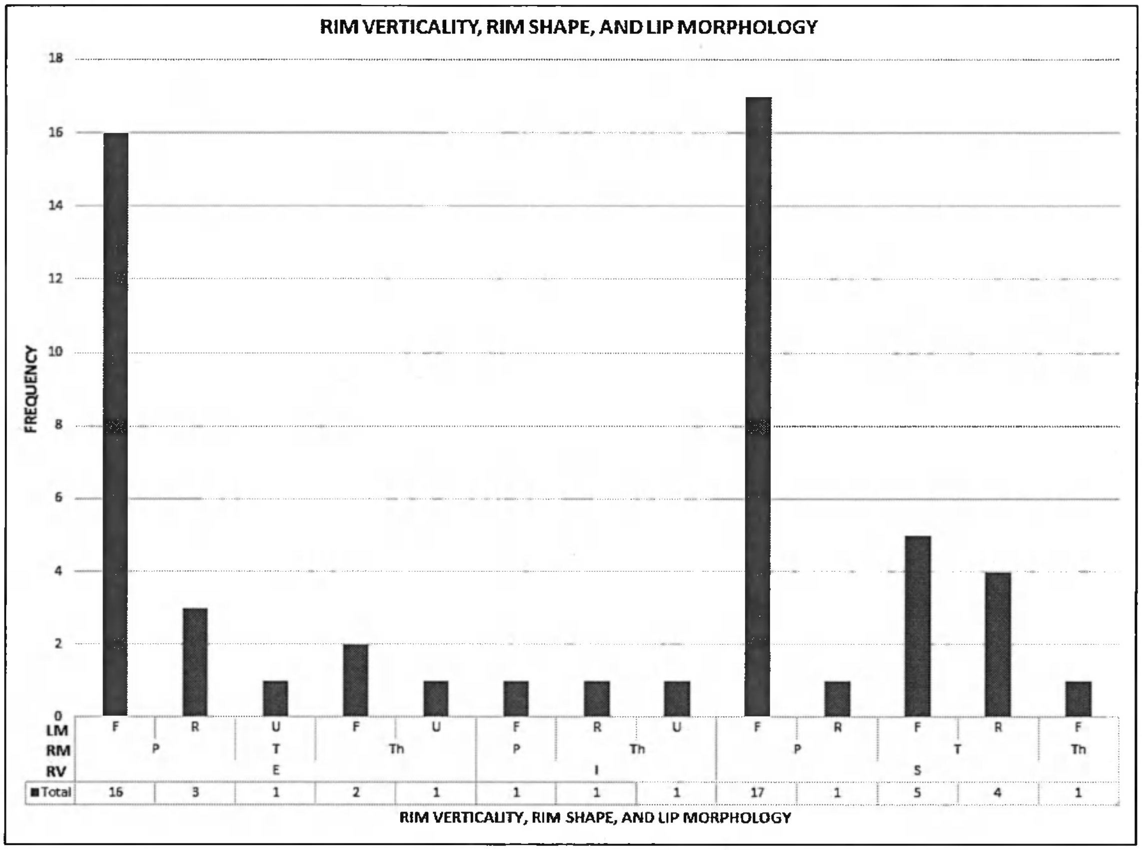

Figure 6.23: Verticality, Shape, and Lip Morphology of Rims from AK Surface Collection

LM: Lip Morphology -> Flattened (**F**); Rounded (**R**); U-shaped (**U**)
RM: Rim Wall Shape -> Thickened (**Th**); Parallel (**P**); Tapered (**T**)
RV: Rim Verticality -> Everted (**E**); Inverted (**I**); Straight (**S**)

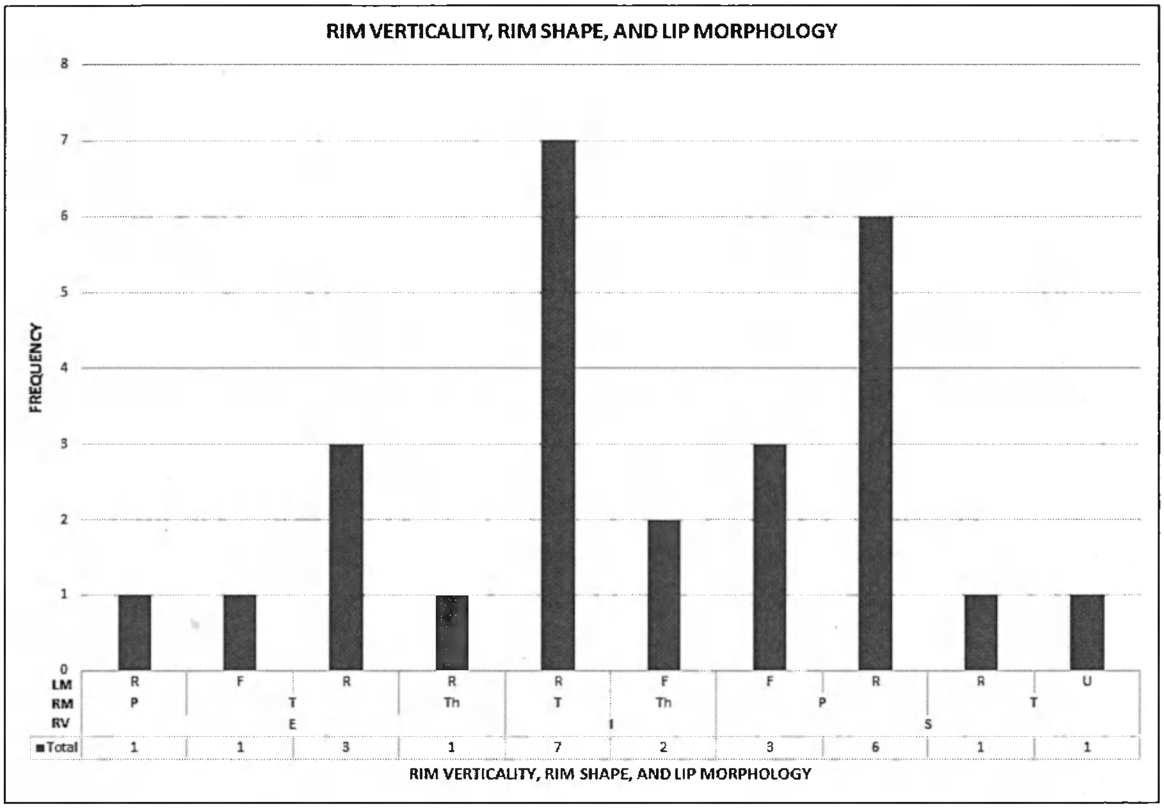

Figure 6.24: Verticality, Shape, and Lip Morphology of Rims from Excavation Unit 3

LM: Lip Morphology -> Flattened (**F**); Rounded (**R**); U-shaped (**U**)
RM: Rim Wall Shape -> Thickened (**Th**); Parallel (**P**); Tapered (**T**)
RV: Rim Verticality -> Everted (**E**); Inverted (**I**); Straight (**S**)

As most vessels at Ankilivalo were small, they could be carried short and long distances. The sparsity of necks in the assemblage indicates that they would have spilled their contents if transported over a long distance (Table 6.37). Furthermore, the majority of sherds from AK did not show any surface patterning or handle, indicating low graspability. Only three of 140 sherds from the surface collection and five of 83 sherds from Excavation Unit 3 showed combing patterns on their exterior walls (Figure 6.25; Figure 6.26).

Table 6.37: Necks Analyzed from AK Systematic Surface Collection

Grid#	SL	ST	SP	SC	PD	DS	PC	PT	Tp	FC	Th	H	L	W
D7	**AK_D7_S2**	BB	NP	PB	ND	ND	Br	C	S	R	10	23	23	4.8
D7	**AK_D7_S5**	BB	NP	PB	ND	ND	RB	C	S	R	8	13	18	2.2
E7	**AK_E7_S1**	BB	NP	PB	ND	ND	Br	C	S	R	9	16	30	4.9
E7	**AK_E7_S6**	BB	NP	PB	ND	ND	RB	C	S	R	7	18	19	2.7
F7	**AK_F7_S10**	BB	NP	PB	ND	ND	RB	C	S	R	8	13	17	1.9
D5	**AK_D5_S5**	PB	NP	BB	ND	ND	R	CF	S	R	8	23	18	3.4
E5	**AK_E5_S2**	BB	NP	PB	ND	ND	DB	C	S	R	8	23	39	7.4
E5	**AK_E5_S4**	BB	NP	PB	ND	ND	B	C	S	R	8	23	20	4
E5	**AK_E5_S5**	BB	NP	PB	ND	ND	G	C	S	R	8	19	20	3.9
E5	**AK_E5_S7**	BB	NP	PB	ND	ND	Br	C	S	R	7	16	21	2.9
F5	**AK_F5_S3**	BB	NP	PB	ND	ND	Br	C	S	R	9	21	31	8.8
F4	**AK_F4_S9**	BI	NP	PB	ND	ND	Br	C	S	R	6	13	19	2.7

SL: Sherd Label; **Th:** Thickness; **H:** Height; **L:** Length **W:** Width

ST: Surface Treatment -> Burnished on both walls (**BB**); Burnished on the interior wall (**BI**)

SP: Surface Patterning -> No Patterning (**NP**)

SC: Surface Coating -> Plain on both walls (**PB**)

PD: Place of Decoration -> No Decoration (**ND**)

DS: Decoration Motif Style -> No Decoration (**ND**)

PC: Paste Color -> Black (**Bl**); Brown (**Br**); Red Brown (**RB**); Red (**R**); Gray (**G**)

PT: Paste Texture -> Coarse (**C**); Coarse Fine (**CF**)

Tp: Tempers -> Sand (**S**)

FC: Firing Condition -> Reduced Atmosphere (**R**)

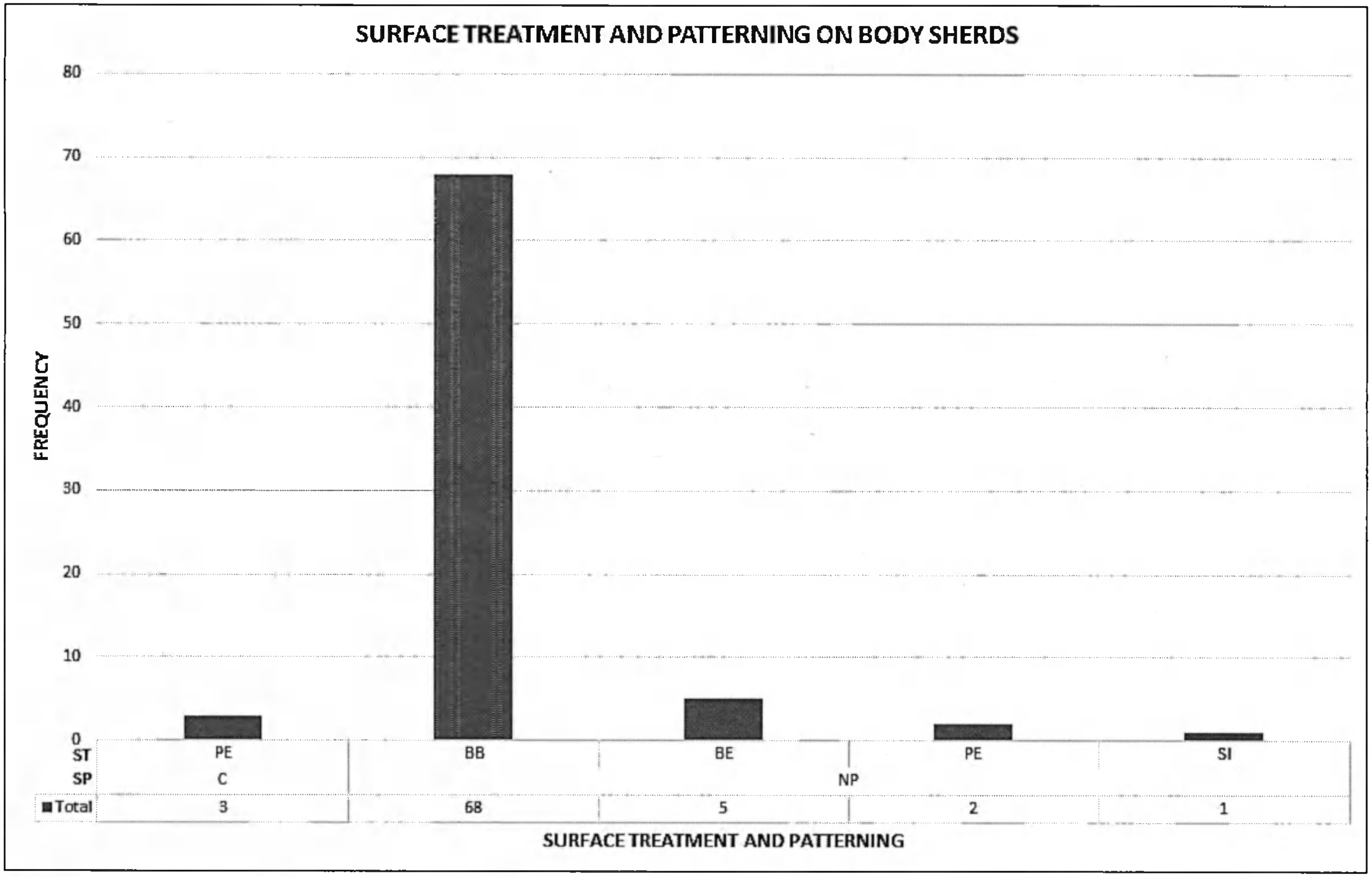

Figure 6.25: Surface Treatment and Patterning of Vessel from AK Surface Collection

ST: Surface Treatment -> Burnished on both Walls (**BB**); Burnished on the exterior wall (**BE**); Smoothed on the interieur wall (**SI**); Patterned on the exterior wall (**PE**)

SP: Surface Patterning -> Combing (**C**); No Patterning (**NP**)

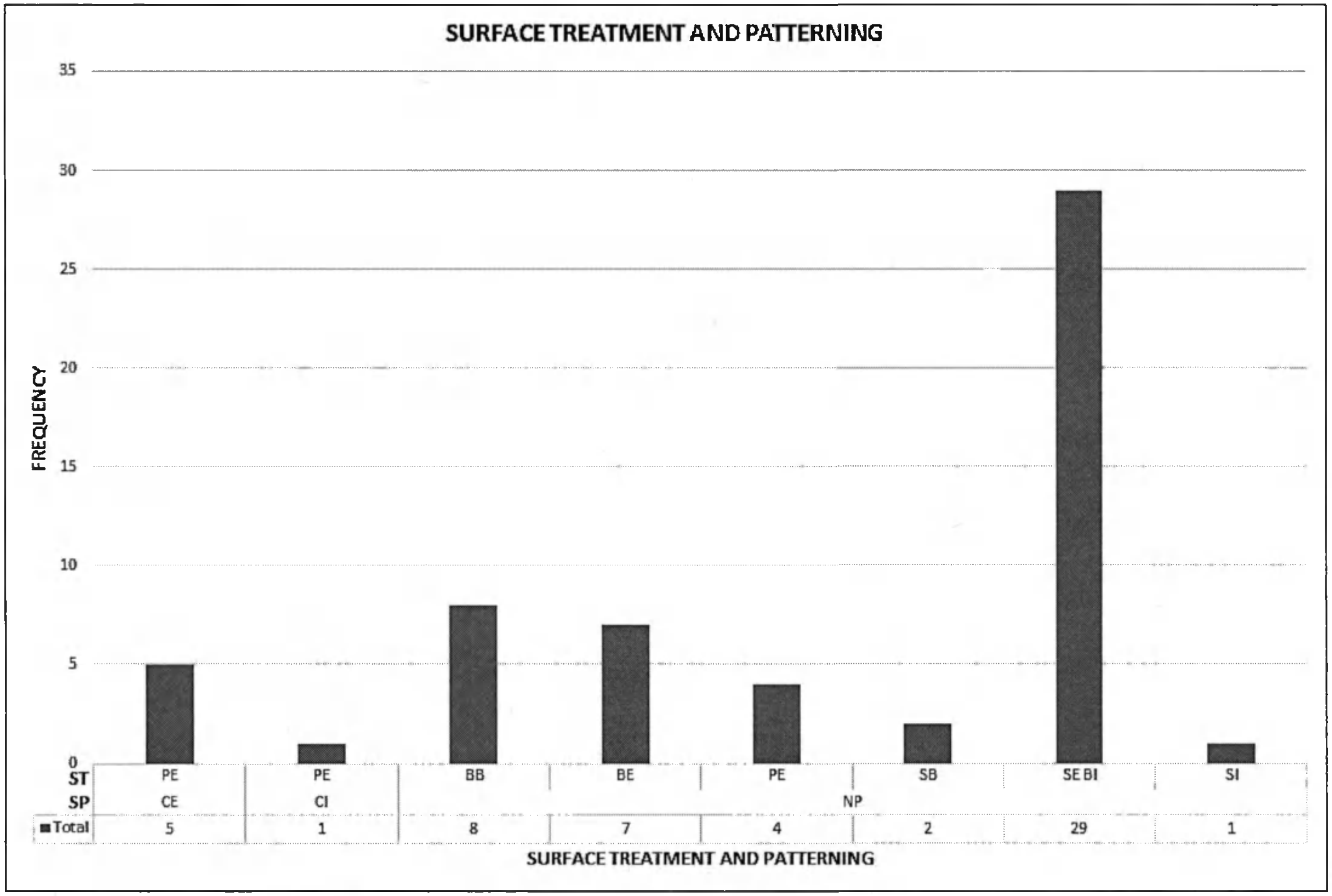

Figure 6.26: Surface Treatment and Patterning of Vessel from Excavation Unit 3

ST: *Surface Treatment -> Burnished on both Walls* (**BB**); *Burnished on the exterior wall* (**BE**); *Smoothed on the interieur wall* (**SI**); *Patterned on the exterior wall* (**PE**)

SP: *Surface Patterning -> Combing* (**C**); *No Patterning* (**NP**)

The heating effectiveness of vessels from AK was good, showing the ingenuity of their makers:

Vessel walls were thin enough for heat to travel through. The thickness of body sherds from the surface collection ranged from 4 – 21 mm in thickness (mean = 7.58 mm, SD ± 2.7; Figure 6.27), while those from Excavation Unit 3 ranged from 3.91 mm – 9.42 mm (mean = 7.37 mm, SD ±1.23; Figure 6.28).

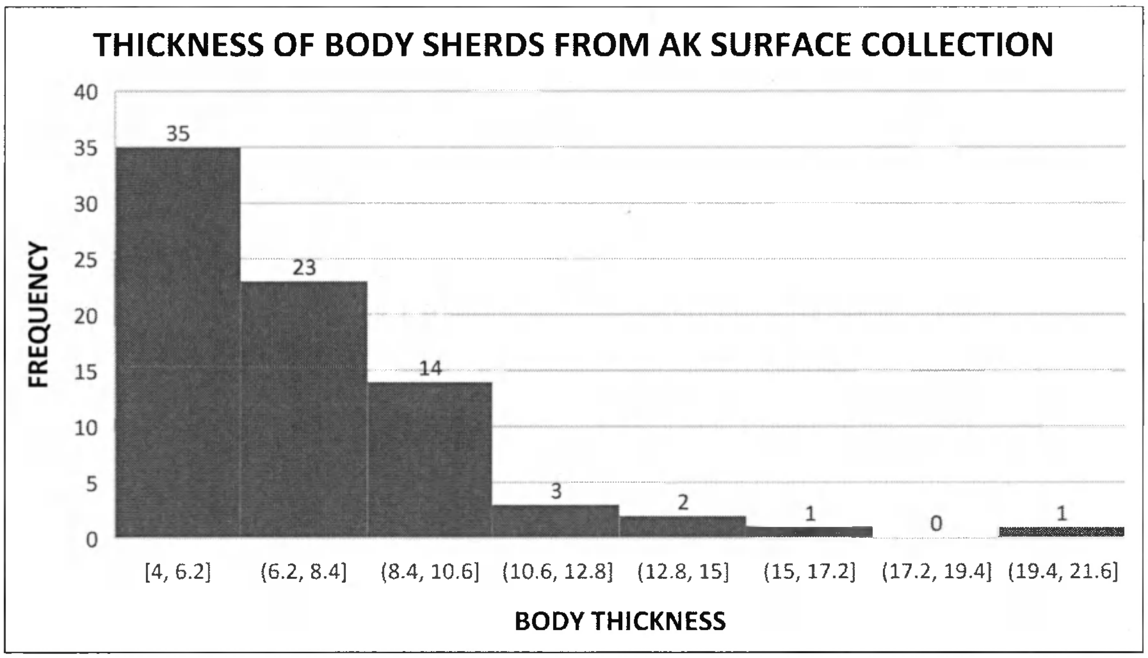

Figure 6.27: Thickness of Body Sherds from AK Surface Collection

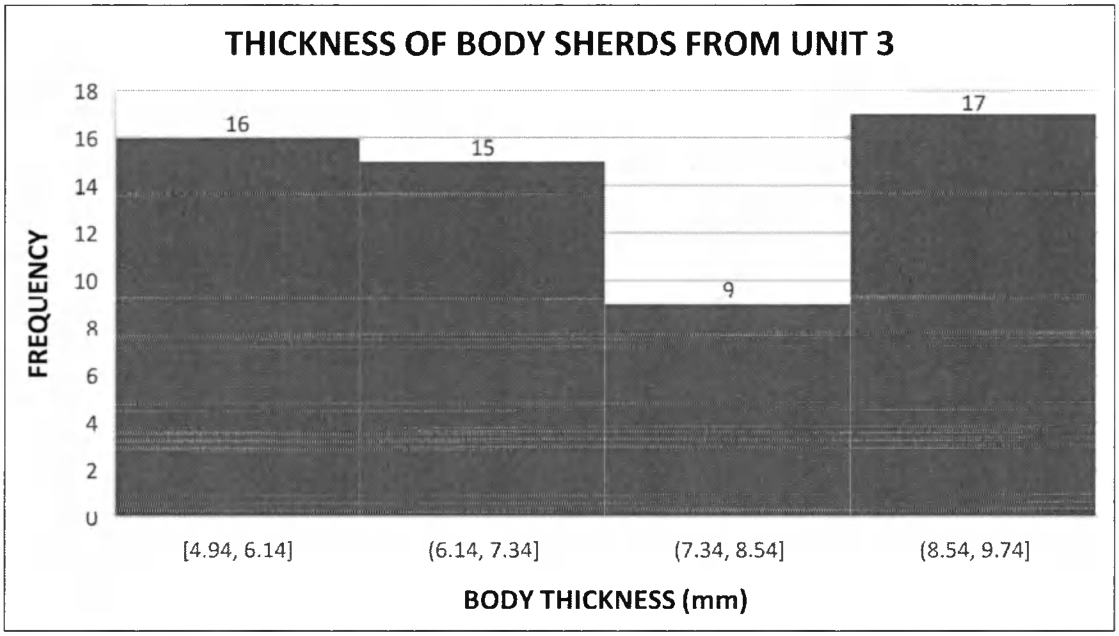

Figure 6.28: Thickness of Body Sherds from AK Excavation Unit 3

The paste color and texture of sherds from AK showed that vessels were permeable, and therefore thermal shock resistant and suitable for cooking (Chami 1994: 84; Skibo 2013: 39). They were coarse and fired at a reduced atmosphere (Figure 6.29; Figure 6.30). The effectiveness with which they could be heated was amplified by the addition of a mineral temper (Skibo 2013: 43).

The only difference between body sherds from Excavation Unit 3 and those from the surface collection is the surface treatment. Sherds from Excavation Unit 3 were red-slipped, while those from surface collection were plain. Red-slipped vessels are less permeable than plain ones, the former being suitable for storing liquids, the latter for cooking (Rice 1987: 238). The red-slipping technique might have been applied to close surface pores and reduce the permeability of the wall (Skibo 2013: 40). It is not clear, however, whether this difference was intended by the potters or due to post-depositional alteration. Sherds from the surface collection might have been originally slipped like those from excavations, but subsequently lost their slips due to exposure to weather and abrasion.

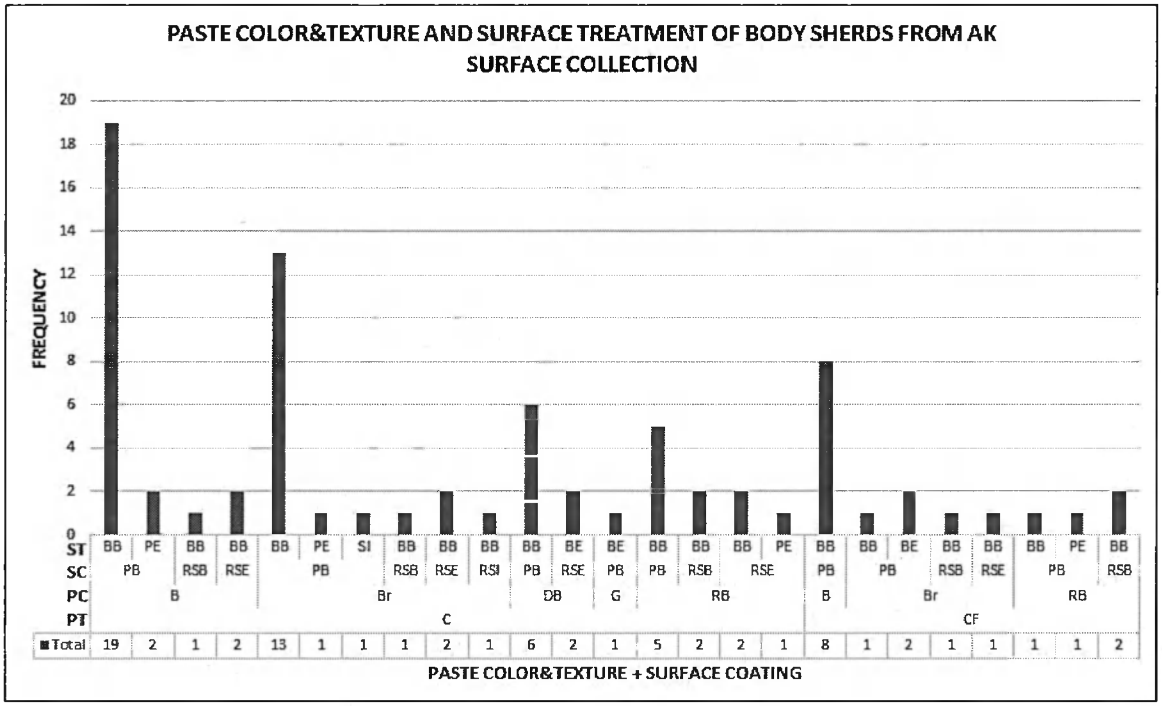

Figure 6.29: Heating Effectiveness of Body Sherds from AK Surface Collection Based on Paste Texture, Firing Condition, and Surface Treatment

ST: *Surface Treatment -> Burnished on both walls* (**BB**); *Burnished on the Interior Wall* (**BI**); *Burnished on the Exterior Wall* (**BE**); *Smoothed on the interieur wall* (**SI**); *Patterned on the exterior wall* (**PE**)

SC: *Surface Coating -> Red Slipped on Both Walls* (**RSB**); *Red Slipped on the Exterior Wall* (**RSE**); *Red Slipped on the Interior Wall* (**RSI**); *Plain on both walls* (**PB**)

PC: *Paste Color -> Black* (**B**); *Dark Brown* (**DB**); *Brown* (**Br**); *Red Brown* (**RB**)

PT: *Paste Texture -> Coarse* (**C**); *Coarse Fine* (**CF**)

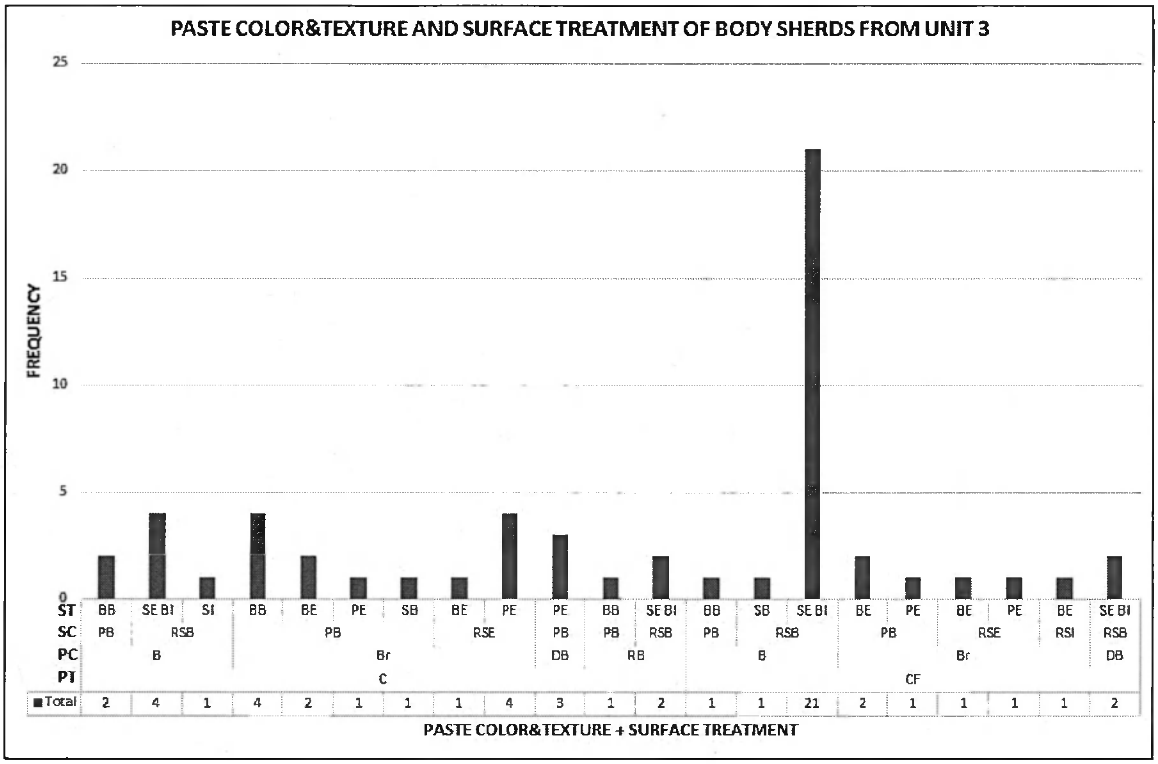

Figure 6.30: Heating Effectiveness of Body Sherds from Excavation Unit 3 Based on Paste Texture, Firing Condition, and Surface Coating

ST: *Surface Treatment -> Burnished on both walls* (**BB**); *Burnished on the Interior Wall* (**BI**); *Burnished on the Exterior Wall* (**BE**); *Patterned on the exterior wall* (**PE**); *Smoothed on the interior wall* (**SI**); *Smoothed on the exterior wall and burnished in the interior* (**SE BI**).

SC: *Surface Coating -> Red Slipped on Both Walls* (**RSB**); *Red Slipped on the Exterior Wall* (**RSE**); *Red Slipped on the Interior Wall* (**RSI**); *Plain on both walls* (**PB**)

PC: *Paste Color -> Black* (**B**); *Dark Brown* (**DB**); *Brown* (**Br**); *Red Brown* (**RB**)

PT: *Paste Texture -> Coarse* (**C**); *Coarse Fine* (**CF**)

Table 6.37: Body Sherds Analyzed from AK Systematic Surface Collection

Grid	Sherd Label	ST	SP	SC	PD	DS	PC	PT	Tp	FC	Th	H	L	W
D7	AK_D7_S1	BB	NP	PB	ND	ND	B	C	S	R	11	40	46	24.6
D7	AK_D7_S4	BB	NP	PB	ND	ND	B	C	S	R	6	15	19	2.3
E7	AK_E7_S3	BB	NP	PB	ND	ND	B	C	S	R	8	24	21	3.8
F7	AK_F7_S2	BB	NP	PB	ND	ND	B	C	S	R	9	31	42	16.9
F7	AK_F7_S3	BB	NP	PB	ND	ND	B	CF	S	R	5	26	43	8.8
F7	AK_F7_S4	BB	NP	PB	ND	ND	B	CF	S	R	6	26	28	6
F7	AK_F7_S5	BB	NP	PB	ND	ND	Br	CF	S	R	11	30	33	9.9
F7	AK_F7_S6	BB	NP	RSE	ND	ND	B	C	S	R	10	25	30	8.4
E6	AK_E6_S4	BB	NP	RSB	ND	ND	Br	CF	S	R	5	31	38	10.2
E6	AK_E6_S6	BB	NP	PB	ND	ND	B	C	S	R	13	21	34	11.1
E6	AK_E6_S7	BB	NP	PB	ND	ND	Br	C	S	R	9	25	33	8.4
E6	AK_E6_S9	BB	NP	RSB	ND	ND	RB	C	S	R	7	18	35	6
E6	AK_E6_S10	BB	NP	PB	ND	ND	B	CF	S	R	6	24	30	5.5
E6	AK_E6_S11	BB	NP	PB	ND	ND	Br	C	S	R	8	29	22	5.6
E6	AK_E6_S12	BB	NP	PB	ND	ND	RB	C	S	R	5	25	28	4.5
E6	AK_E6_S13	BB	NP	PB	ND	ND	RB	C	S	R	8	20	20	4.7
F6	AK_F6_S1	BB	NP	PB	ND	ND	DB	C	S	R	17	30	38	19.8
F6	AK_F6_S2	BB	NP	PB	ND	ND	RB	C	S	R	7	49	66	28.2
F6	AK_F6_S3	BB	NP	PB	ND	ND	B	CF	S	R	6	53	55	26.1
F6	AK_F6_S4	BB	NP	PB	ND	ND	B	C	S	R	9	33	34	15.4
F6	AK_F6_S5	BB	NP	PB	ND	ND	B	CF	S	R	9	29	32	11.1
F6	AK_F6_S6	BB	NP	PB	ND	ND	B	CF	S	R	6	31	36	8.2
F6	AK_F6_S12	BB	NP	PB	ND	ND	DB	C	S	R	6	17	23	2.7
G6	AK_G6_S1	BB	NP	PB	ND	ND	RB	C	S	R	6	26	42	11.9

G6	AK_G6_S2	BB	NP	PB	ND	ND	Br	C	S	R	8	26	27	7.6
D5	AK_D5_S1	BB	NP	RSE	ND	ND	Br	C	S	R	9	20	30	6.1
D5	AK_D5_S2	BB	NP	RSB	ND	ND	B	C	S	R	6	19	26	4.9
D5	AK_D5_S3	BB	NP	PB	ND	ND	B	C	S	R	9	19	25	4.8
D5	AK_D5_S4	PE	C	PB	ND	ND	RB	CF	S	R	8	19	26	4.8
D5	AK_D5_S6	BB	NP	PB	ND	ND	Br	C	S	R	6	18	20	3
D5	AK_D5_S7	BB	NP	PB	ND	ND	RB	C	S	R	6	17	24	2.9
D5	AK_D5_S8	PE	C	PB	ND	ND	B	C	S	R	6	19	16	1.8
E5	AK_E5_S1	BB	NP	PB	ND	ND	B	C	S	R	7	25	35	7.9
E5	AK_E5_S3	BB	NP	PB	ND	ND	B	C	S	R	8	25	30	7.2
B5	AK_B5_S3	BB	NP	PB	ND	ND	B	C	S	R	6	24	28	4.6
B5	AK_B5_S6	BB	NP	RSB	ND	ND	RB	CF	S	R	6	13	23	2.3
F5	AK_F5_S1	BB	NP	PB	ND	ND	B	C	S	R	7	36	49	18.5
F5	AK_F5_S2	BB	NP	PB	ND	ND	DB	C	S	R	7	28	47	10.1
F5	AK_F5_S5	BB	NP	PB	ND	ND	RB	CF	S	R	5	12	21	3
F5	AK_F5_S7	BB	NP	PB	ND	ND	Br	C	S	R	6	15	21	2.3
F5	AK_F5_S8	BB	NP	RSE	ND	ND	Br	CF	S	R	4	17	18	1.8
F5	AK_F5_S10	BB	NP	RSE	ND	ND	B	C	S	R	9	29	38	16.4
F5	AK_F5_S11	BB	NP	RSB	ND	ND	RB	C	S	R	6	19	23	3.6
F5	AK_F5_S12	BB	NP	RSB	ND	ND	Br	C	S	R	6	21	20	2.6
F5	AK_F5_S13	BB	NP	PB	ND	ND	B	C	S	R	6	15	18	2.1
F5	AK_F5_S1	BB	NP	PB	ND	ND	B	C	S	R	6	16	31	4.3
F5	AK_F5_S2	BB	NP	PB	ND	ND	DB	C	S	R	5	14	28	3
F5	AK_F5_S4	BB	NP	PB	ND	ND	DB	C	S	R	21	34	34	24.7
F5	AK_F5_S6	BB	NP	PB	ND	ND	B	CF	S	R	6	24	43	7.8
F5	AK_F5_S7	BB	NP	PB	ND	ND	B	C	S	R	5	23	39	7

F5	AK_F5_S8	BB	NP	PB	ND	ND	B	CF	S	R	5	23	28	6.4
F5	AK_F5_S12	BB	NP	PB	ND	ND	Br	C	S	R	7	31	27	6.7
F5	AK_F5_S13	BB	NP	PB	ND	ND	B	C	S	R	7	22	31	6.1
F5	AK_F5_S14	BB	NP	PB	ND	ND	DB	C	S	R	5	19	28	4.6
F5	AK_F5_S15	BB	NP	PB	ND	ND	Br	C	S	R	5	18	28	4.2
F5	AK_F5(2)_S1	BB	NP	RSE	ND	ND	Br	C	S	R	6	56	61	32.3
F5	AK_F5(2)_S2	BB	NP	PB	ND	ND	B	C	S	R	6	35	40	9.7
F5	AK_F5(2)_S3	BB	NP	RSE	ND	ND	RB	C	S	R	10	36	24	10.7
F5	AK_F5(2)_S4	BB	NP	PB	ND	ND	B	C	S	R	8	30	31	7.1
G5	AK_G5_S1	BB	NP	PB	ND	ND	Br	C	S	R	8	25	28	6.2
G5	AK_G5_S2	PE	C	PB	ND	ND	B	C	S	R	10	21	21	4.8
D4	AK_D4_S1	BB	NP	PB	ND	ND	B	C	S	R	7	22	25	6.5
D4	AK_D4_S2	PE	NP	RSE	ND	ND	RB	C	S	R	9	23	27	7.6
D4	AK_D4_S1	BB	NP	PB	ND	ND	Br	C	S	R	8	15	23	3
E4	AK_E4_S1	BB	NP	PB	ND	ND	Br	C	S	R	9	17	32	8.3
F4	AK_F4_S1	SI	NP	PB	ND	ND	Br	C	S	R	9	32	66	25.1
F4	AK_F4_S2	BE	NP	PB	ND	ND	G	C	S	R	15	30	37	15.8
F4	AK_F4_S3	BE	NP	PB	ND	ND	Br	CF	S	R	6	30	38	7.7
F4	AK_F4_S4	BE	NP	PB	ND	ND	Br	CF	S	R	7	26	28	8.1
F4	AK_F4_S11	BB	NP	RSB	ND	ND	RB	CF	S	R	5.5	16	16	2.2
G4	AK_G4_S1	BB	NP	PB	ND	ND	Br	C	S	R	8	21	38	7.3
G4	AK_G4_S2	BB	NP	PB	ND	ND	Br	C	S	R	6	22	27	5.3
G4	AK_G4_S3	BB	NP	PB	ND	ND	B	C	S	R	6.5	21	23	5.2
G4	AK_G4_S4	PE	NP	PB	ND	ND	Br	C	S	R	7	18	26	5,3,
H4	AK_H4_S1	BB	NP	RSI	ND	ND	Br	C	Q	R	8	25	25	5.69
D3	AK_D3_S1	BB	NP	PB	ND	ND	Br	C	S	R	6	17	23	2.8

F3	AK_F3_S1	BB	NP	RSE	ND	ND	RB	C	S	R	11	21	29	6.9
G3	AK_G3_S1	BE	NP	RSE	ND	ND	DB	C	S	R	8	25	53	17.7
E2	AK_E2_S1	BE	NP	RSE	ND	ND	DB	C	S	R	9	31	41	11

SL: *Sherd Label*; **UT:** *Upper thickness*; **LT:** *Lower thickness*; **H:** *Height*; **W:** *Width*

ST: *Surface Treatment -> Burnished on both Walls* (**BB**); *Burnished on the Interior Wall* (**BI**); *Smoothed on the exterior wall* (**SE**); *Smoothed on both walls* (**SB**); *Smoothed on the interieur wall* (**SI**); *Patterned on the exterior wall* (**PE**)

SP: *Surface Patterning -> Patterned* (**P**); *Not Patterned* (**NP**)

SC: Surface Coating -> Red Slipped on Both Walls (**RSB**); Red Slipped on the Exterior Wall (**RSE**); Red Slipped on the Interior Wall (**RSI**); Graphite Burnished on Both Walls (**GBB**); Graphite Burnished on the Exterior Wall (**GBE**); Plain on the interior wall (**PI**)

PD: *Place of Decoration -> No Decoration* (**ND**)

DS: *Decoration Motif Style -> No Decoration* (**ND**)

PC: *Paste Color -> Black* (**B**); *Dark Brown* (**DB**); *Brown* (**Br**); *Red Brown* (**RB**); *Red* (**R**); *Gray* (**G**)

PT: *Paste Texture -> Coarse* (**C**); *Coarse Fine* (**CF**)

Tp: *Tempers -> Sand* (**S**)

FC: *Firing Condition -> Reduced Atmosphere* (**R**)

Table 6.38: Body Sherds Analyzed from Excavation Unit 3

SU#	sherd_label	UT	LT	H	W	ST	SP	SC	PC	PT	Tp	FC
SU1	**AK_U3_SU1_L5_S1**	8	4	15	6	BB	NP	PB	Br	C	S	R
SU1	**AK_U3_SU1_L5_S1**	5.7	5.3	27.8	39.9	SE BI	NP	RSB	B	CF	S	R
SU1	**AK_U3_SU1_L5_S2**	8	5	19	5.5	BB	NP	PB	B	C	S	R
SU1	**AK_U3_SU1_L5_S2**	6.9	6.2	21.2	24	SE BI	NP	RSB	B	CF	S	R
SU2	**AK_U3_SU2_L5_S3**	7	5	19	5	SB	NP	PB	Br	C	S	R
SU2	**AK_U3_SU2_L5_S4**	6	5	14	7	PE	CE	PB	Br	C	S	R
SU3	**AK_U3_SU3_L5_S1**	6.5	4.9	24	35.1	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S2**	6.5	3.9	32.7	28.2	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S3**	7.1	4.9	24	34.9	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S4**	5.9	4.4	25	29.2	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S5**	5.7	4.7	37.56	31.2	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S6**	6.3	5	21.7	36.9	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S7**	5.8	4.9	21.9	31.6	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S8**	5.9	5.2	24.8	27.5	SE BI	NP	RSB	B	CF	S	R
SU3	**AK_U3_SU3_L5_S1**	7	7	18	5.2	BE	NP	PB	Br	CF	S	R
SU3	**AK_U3_SU3_L5_S3**	8	7	20	5	BB	NP	PB	B	CF	S	R
SU4	**AK_U3_SU4_L5_S1**	4.9	4.8	22.1	28.4	SE BI	NP	RSB	B	CF	S	R
SU4	**AK_U3_SU4_L5_S2**	6.1	4.3	18.9	30.5	SE BI	NP	RSB	B	CF	S	R
SU4	**AK_U3_SU4_L5_S3**	7.	6.8	24.8	27.4	SE BI	NP	RSB	B	CF	S	R
SU4	**AK_U3_SU4_L5_S4**	9.4	9.4	18.8	28.6	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S1**	9.3	7.5	37.8	52.3	SE BI	NP	RSB	DB	CF	S	R
SU5	**AK_U3_SU5_L5_S2**	8	7.2	30.8	35.7	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S3**	6.9	5.8	22.9	40.5	SB	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S4**	7	6.9	32.5	39.2	SE BI	NP	RSB	DB	CF	S	R

SU5	**AK_U3_SU5_L5_S5**	9.5	7.8	35.6	49.2	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S6**	6.9	6.1	23.7	41.6	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S7**	7.1	6.3	32.3	29.2	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S8**	8.7	7.2	28.5	32.4	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S9**	7.3	4.4	33.1	38	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S10**	6.6	5.9	20.4	38	SE BI	NP	RSB	B	CF	S	R
SU5	**AK_U3_SU5_L5_S2**	9	4	38	7.5	BB	NP	PB	B	C	S	R
SU5	**AK_U3_SU5_L5_S3**	7	6	51	11	BB	NP	PB	Br	C	S	R
SU5	**AK_U3_SU5_L5_S4**	6	7	37	11	BB	NP	PB	Br	C	S	R
SU5	**AK_U3_SU5_L5_S10**	6	6	26.5	7	BE	NP	PB	Br	C	S	R
SU5	**AK_U3_SU5_L5_S11**	8	7	21	7	BB	NP	PB	RB	C	S	R
SU5	**AK_U3_SU5_L5_S12**	7	5	12	6	BB	NP	PB	Br	C	S	R
SU5	**AK_U3_SU5_L5_S13**	6	6	36	6	BE	NP	RSE	Br	C	Q	R
SU5	**AK_U3_SU5_L5_S14**	8	5	20	6	BE	NP	PB	Br	C	Q	R
SU5	**AK_U3_SU5_L5_S15**	7	5	21	8	BE	NP	RSE	Br	CF	S	R
SU6	**AK_U3_SU6_L5_S1**	8	6.6	38.1	46.1	SE BI	NP	RSB	B	C	S	R
SU6	**AK_U3_SU6_L5_S2**	8	6.6	29.1	38.2	SE BI	NP	RSB	B	C	S	R
SU6	**AK_U3_SU6_L5_S3**	8.5	7.4	33.2	32.4	SE BI	NP	RSB	B	C	S	R
SU6	**AK_U3_SU6_L5_S4**	8	5	29.5	36.9	SI	NP	RSB	B	C	S	R
SU6	**AK_U3_SU6_L5_S5**	7.7	6.6	23.4	42.1	SE BI	NP	RSB	B	C	S	R
SU6	**AK_U3_SU6_L5_S6**	9.2	8.1	25.5	28.5	SE BI	NP	RSB	RB	C	S	O
SU6	**AK_U3_SU6_L5_S7**	9	6.7	27.8	33.9	SE BI	NP	RSB	RB	C	S	O
SU6	**AK_U3_SU6_L5_S2**	7	5	20	6	PE	CE	PB	DB	C	S	R
SU6	**AK_U3_SU6_L5_S3**	7	4	15	8	PE	CE	PB	DB	C	S	R
SU6	**AK_U3_SU6_L6_S1**	9	4	18	5	PE	NP	RSE	Br	C	Q	R
SU6	**AK_U3_SU6_L6_S2**	6	7	16	4	PE	NP	RSE	Br	C	Q	R

SU6	**AK_U3_SU6_L6_S3**	9	5	12	5	PE	NP	RSE	Br	C	Q	R
SU6	**AK_U3_SU6_L6_S4**	7	5	18	5	PE	CI	RSE	Br	C	Q	R
SU6	**AK_U3_SU6_L6_S5**	9	7	21	6	PE	NP	RSE	Br	CF	S	R
SU6	**AK_U3_SU6_L6_S6**	7	6	13	2	BE	NP	PB	Br	CF	S	R
SU6	**AK_U3_SU6_L6_S7**	9	4	13	3	BE	NP	RSI	Br	CF	S	R
SU6	**AK_U3_SU6_L6_S8**	6	5	8	3	PE	CE	PB	Br	CF	S	R
SU6	**AK_U3_SU6_L6_S1**	8	6	28	7	PE	CE	PB	DB	C	Q	R

SL: *Sherd Label*; **UT:** *Upper thickness*; **LT:** *Lower thickness*; **H:** *Height*; **W:** *Width*

ST: *Surface Treatment -> Burnished on both Walls* (**BB**); *Burnished on the Interior Wall* (**BI**); *Patterned* (**P**); *Smoothed on the exterior wall* (**SE**); *Smoothed on both walls* (**SB**); *Smoothed on the interieur wall* (**SI**); *Patterned on the exterior wall* (**PE**)

SP: *Surface Patterning -> Patterned* (**P**); *Not Patterned* (**NP**)

SC: *Surface Coating -> Red Slipped on Both Walls* (**RSB**); *Red Slipped on the Exterior Wall* (**RSE**); *Red Slipped on the Interior Wall* (**RSI**); *Graphite Burnished on Both Walls* (**GBB**); *Graphite Burnished on the Exterior Wall* (**GBE**); *Plain on the interior wall* (**PI**)

PC: *Paste Color -> Black* (**Bl**); *Dark Brown* (**DB**); *Brown* (**Br**); *Red Brown* (**RB**)

PT: *Paste Texture -> Coarse* (**C**); *Coarse Fine* (**CF**)

Tp: *Tempers -> Sand* (**S**); *Quartz* (**Q**)

FC: *Firing Condition -> Reduced* (**R**); Oxidized (**O**)

6.3.6. Dating of Ankilivalo

The fragmentary nature and plain design of potsherds from Ankilivalo made it hard to estimate their age. Drs. Henry Wright and Chantal Radimilahy, based on their expertise on Malagasy pottery tradition, tentatively dated the occupation of the site to the 18^{th} – 19^{th} centuries CE. Two cattle bones from a secure cultural layer at Ankilivalo (the ones that provided the isotopic values above) were dated using the AMS technique at the Accelerator Mass Spectrometry Lab of the Institute of Energy and Environmental Sustainability at Penn State University. Results yielded ^{14}C dates of 195 ± 15 BP and 200 ±15 BP. Using the SHCal13 calibration curve in OxCal 4.3.2. this yields a site occupation time range between the late 17^{th} and early 19^{th} century CE (Figure 6.31, 6.32).

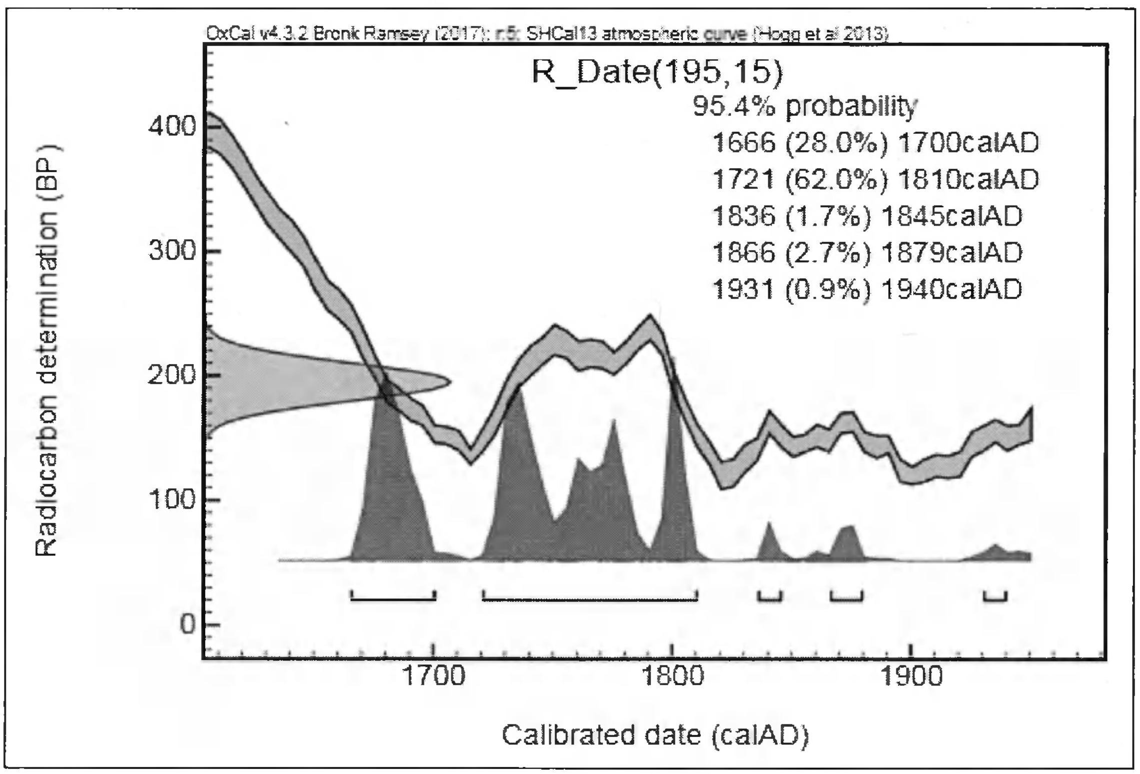

Figure 6.31: Calibrated AMS Dates for Cattle Remains (Sample 1) from Ankilivalo.

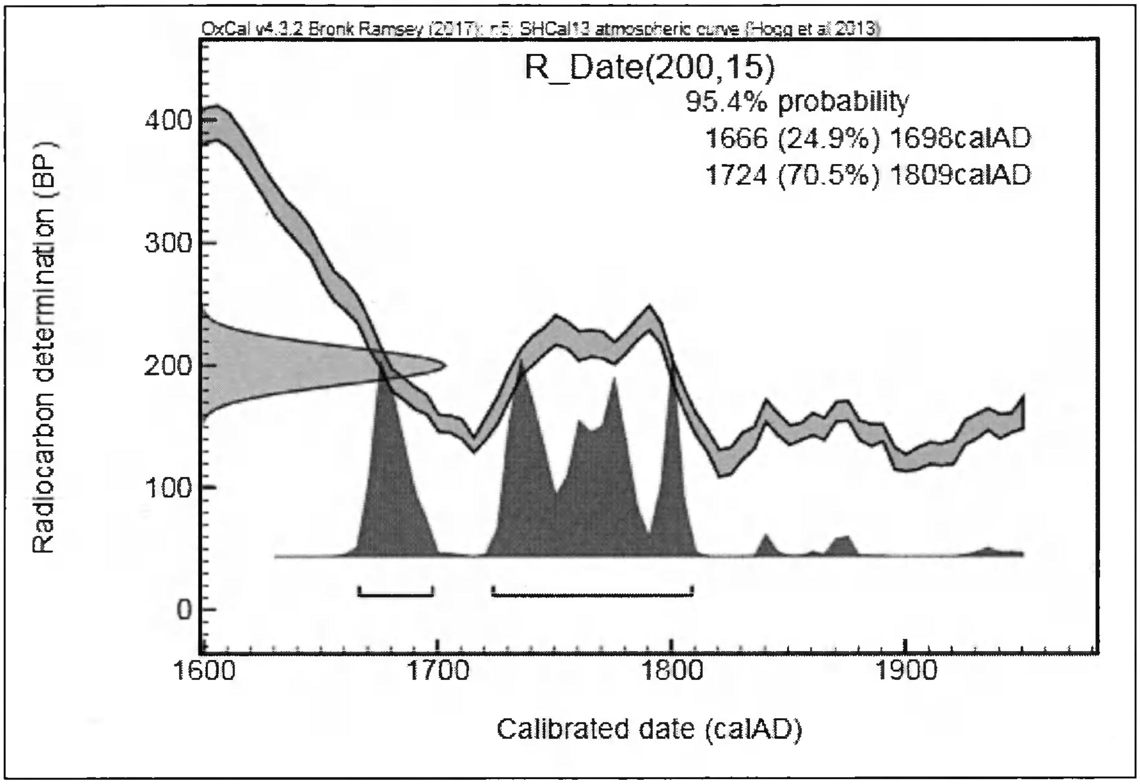

Figure 6.32: Calibrated AMS Dates for Cattle Remains (Sample 2) from Ankilivalo.

CHAPTER SEVEN: SITE LOCATION ANALYSES

This chapter zeroes in on site location analysis. As discussed in Chapter 5, its first aim is to analyze the spatial relationship between the location of archaeological sites and positioning of natural resources around them (see Jones 2010). This was to assess whether economic factors influenced the decisions of people to settle at Ankilivalo and Keliangebo. The second objective was to analyze the defensibility of archaeological sites. This was to evaluate whether sociopolitical factors influenced the decisions of people to settle at AK and KG. The first objective is approached with proximity analyses, while the second is approached with site defensibility analysis.

7.1. PROXIMITY ANALYSES

Proximity analyses were used to explore economic factors influencing settlement decisions by the community (see Chapter 5.6 for details of methods). Drawing from the concept of NCT *counteractive relocation,* I posited that the unpredictability of climate and the recurrence of droughts during the 16^{th} – 19^{th} centuries CE pushed people to move to areas with abundant resources and that proximity of natural resources to a particular site would have made it attractive for settlement. This chapter focuses on the proximity of archaeological sites to perennial water sources, arable lands, pastures, and forest resources (Jones 2006: 523). This is based on the assumption that during a period of unpredictable climate, people broadened their subsistence strategies, therefore maximized their chance to access to different resources (Volkmann 2018: 30).

7.1.1. Proximity to High Flow Accumulation:

7.1.1.1. Proximity of Ankilivalo to High Flow Accumulation

Ankilivalo is located 118 m away from the nearest high flow accumulation of water (Figure 7.1). The least cost path from Ankilivalo to the nearest high flow accumulation is 0.047 (Figure 7.2; Table 7.1).

7.1.1.2. Proximity of Keliangebo to High Flow Accumulation

Keliangebo is located 304 m away from the nearest high flow accumulation of water (Figure 7.3). The least cost path from Keliangebo to the nearest high flow accumulation is 0.36 (Figure 7.4; Table 7.1).

Table 7.1: Travel Time from Archaeological Sites to Nearest High Flow Accumulation

Site	Near Distance	Path Cost (per Pixel)	Cell Count	Total Cost
Ankilivalo	118	0.011944	4	0.047776
Keliangebo	304	0.040502	9	0.364518

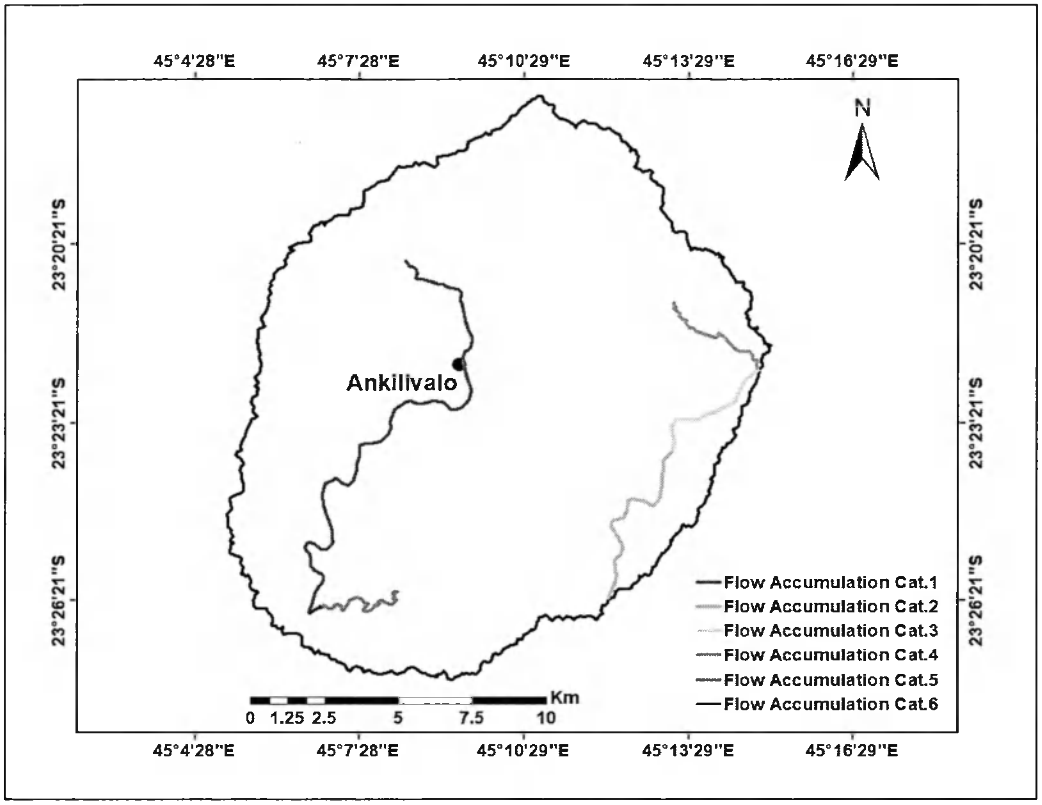

Figure 7.1: Proximity of Ankilivalo to High Flow Accumulation

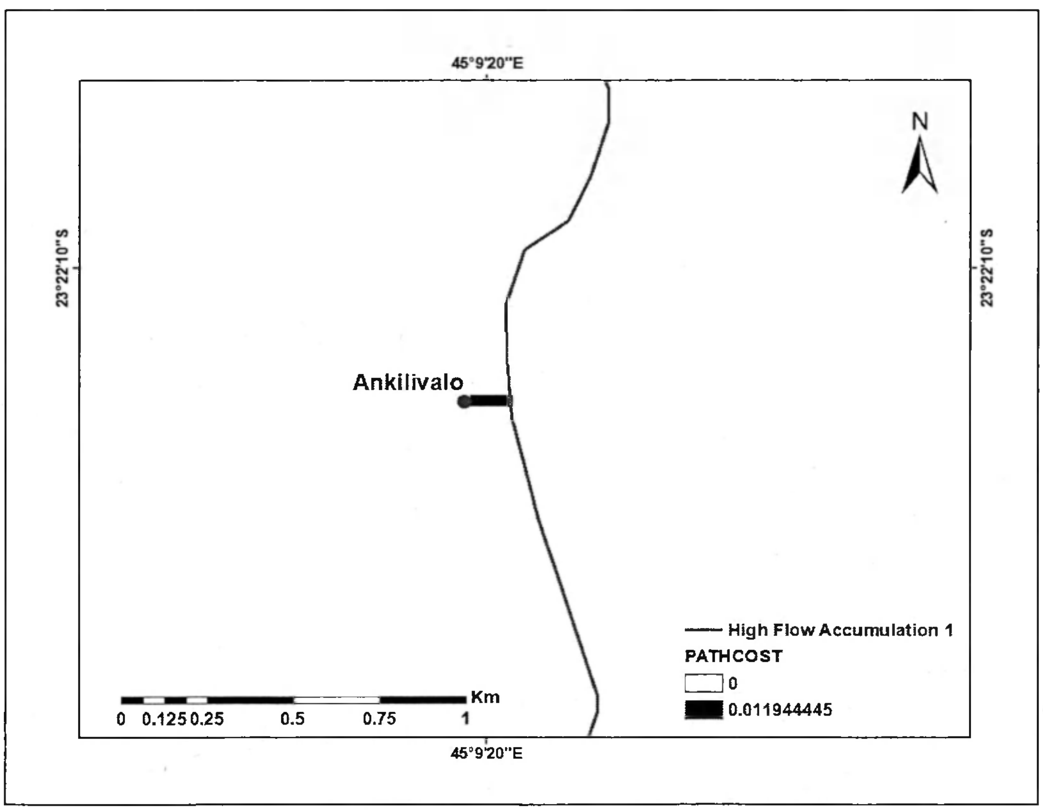

Figure 7.2: A Least Cost Path from Ankilivalo to the Nearest High Flow Accumulation

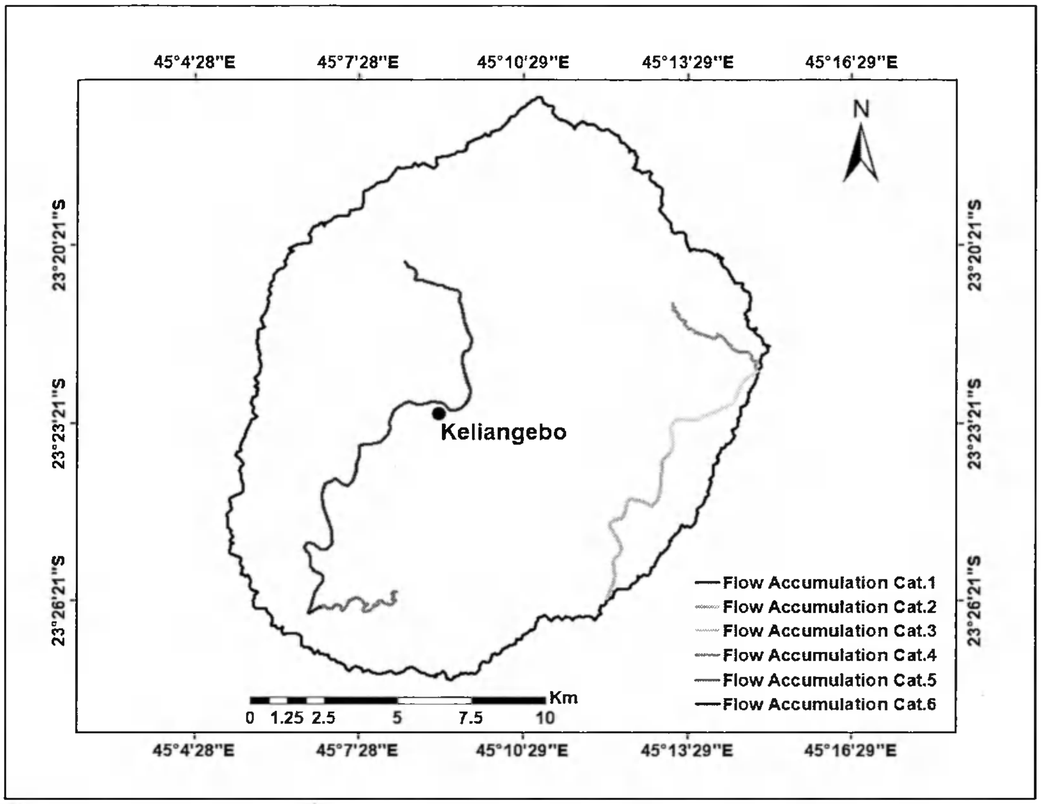

Figure 7.3: Proximity of Keliangebo to High Flow Accumulation

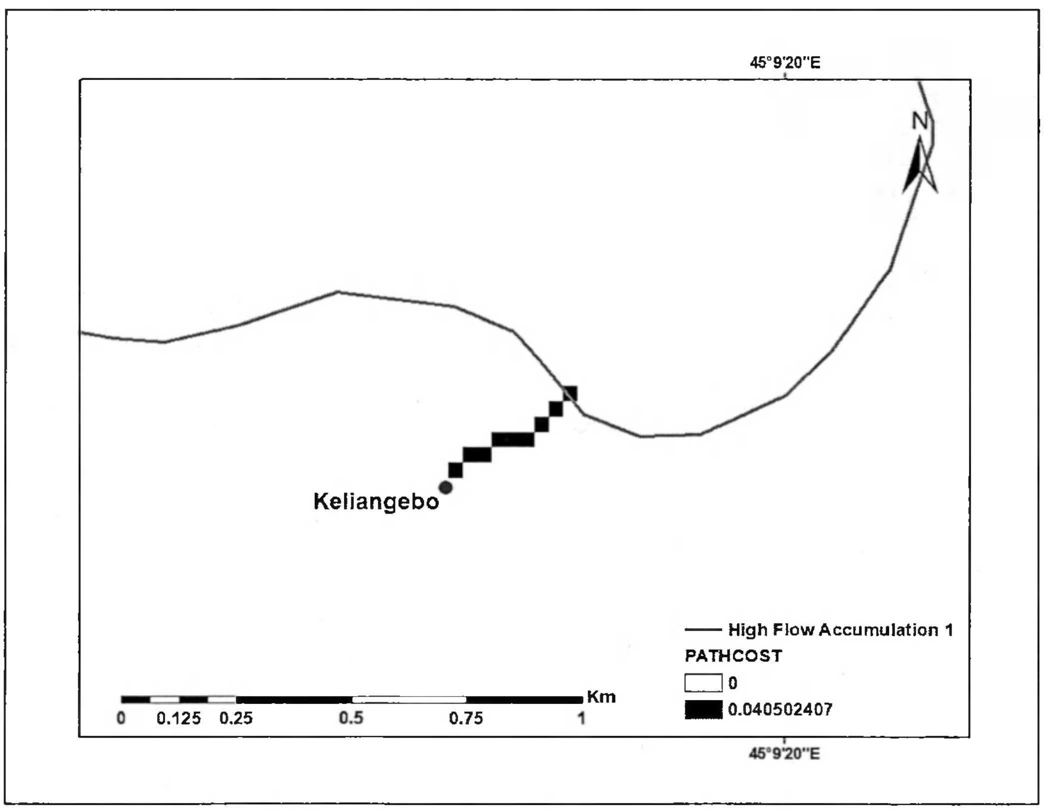

Figure 7.4: Cost Path from Keliangebo to the Nearest High Flow Accumulation

7.1.1.3. Proximity of Random Sites to High Flow Accumulations

The proximity analysis demonstrated that only one (RS23 = **75 m**) out of 50 random sites (2%) was closer to a high flow accumulation than Ankilivalo (**118 m**) and Keliangebo (**304 m**) (Table 7.1, 7.2). This gives us a probability value (p-value) of 0.02, which is lower than the significance level ($\alpha = 0.05$). The statistical significance of the proximity of archaeological sites to permanent water sources was thus high. That is, there is a very high probability that proximity to the Sakamarekely River influenced the decision of the occupants of Ankilivalo and Keliangebo to settle at these sites.

The least cost path analysis also corroborated that all random sites have costlier paths than Ankilivalo (0.04) and Keliangebo (0.364) (Figure 7.5; Table 7.1, 7.2).

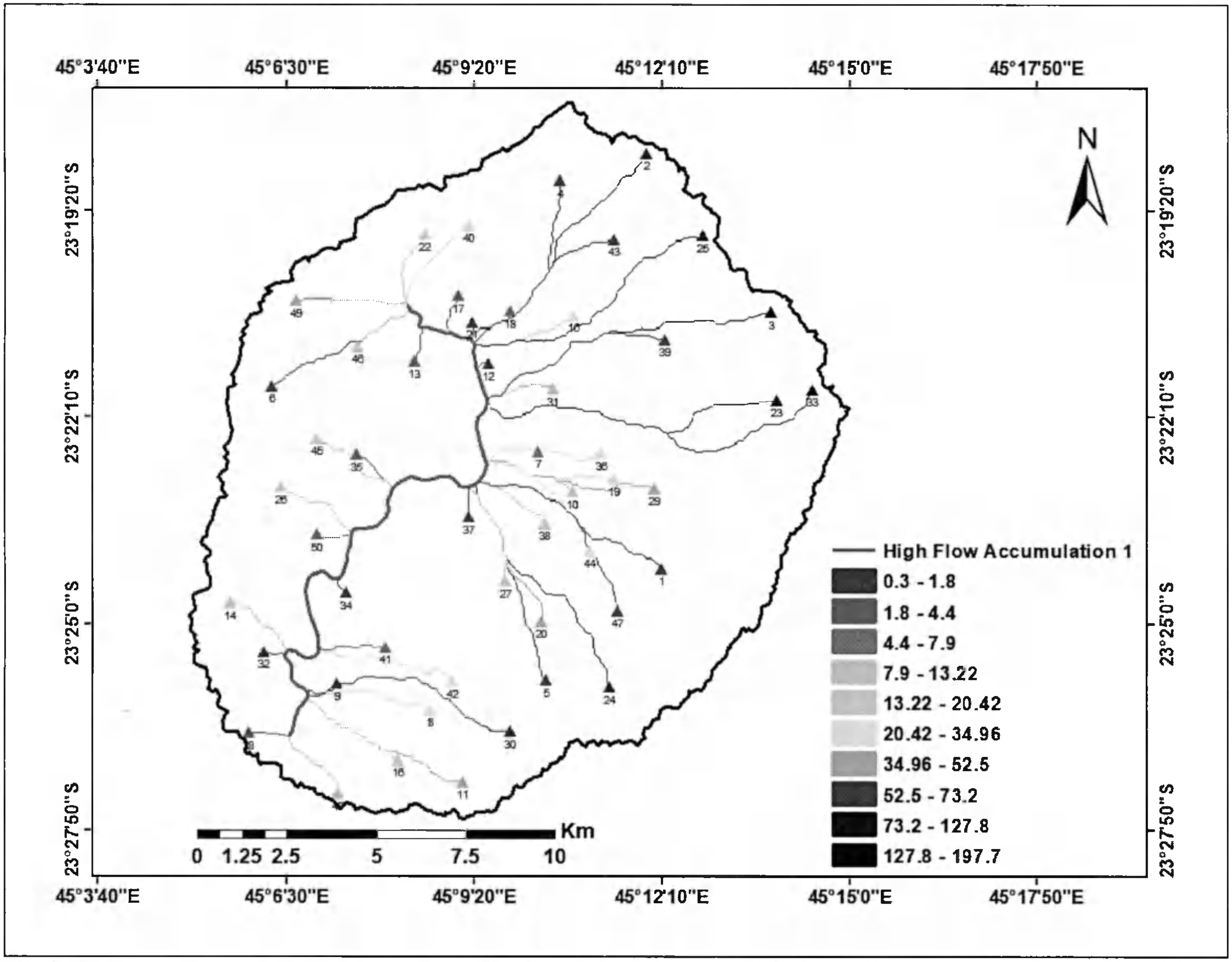

Figure 7.5: Least Cost Path from Random Sites to High Flow Accumulation

Table 7.2: Random Sites and Coordinates of their Nearest High Flow Accumulation Points

Random Sites #	Distance (m)	Near Latitude	Near Longitude	Cell Cost Value	Cell Count	Least Cost Path
RS1	5214	-23.382358	45.15759	0.407798	170	69.32569
RS2	6559	-23.351545	45.154397	0.553195	194	107.3197
RS3	7652	-23.365113	45.158701	0.652675	264	172.3063
RS4	4643	-23.351545	45.154397	0.44498	154	68.52689
RS5	5305	-23.385314	45.153902	0.454819	161	73.22585
RS6	3989	-23.344984	45.139179	0.581222	123	71.49028
RS7	1391	-23.379692	45.15842	0.111246	50	5.562275
RS8	3208	-23.43319	45.113464	0.261472	113	29.54638
RS9	800	-23.432173	45.113475	0.06683	27	1.804401
RS10	2361	-23.380098	45.158437	0.204537	80	16.36297
RS11	4568	-23.434168	45.113011	0.354755	148	52.50374
RS12	335	-23.357873	45.155983	0.033511	11	0.368621
RS13	882	-23.348833	45.14237	0.133081	28	3.726279
RS14	1857	-23.422951	45.10827	0.174453	57	9.943807
RS15	2699	-23.352356	45.155209	0.287659	92	26.46461
RS16	2833	-23.434168	45.113011	0.234812	87	20.42866
RS17	955	-23.349982	45.149638	0.139746	31	4.332124
RS18	1269	-23.352356	45.155209	0.154915	38	5.886786
RS19	3334	-23.380098	45.158437	0.274974	117	32.172
RS20	3334	-23.380098	45.158437	0.35897	115	41.28152
RS21	436	-23.351545	45.154397	0.057184	14	0.800572
RS22	1846	-23.343607	45.138505	0.249382	58	14.46418
RS23	7474	-23.365942	45.158711	0.569363	270	153.728
RS24	6230	-23.384613	45.155551	0.510563	194	99.04926
RS25	6536	-23.352356	45.155209	0.583593	219	127.8069
RS26	2094	-23.395479	45.124552	0.22717	67	15.22039

RS27	2584	-23.385314	45.153902	0.225936	79	17.84891
RS28	1020	-23.442421	45.109045	0.122892	36	4.424117
RS29	4389	-23.380098	45.158437	0.331711	153	50.75179
RS30	5318	-23.43319	45.113464	0.394953	185	73.06631
RS31	1720	-23.365113	45.158701	0.183367	60	11.002
RS32	504	-23.423943	45.107769	0.037025	17	0.629427
RS33	8379	-23.365113	45.158701	0.639802	309	197.6987
RS34	418	-23.406455	45.121139	0.036828	12	0.441936
RS35	1235	-23.385404	45.135086	0.135437	33	4.469407
RS36	2981	-23.379692	45.15842	0.248415	107	26.58036
RS37	769	-23.385319	45.153786	0.07337	25	1.834261
RS38	2039	-23.383124	45.157	0.216744	61	13.22141
RS39	4814	-23.365113	45.158701	0.41677	167	69.60057
RS40	2561	-23.343607	45.138505	0.39362	70	27.55343
RS41	1720	-23.422294	45.116419	0.130463	61	7.958241
RS42	3559	-23.4229	45.116273	0.257032	122	31.35784
RS43	3559	-23.4229	45.116273	0.433948	137	59.45089
RS44	3401	-23.382358	45.15759	0.304065	115	34.96747
RS45	2300	-23.385404	45.135086	0.254129	71	18.04313
RS46	1600	-23.344984	45.139179	0.249338	47	11.7189
RS47	4882	-23.38384	45.15645	0.420531	165	69.38761
RS48	1912	-23.442421	45.109045	0.170031	59	10.0318
RS49	2830	-23.343607	45.138505	0.421879	100	42.1879
RS50	861	-23.396581	45.124479	0.090064	30	2.701929

7.1.2. Proximity to Arable Land

This section presents the results of proximity analysis in reference to areas of arable lands available to sites within 2km search radius.

7.1.2.1. Proximity of Ankilivalo to Arable Land

Ankilivalo had 182 Ha of potentially arable lands available within 2km (Figure 7.6), the nearest located only 118 m away (-23.372587; 45.156157).

7.1.2.2. Proximity of Keliangebo to Arable Land

There were 135 Ha of potential arable lands available for the occupants of Keliangebo within 2km (Figure 7.7), the nearest located 319 m away (-23.385414 S; 45.151944 E).

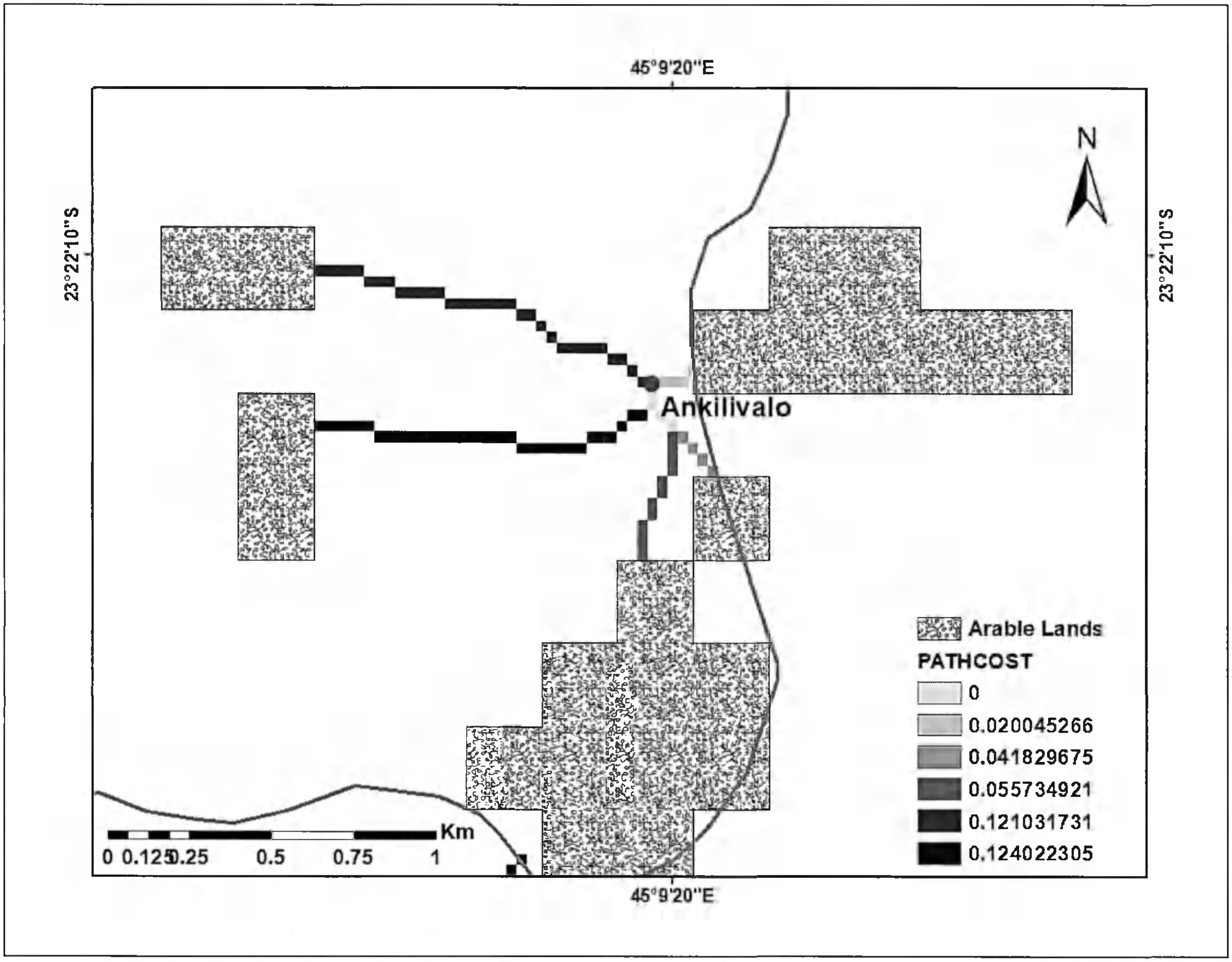

Figure 7.6: Arable Lands within 2km Search Radius from Ankilivalo, and LCP Reaching Them

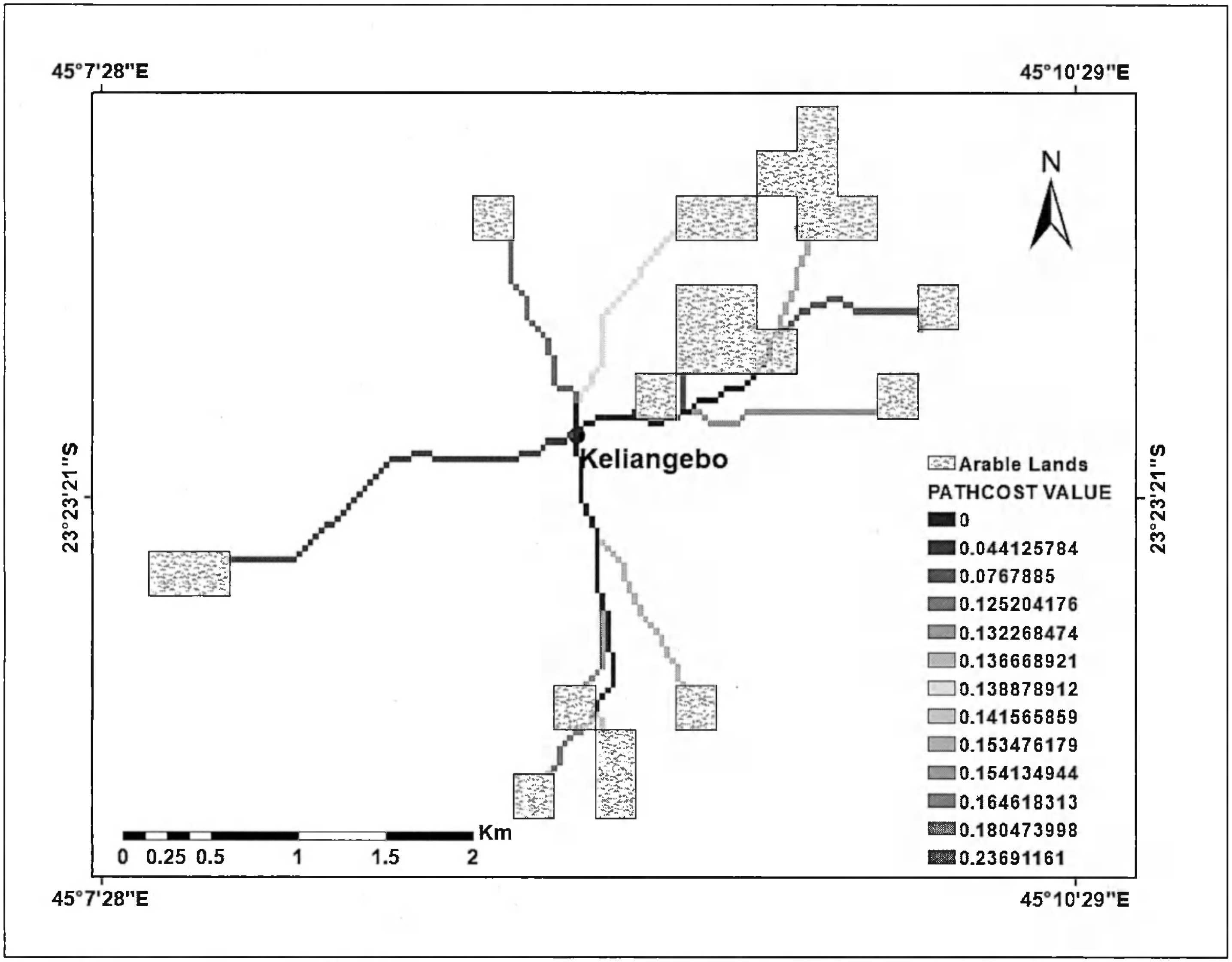

Figure 7.7: Arable Lands within 2km Search Radius from Keliangebo, and LCP Reaching Them

7.1.2.3. Proximity of Random Sites to Arable Land

Results of the proximity analysis showed that 7 of 50 random sites are located closer to potential arable lands than Ankilivalo, while 13 of 50 for Keliangebo. This gives p-values of 0.14 and 0.26 respectively, which are both higher than the significance level ($\alpha = 0.05$). This suggests that the proximity of sites to arable lands did not influence community's decisions.

Meanwhile, I observed that no random sites have access to larger areas of arable lands within 2km radius than Ankilivalo (**182 Ha**) and Keliangebo (**135 Ha**). Although RS3 is located in a relatively large area of potential arable land (**123 Ha**), it is almost at the fringe of the northeast boundary of the study area in the Maloto valley. I have not surveyed the Maloto Valley yet, but a comparison of current population densities and numbers of settlements shows that the MSV attracts more people (especially agrarian-oriented communities) today than the larger Maloto Valley. Overall, the Maloto valley and its surroundings offer less arable lands than the MSV (see Chapter 5, Figure 5.34). In addition, the biomass plants is greater in the MSV than the Maloto Valley (see Chapter 5, Figure 5.38). Furthermore, annual flooding of the Sakamarekely River deposits fertile alluvium soils on its banks. I therefore posit that, even in the past, the MSV was more strategic in terms of arable lands than other areas in the vicinity. Further research is needed to confirm this.

Table 7.3: Random Sites Having Accesses to Arable Lands within 2km Search Radius

Random Site #	**Number of Nearest Patches**	**Minimum Distance**	**Maximum Distance**	**Mean Distance (m)**	**Total Shape Areas (Ha)**
Random Site 3	8	0	826	531.45	123.02
Random Site 4	2	570.7	634.64	602.6	11.71
Random Site 6	3	101.17	952.07	609.2	17.57
Random Site 7	7	384.64	857.88	585.6	64.45
Random Site 8	4	99.7	602.41	459.57	35.17
Random Site 9	2	869.5	905.6	887.57	17.58
Random Site 10	1	375.46	-	-	5.86
Random Site 11	1	762.1	-	-	5.86
Random Site 12	1	329.34	-	-	29.29
Random Site 13	1	531.77	-	-	5.85
Random Site 14	3	303.5	403.6	339.82	17.58
Random Site 15	5	29.2	893.2	527.82	46.86
Random Site 16	4	415.2	761.2	584.77	35.17
Random Site 17	2	818.53	842.1	830.32	11.71
Random Site 18	2	0	192.5	96.28	46.86
Random Site 20	2	244.96	969.4	607.18	11.72
Random Site 21	2	421.1	547.15	484.13	11.71
Random Site 23	2	627.35	904.1	765.72	11.71
Random Site 25	1	825.03	-	-	11.71
Random Site 26	2	694.5	792.86	743.69	11.71
Random Site 27	2	324.65	749.4	537.05	17.58
Random Site 28	4	238.52	453.66	310.87	111.38
Random Site 29	2	798.76	963.96	881.36	23.43
Random Site 30	1	637.2	-	-	5.86
Random Site 31	5	0	712.3	427.39	76.16

Random Site 32	4	263.1	886.069452	560.31	64.47
Random Site 33	2	617	927.816333	772.4	11.71
Random Site 34	2	744.3	976.706156	860.5	11.72
Random Site 37	5	626.5	988.558001	804.08	58.6
Random Site 42	1	565.56	-	-	5.86
Random Site 43	1	724.8	-	-	5.85
Random Site 46	1	146.5	-	-	5.85
Random Site 48	4	201.5	990.95801	553.5	76.21
Random Site 49	2	0	383.71848	191.85	11.71
Random Site 50	6	328	920.633351	726.26	35.16

7.1.3. Proximity to Pasturelands

This section presents the results of proximity analysis in reference to pasturelands.

The results of proximity analysis and the statistical significance test showed that within 5 km search radius, there is a weak relationship between the location of archaeological sites and the proximity to pasturelands (see Table 7.4). However, if I consider the size of pasturelands available to archaeological sites and random sites within 5 km search radius, I observed that the statistical significance of the proximity to scrublands is strong for both Ankilivalo and Keliangebo (Table 7.5). The proximity of Ankilivalo to Isalo grasslands also has a strong statistical significance compared to random sites (Table 7.5).

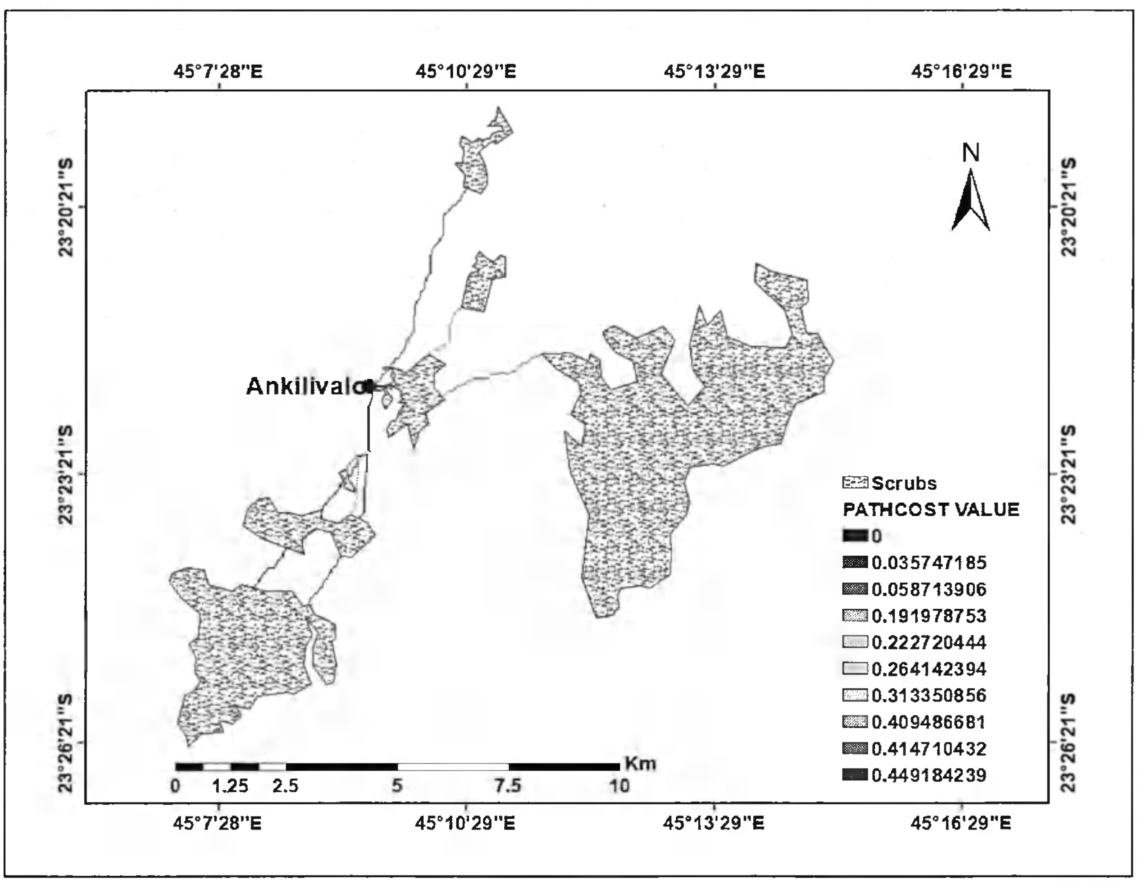

Figure 7.8: Cost Paths from Ankilivalo to Scrublands within 5 km Search Radius

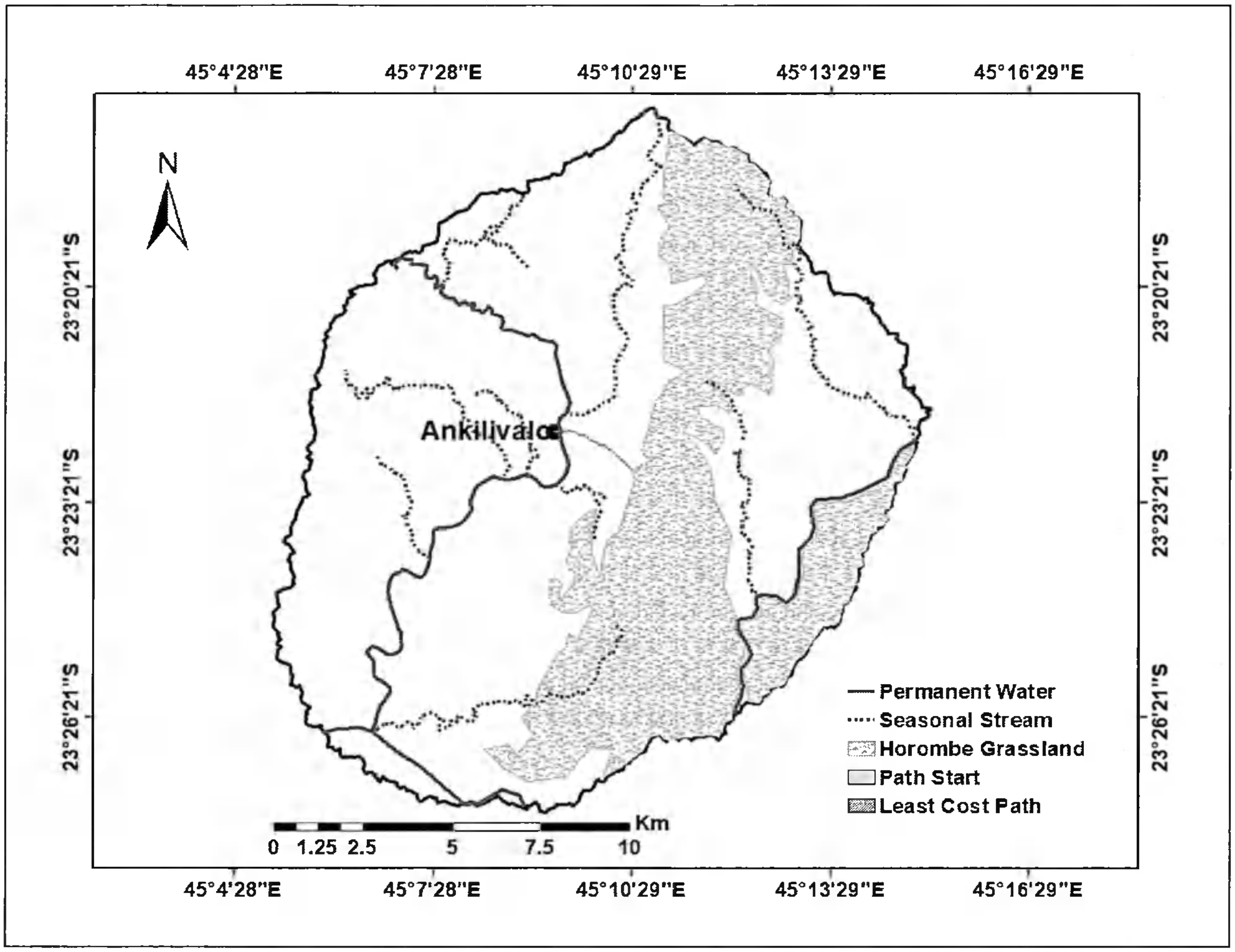

Figure 7.9: A Cost Path from Ankilivalo to the Nearest Horombe Grassland

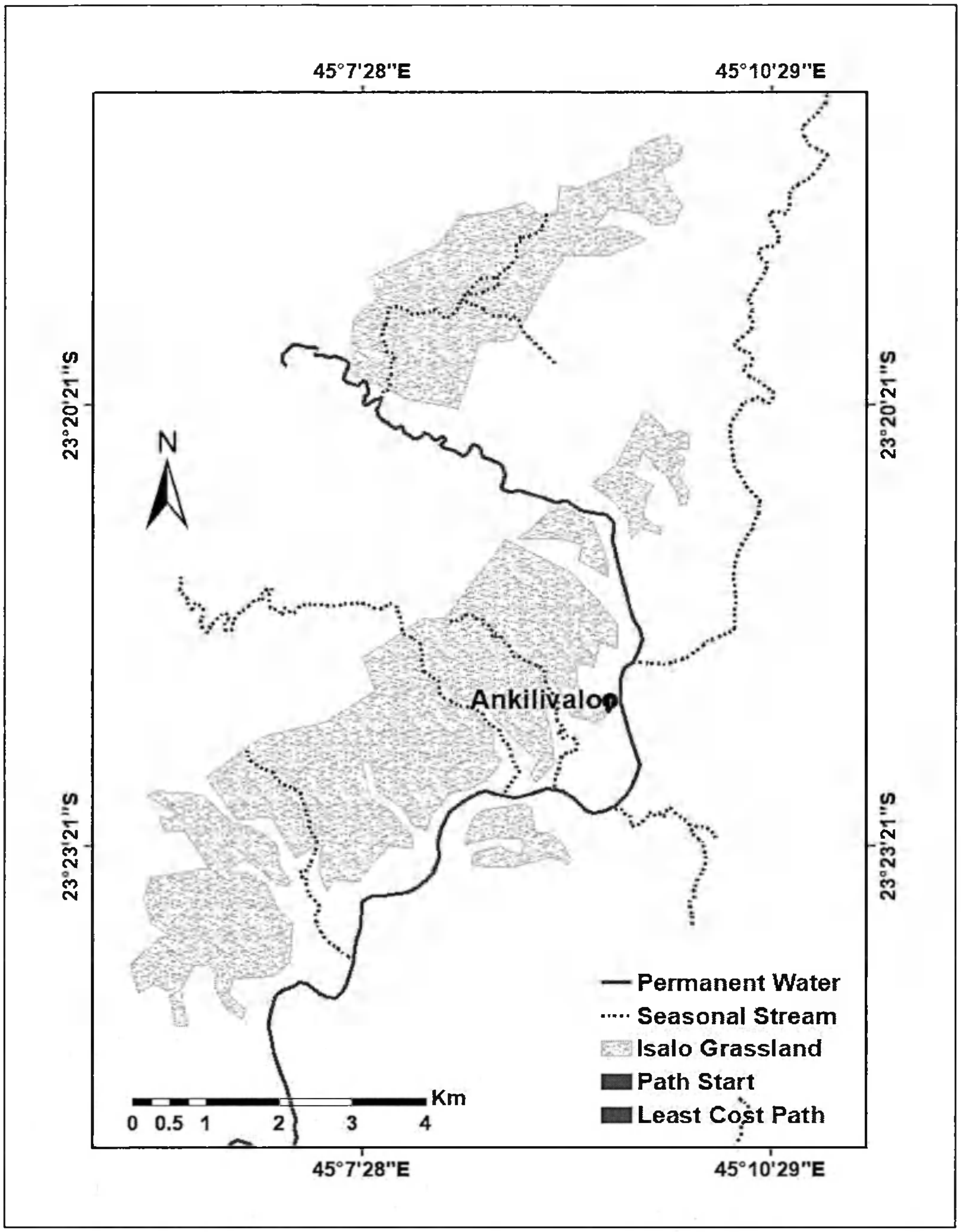

Figure 7.10: Cost Path from Ankilivalo to Grassland in the Isalo Massif

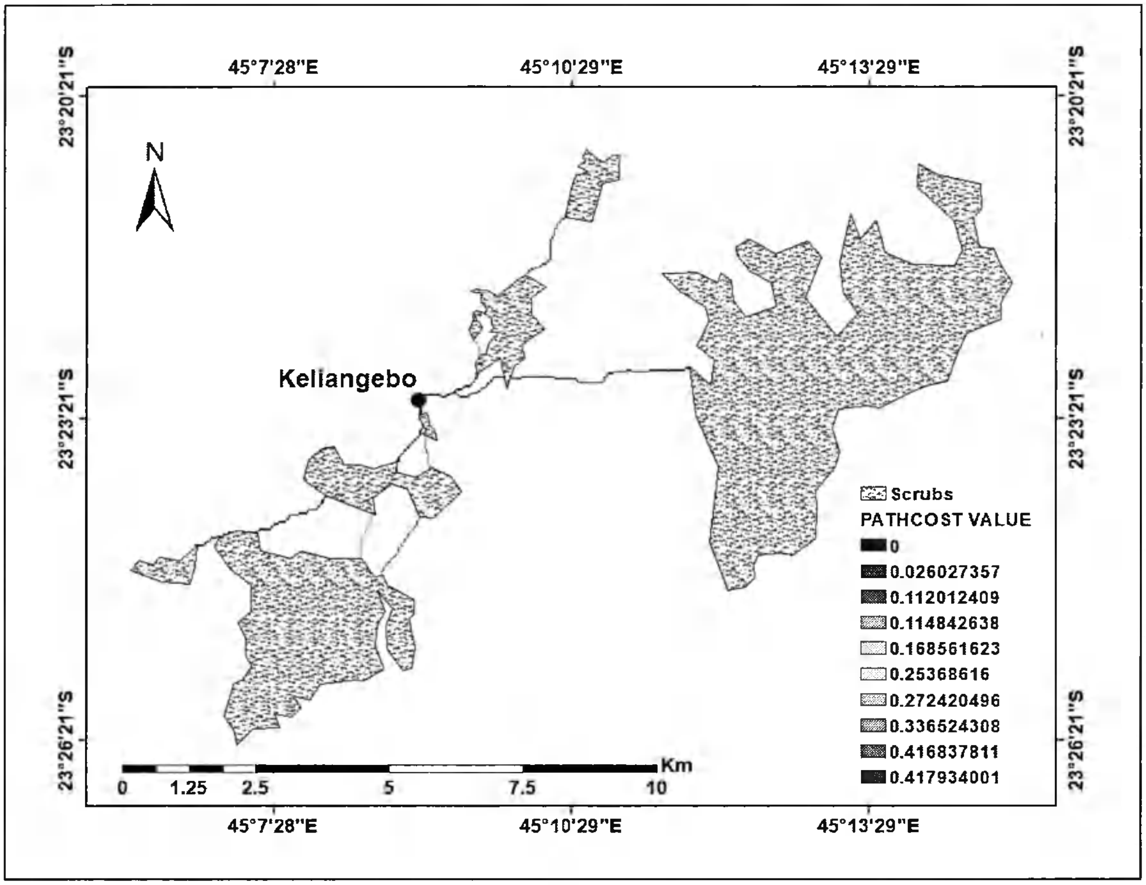

Figure 7.11: Cost Paths from Keliangebo to Scrublands within 5km Radius

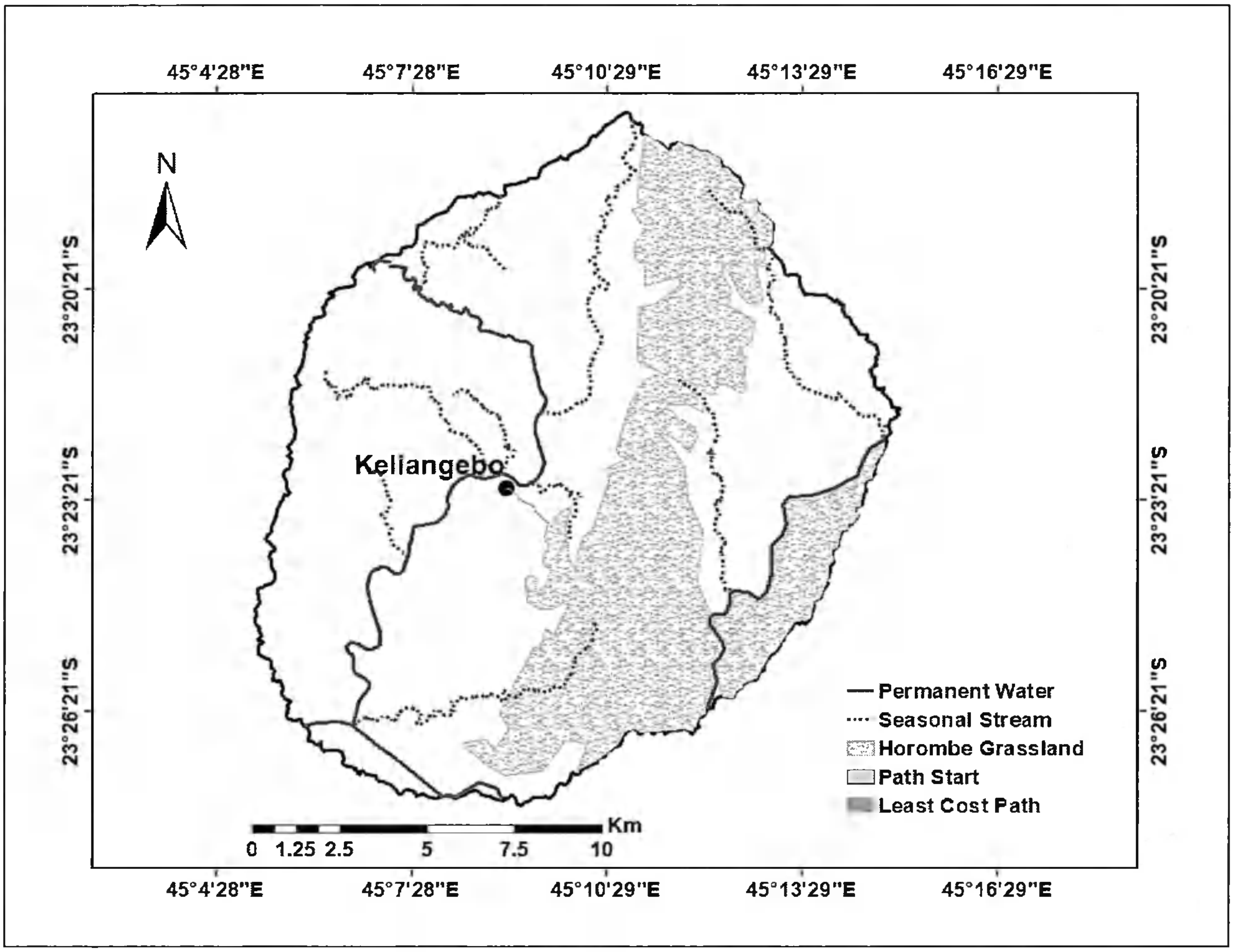

Figure 7.12: Cost Path from Keliangebo to Grassland in the Horombe Plateau

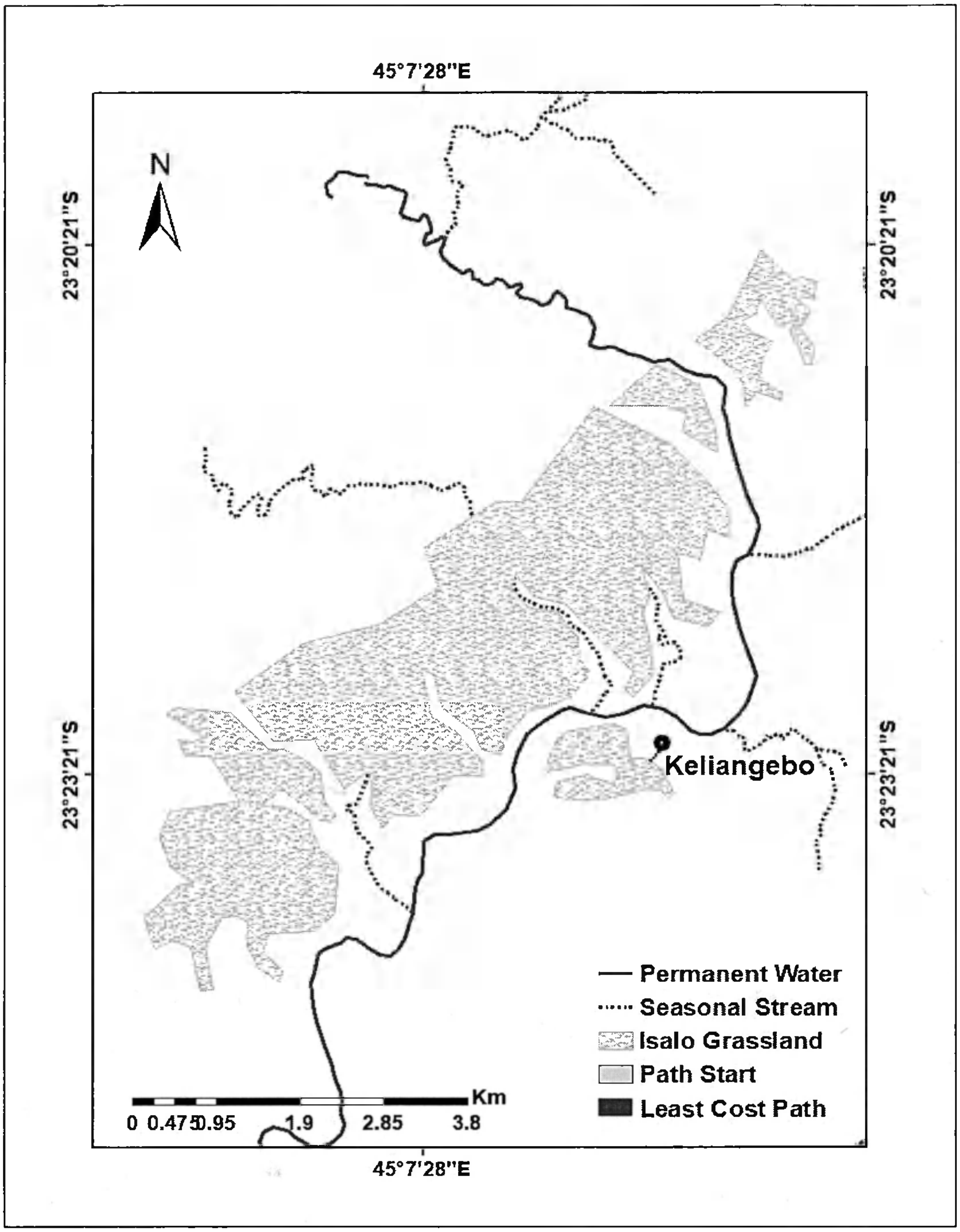

Figure 7.13: Cost Path from Keliangebo to Grasslands in the Isalo Massif

Table 7.4: Recapitulation of Proximity of Archaeological Sites and Random Sites to Pasturelands

	Distance from AK (m)	**Distance from KG (m)**	**# RS Closer Than AK**	**# RS Closer Than KG**
Scrublands	292	225	10 (p-value = 0.2)	9 (p-value = 0.18)
Horombe Grassland	2206	1403	32 (p-value = 0.64)	26 (p-value = 0.52)
Isalo Grassland	119	230	5 (p-value = 0.1)	7 (p-value = 0.14)

Table 7.5: Recapitulation of Areas of Pasturelands Available to Archaeological Sites and Random Sites within 5 km Search Radius

	Areas for AK (Ha)	**Areas for KG (Ha)**	**# RS Having Access**	**Range of Areas (Ha)**	**# RS Having Access ≥ AK**	**# RS Having Access ≥ KG**
Scrublands	3364	3329	49	159 – 3364	1 (p-value = 0.02)	2 (p-value = 0.04)
Horombe Grassland	6093	6093	45	6093 – 7086	45 (p-value = 0.9)	45 (p-value = 0.9)
Isalo Grassland	2319.17	1689.25	39	71.7 – 1689.25	0 (p-value = 0)	5 (p-value = 0.1)

The proximity analysis thus showed a weak relationship between archaeological sites and grasslands. It is noteworthy, however, that local communities in the southwest today practice extensive herding, that is, they leave herds to roam without a keeper. Immediate proximity of settlement to grasslands is thus not necessarily expected. But this does not rule out the idea that occupants of Ankilivalo and Keliangebo considered the availability of pastures. Both sites yielded livestock remains, although no livestock pens were found. Access to Keliangebo itself is too steep for cattle. But this does not rule out the idea that occupants of this village considered the availability and proximity of pastures when choosing its location. They might have practiced seasonal transhumance such as described in historical documents (see Chapter 4).

This uncertainty led me to consider the seasonality of activities at the archaeological sites. The least costly pasture to reach from Ankilivalo is the Isalo grassland (= **0.01**), then the scrublands (= **0.037**), and finally the Horombe grassland (= **0.2**), with the same trend at Keliangebo. Today, when local herders take their herds to the Isalo grasslands or the scrublands, they are able to return to their villages in the afternoon. But when they take their herds in the Horombe grasslands, they have to camp there throughout a season (*Toets'aomby*). This practice might have been practiced in the past as well.

To assess the possible seasonal use of the archaeological sites, I estimated their exposure to solar insolation during the winter (May-August) and summer (November-February), on the assumption that people would have preferred a shady site during the summer, and highly insolated site during the winter.

I estimated solar insolation using the *Hillshade* tool in ArcMap (*ArcToolbox > Spatial Analyst Tool > Surface > Hillshade*). This combines a DEM with assigned altitude and azimuth to measure the amount of sunlight reaching a given place (Chang 2008). Altitude is the angle 0 degree from the horizon to 90 degrees overhead, while azimuth is the angle along the horizon from 0 degrees in the North, 90 degrees in the East, 180 degrees in the South, and 270 degrees in the West. ArcGIS requires these two angles to determine the position of the sun at a given period. Thanks to the Astronomical Applications Department US Naval Observatory online program (http://aa.usno.navy.mil/data/docs/AltAz.php), I could determine the altitude and azimuth of the sun at midday during the winter (June selected) and the summer (January selected) in the MSV (Table 7.6). At noon during the austral summer (January Selected), the altitude of the sun is at 89 degrees, while the azimuth is at 280 degrees. On the other hand, at noon during the austral winter (June Selected), the altitude of the sun is at 45 degrees, while the azimuth is at 359 degrees.

Table 7.6: Seasonal Altitude and Azimuth for the Study Area (Source: http://aa.usno.navy.mil/data/docs/AltAz.php)

Season	Hour	Altitude	Azimuth
Summer (January)	12:00 pm	89	280
Winter (June)	12:00 pm	45	359

I use these values to estimate the hillshade of my study area during the winter and summer. The results showed solar insolation during the winter scaled from total shade (= 0) to total exposure to sunlight (= 180) (Figure 7.20), and during the summer from 0 to 254 (Figure 7.21).

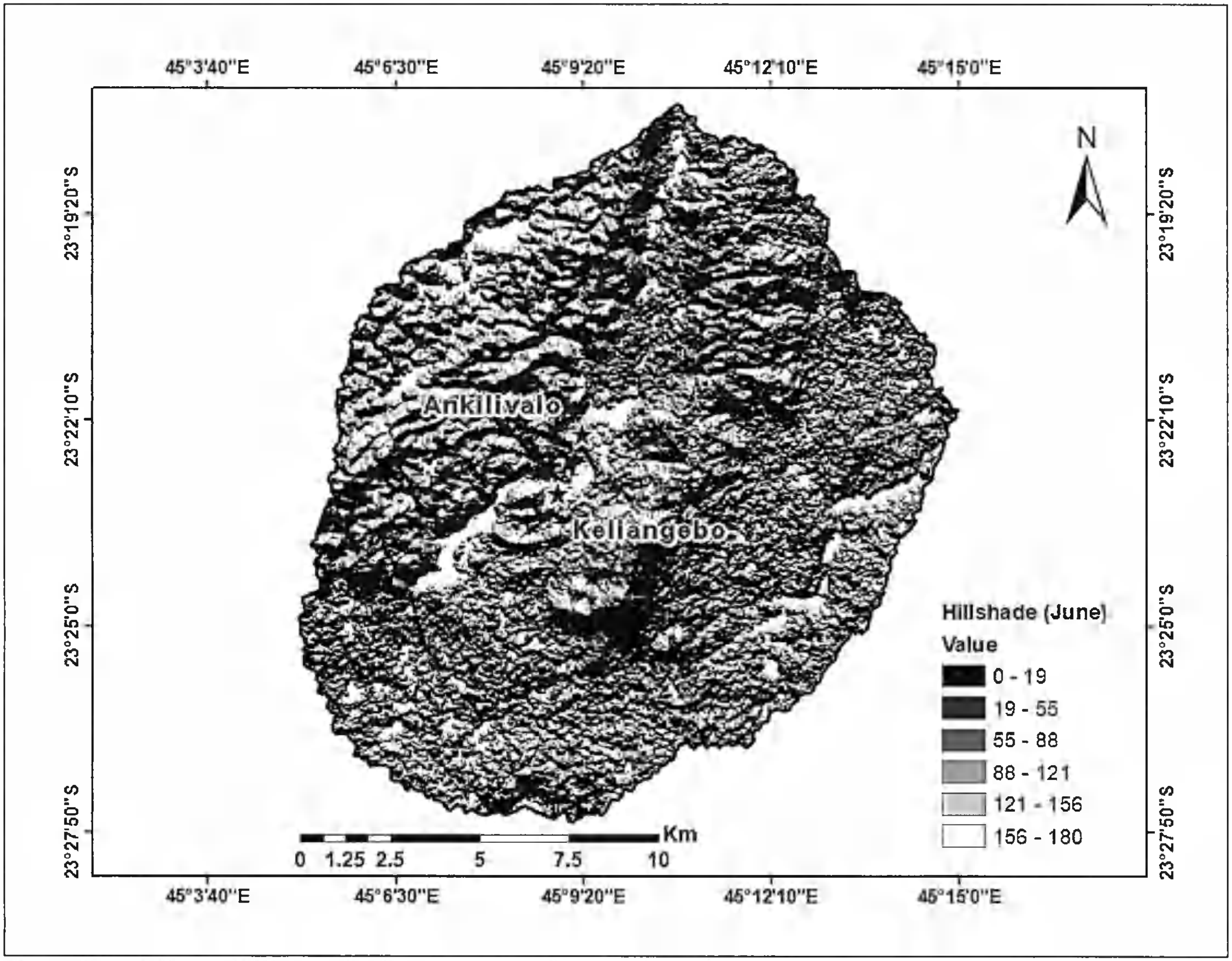

Figure 7.20: Midday Hillshade in June (Austral Winter) of the Study Area

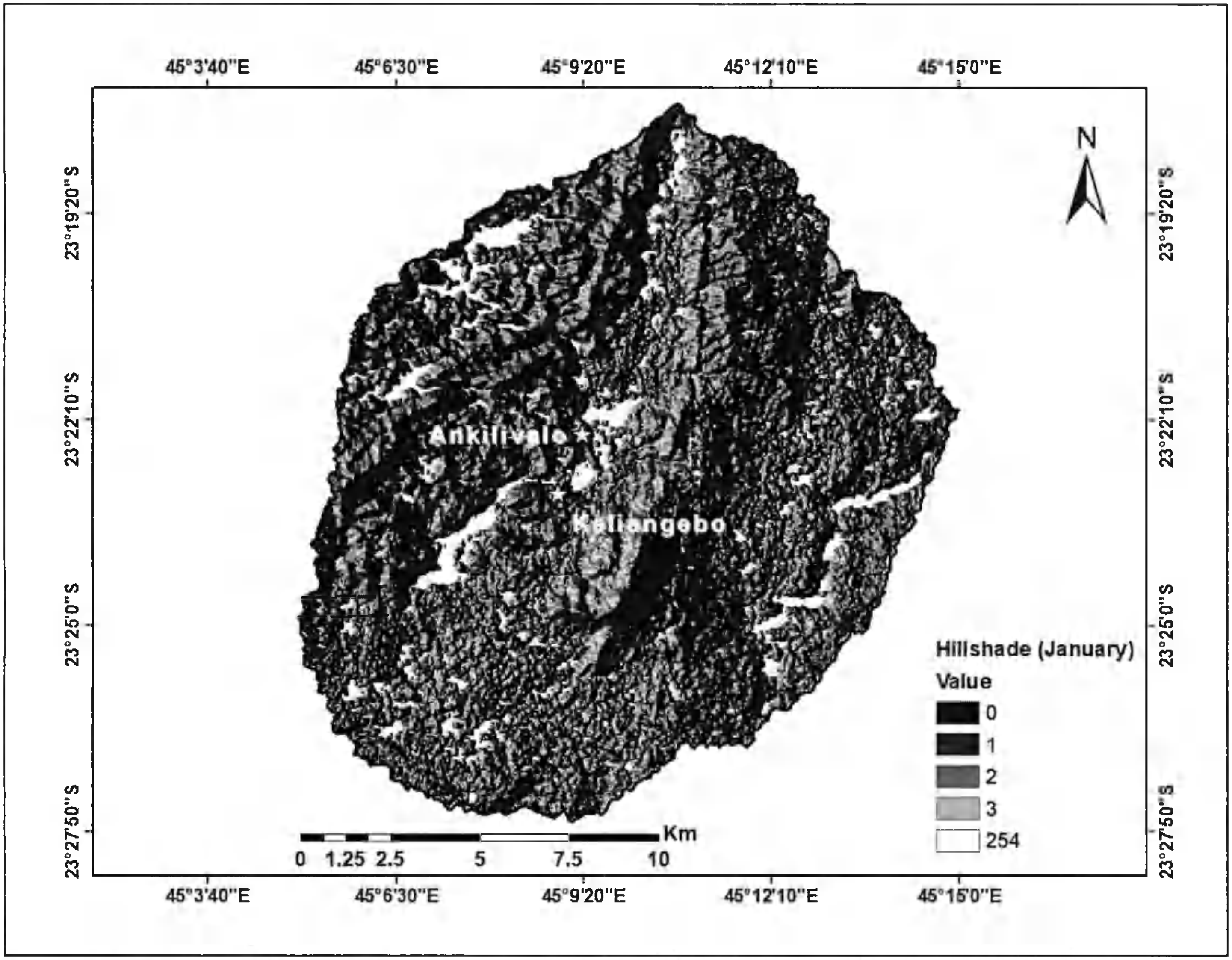

Figure 7.21: Midday Hillshade in January (Austral Summer) of the Study Area

To determine the solar insolation of archaeological sites, I extracted their hillshade values using the *Extract Values to Points* tool (*ArcToolbox > Spatial Analyst Tools > Extraction > Extract Values to Points*). The results showed that the hillshade value for Ankilivalo is 4 during the summer and 17 during the winter (Table 7.10). For Keliangebo, the hillshade value is 1 during the summer, and 179 during the winter (Table 7.7).

Table 7.7: Seasonal Hillshade for Ankilivalo and Keliangebo

Season	Hour	Altitude	Azimuth	Ankilivalo	Keliangebo
Summer (January)	12:00 pm	89	280	4	1
Winter (June)	12:00 pm	45	359	17	179

The results of the analysis thus show that Ankilivalo is shadier almost throughout the year (2.2 percent of insolation during the summer, and 9.4 percent of insolation during the winter). Based on my earlier assumption, Ankilivalo is suitable for summer settlement, but less desirable in winter, and its occupants may have moved away at that time. Keliangebo, on the other hand, is shady (0.5 percent insolated) during the summer, and highly exposed to sun (70.47 percent insolated) during the winter, making the site ideal for settlement throughout the year. The possible practice of seasonal transhumance is discussed further in Chapter 9.

Table 7.8: Proximity of Random Sites to Scrublands

Random Site #	Number of Near Patches	Minimum Distance (m)	Maximum Distance (m)	Mean Distance (m)	Total Shape Areas (Ha)
Random Site 1	3	0	4803.483725	3120.132842	2387.95
Random Site 2	3	2233.730438	4669.46309	3157.468898	159.04
Random Site 3	2	533.229282	4915.772813	2724.501047	2142.15
Random Site 4	3	629.193311	3559.626777	1616.266611	159.04
Random Site 5	6	2658.028439	4817.136308	3757.643285	3150.12
Random Site 6	1	4458.547097	-	-	184.21
Random Site 7	9	310.849954	4977.585193	2871.148666	3363.51

Random Site 8	7	874.586525	4921.65633	3115.061947	1157.84
Random Site 9	7	0	3488.500116	2025.822911	1179.6
Random Site 10	8	1489.546234	4851.21806	3024.558332	3285.64
Random Site 11	3	2655.472072	4485.238828	3320.697797	888.12
Random Site 12	8	1314.730481	4456.342458	2831.811989	2561.24
Random Site 13	6	2239.829117	4152.994982	3339.084203	481.33
Random Site 14	7	604.56751	4942.065654	2539.278161	1179.6
Random Site 15	6	235.396129	3630.927949	2084.048065	2369.68
Random Site 16	6	909.620746	4887.484854	3242.306677	1150.5
Random Site 17	6	2396.241361	4776.783455	3266.97605	2369.68
Random Site 18	7	1236.10591	4980.982503	2743.485699	2377.02
Random Site 19	6	399.221969	4095.361573	2873.162247	2473.9
Random Site 20	7	2435.29625	4595.05283	3181.446478	3213.93
Random Site 21	7	2061.764366	4498.565921	3075.856429	2377.02
Random Site 22	4	2989.555726	4836.665219	3815.361769	292.32
Random Site 23	1	0	-	-	2070.44
Random Site 24	3	2058.828222	4859.653636	3739.943518	3066.39
Random Site 25	4	3018.056357	3890.243422	3402.567298	2229.48
Random Site 26	7	2581.580122	4787.868393	3594.66713	1110.5
Random Site 27	7	1057.597287	3517.098311	2367.788022	3213.93
Random Site 28	5	1461.198376	3083.722277	2054.572934	995.38
Random Site 29	5	0	4862.574529	3292.48035	2466.56
Random Site 30	5	2288.729467	4656.825788	3742.410639	3142.78
Random Site 31	8	537.771095	4425.267022	2524.989665	2561.24
Random Site 32	7	121.549304	4216.124493	2042.58628	1179.6
Random Site 33	1	0	-	-	2070.4
Random Site 34	9	33.284883	4719.226842	2435.011367	1320.2
Random Site 35	7	1853.502093	4288.106444	3176.103853	1187.26
Random Site 36	7	796.915008	4692.928423	2933.589848	2551.7
Random Site 37	9	221.442772	4723.809389	2464.526227	3329.41
Random Site 38	8	1428.29924	3934.766604	2706.13154	3285.64
Random Site 39	5	1058.119252	3958.369555	2836.783345	2362.7
Random Site 40	4	1948.09094	4743.214476	3067.157497	292.32
Random Site 41	8	0	4363.316491	2377.986616	1186.94
Random Site 42	7	340.368397	4415.229072	2952.822862	1157.84
Random Site 43	5	805.334203	4860.159723	2636.824229	2362.7
Random Site 44	8	1432.44791	4658.385769	3462.250411	3285.64
Random Site 45	6	2717.154111	4287.526721	3724.392565	1187.26
Random Site 46	5	3662.236665	4845.395251	4296.337189	403.45
Random Site 47	6	802.729161	4960.09406	3861.249326	3207.02
Random Site 48	5	786.51258	4906.660753	3078.493127	995.38
Random Site 50	10	1166.21312	4888.070981	3203.32863	1327.13

Table 7.9: Proximity of Random Sites to Horombe Grassland

Random Site #	**Number of Nearest Patches**	**Minimum Distance (m)**	**Maximum Distance (m)**	**Mean Distance (m)**	**Total Shape Areas (Ha)**
Random Site 1	2	456.614487	930.994435	693.804461	7085.72
Random Site 2	1	0	-	-	6093.05
Random Site 3	2	1709.77372	3710.504005	2710.138862	7085.72
Random Site 4	1	529.160035	-	-	6093.05

Random Site 5	2	0	2946.312414	1473.156207	7085.72
Random Site 7	1	523.005126	-	-	6093.05
Random Site 8	1	379.099562	-	-	6093.05
Random Site 9	1	2449.741912	-	-	6093.05
Random Site 10	2	0	3895.518414	1947.759207	7085.72
Random Site 11	1	0	-	-	6093.05
Random Site 12	1	2376.752709	-	-	6093.05
Random Site 13	1	4200.578037	-	-	6093.05
Random Site 15	1	178.681571	-	-	6093.05
Random Site 16	1	137.006823	-	-	6093.05
Random Site 17	1	3177.327867	-	-	6093.05
Random Site 18	1	1805.634737	-	-	6093.05
Random Site 19	2	0	3083.689836	1541.844918	7085.72
Random Site 20	2	0	2995.953436	1497.976718	7085.72
Random Site 21	1	2785.071424	-	-	6093.05
Random Site 22	1	3900.710271	-	-	6093.05
Random Site 23	2	1678.550104	2241.684309	1960.117206	7085.72
Random Site 24	2	0	1349.516518	674.758259	7085.72
Random Site 25	1	0	-	-	6093.05
Random Site 27	2	0	4098.220696	2049.110348	7085.72
Random Site 28	1	3939.149295	-	-	6093.05
Random Site 29	2	595.051457	2022.412815	1308.732136	7085.72
Random Site 30	2	0	4069.92214	2034.96107	7085.72
Random Site 31	1	615.648085	-	-	6093.05
Random Site 32	1	4381.823923	-	-	6093.05
Random Site 33	2	1501.938363	3101.624802	2301.781583	7085.72
Random Site 34	1	3089.169416	-	-	6093.05
Random Site 35	1	3863.046473	-	-	6093.05
Random Site 36	2	0	3610.473344	1805.236672	7085.72
Random Site 37	1	591.916342	-	-	6093.05
Random Site 38	2	0	3930.597665	1965.298832	7085.72
Random Site 39	2	0	4519.508808	2259.754404	7085.72
Random Site 40	1	2791.204289	-	-	6093.05
Random Site 41	1	2131.513684	-	-	6093.05
Random Site 42	1	185.076698	-	-	6093.05
Random Site 43	1	0	-	-	6093.05
Random Site 44	2	0	2592.22453	1296.112265	7085.72
Random Site 45	1	4959.424865	-	-	6093.05
Random Site 47	2	0	1131.718856	565.859428	7085.72
Random Site 48	1	1885.787035	-	-	6093.05
Random Site 50	1	4036.630653	-	-	6093.05

Table 7.10: Proximity of Random Sites to Isalo Grassland

Random Site #	**Number of Nearest Patches**	**Minimum Distance (m)**	**Maximum Distance (m)**	**Mean Distance (m)**	**Total Shape Areas (Ha)**
Random Site 4	2	3276.086071	4804.94846	4040.517266	136.68
Random Site 5	1	4903.201327	-	-	71.7
Random Site 6	4	1753.259749	4277.053651	3097.19524	1597.6
Random Site 7	4	1775.959933	2832.904877	2497.539528	1305.59
Random Site 8	2	4689.266371	4962.981675	4826.124023	455.43

Random Site 9	3	2655.790907	4665.648594	3779.103627	1552.56
Random Site 10	4	2975.937988	4136.814266	3580.034209	1305.59
Random Site 12	4	359.566127	3402.404267	1247.105237	1305.59
Random Site 13	5	0	4499.003403	1908.618023	1689.25
Random Site 14	3	730.58662	4986.064903	2986.497149	1552.56
Random Site 15	3	1676.171883	3235.318627	2612.649741	1233.81
Random Site 17	4	589.100976	4810.689434	2031.664845	1305.59
Random Site 18	4	71.333407	4848.550121	2121.365695	1305.59
Random Site 19	4	3836.954159	4623.266815	4298.351155	1305.59
Random Site 20	2	3610.478499	4674.026264	4142.252381	1168.9
Random Site 21	4	0	4228.378181	1516.37475	1305.59
Random Site 22	3	2097.374212	2970.003326	2546.188404	1233.81
Random Site 26	3	13.461401	3070.825122	1065.402457	1552.56
Random Site 27	3	2232.718132	4920.624758	3487.211564	1552.56
Random Site 28	1	3544.798042	-	-	383.66
Random Site 29	1	4897.283112	-	-	1097.12
Random Site 31	4	1791.420605	3921.829439	2478.196913	1305.59
Random Site 32	2	1484.101011	3649.954431	2567.027721	1480.78
Random Site 34	3	1142.327465	2504.923373	1794.404797	1552.56
Random Site 35	5	0	4143.328564	2115.509984	1689.25
Random Site 36	4	3367.329936	4088.349343	3804.754904	1305.59
Random Site 37	5	438.975427	4225.740086	2750.443832	1689.25
Random Site 38	4	2388.828414	4611.090087	3557.763432	1305.59
Random Site 39	1	3996.116378	-	-	91.64
Random Site 40	3	1641.259499	3421.106306	2622.724118	1233.81
Random Site 41	3	2805.472667	3424.216323	3186.863794	1552.56
Random Site 42	3	4266.139382	4871.602273	4607.107973	1552.56
Random Site 43	2	3075.66508	4684.592944	3880.129012	136.68
Random Site 44	2	3685.698074	4226.143546	3955.92081	1168.9
Random Site 45	5	163.484405	4714.951735	2513.309751	1689.25
Random Site 46	5	1264.515733	4000.562931	2706.673537	1689.25
Random Site 47	1	4940.588754	-	-	71.7
Random Site 49	4	3083.233368	4537.716943	3871.146938	1617.47
Random Site 50	3	156.473775	2288.713784	972.911965	1552.56

7.1.4. Proximity to Forest Resources

This section presents the results of proximity analysis in reference to forests.

The proximity analysis and the statistical significance test demonstrated that the relationship between the locations of archaeological sites and their proximity to forests is weak (Table 7.11). Proximity to deciduous and *Tapia* forests was not therefore influential to the placement of Ankilivalo and Keliangebo. The statistical significance test on forest size available to archaeological sites and random sites confirmed this (Table 7.12).

Table 7.11: Recapitulation of Proximity of Archaeological Sites and Random Sites to Forests

	Distance from AK (m)	**Distance from KG (m)**	**# RS Closer Than AK**	**# RS Closer Than KG**
Deciduous Forest	0	42.83	17 (p-value = 0.34)	17 (p-value = 0.34)
Tapia Forest	2288.57	2851.63m	19 (p-value = 0.38)	19 (p-value = 0.38)

Table 7.12: Recapitulation of Areas of Forests Available to Archaeological Sites and Random Sites within 5 km Search Radius

	Areas for AK (Ha)	**Areas for KG (Ha)**	**# RS Having Access**	**Range of Areas (Ha)**	**# RS Having Access ≥ AK**	**# RS Having Access ≥ KG**
Deciduous Forest	5053.27	4994.4	50	1128 – 6168	15 (p-value = 0.3)	17 (p-value = 0.34)
Tapia Forest	3381.82	3381.82	30	73 – 3455	45 (p-value = 0.9)	17 (p-value = 0.34)

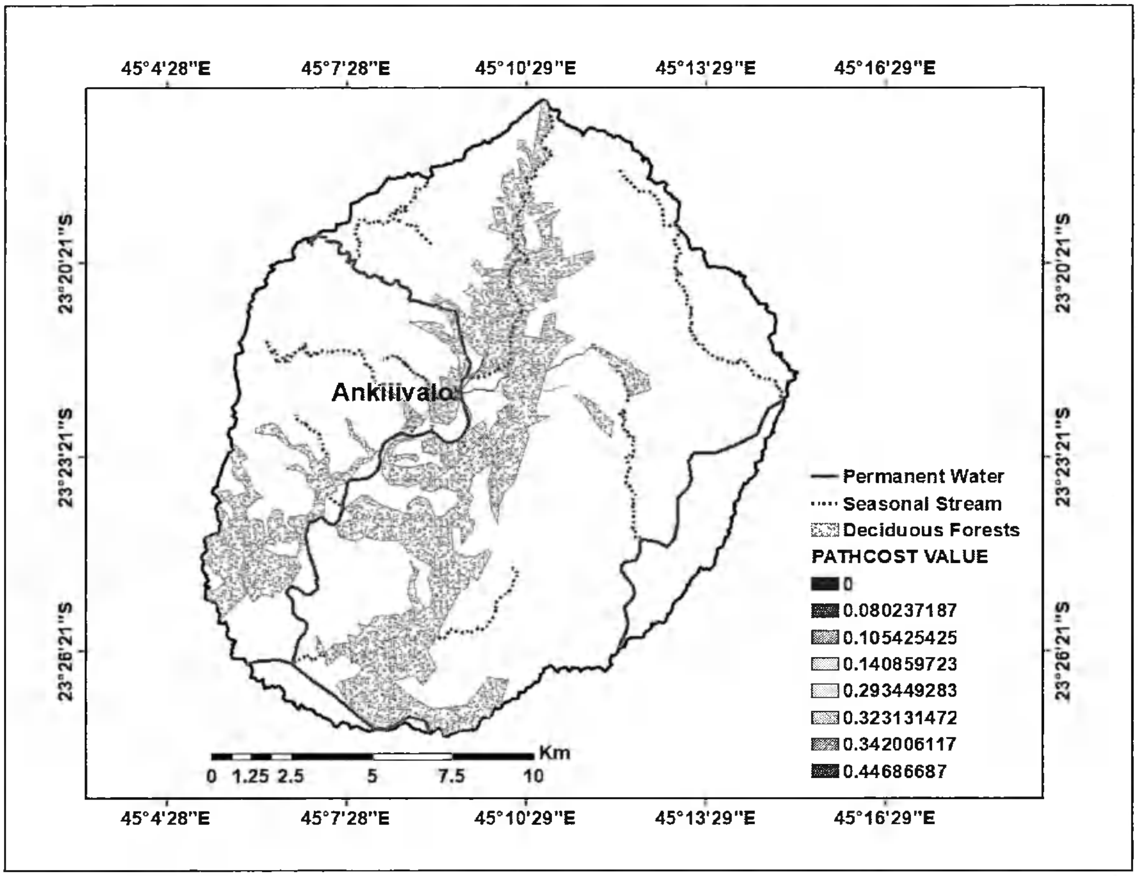

Figure 7.14: Cost Paths from Ankilivalo to Deciduous Forest

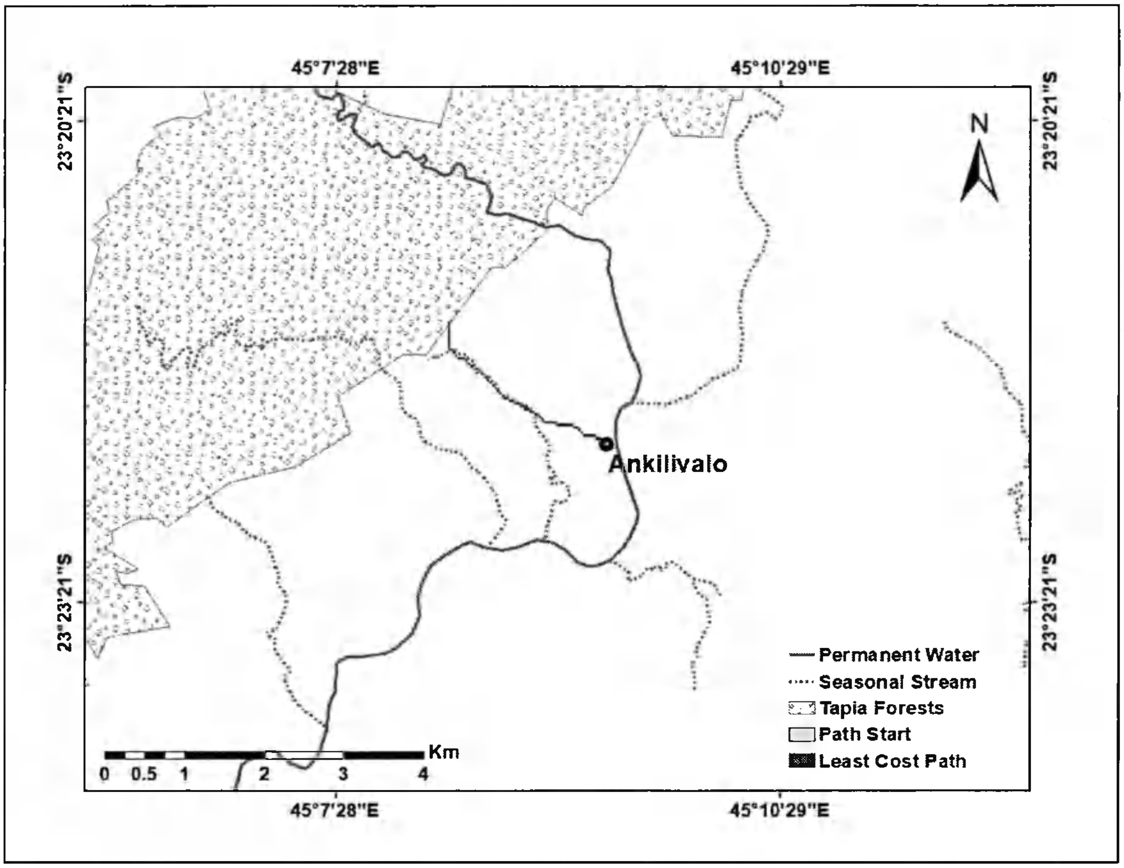

Figure 7.15: A Least Cost Path from Ankilivalo to the Nearest Tapia Forest Patch

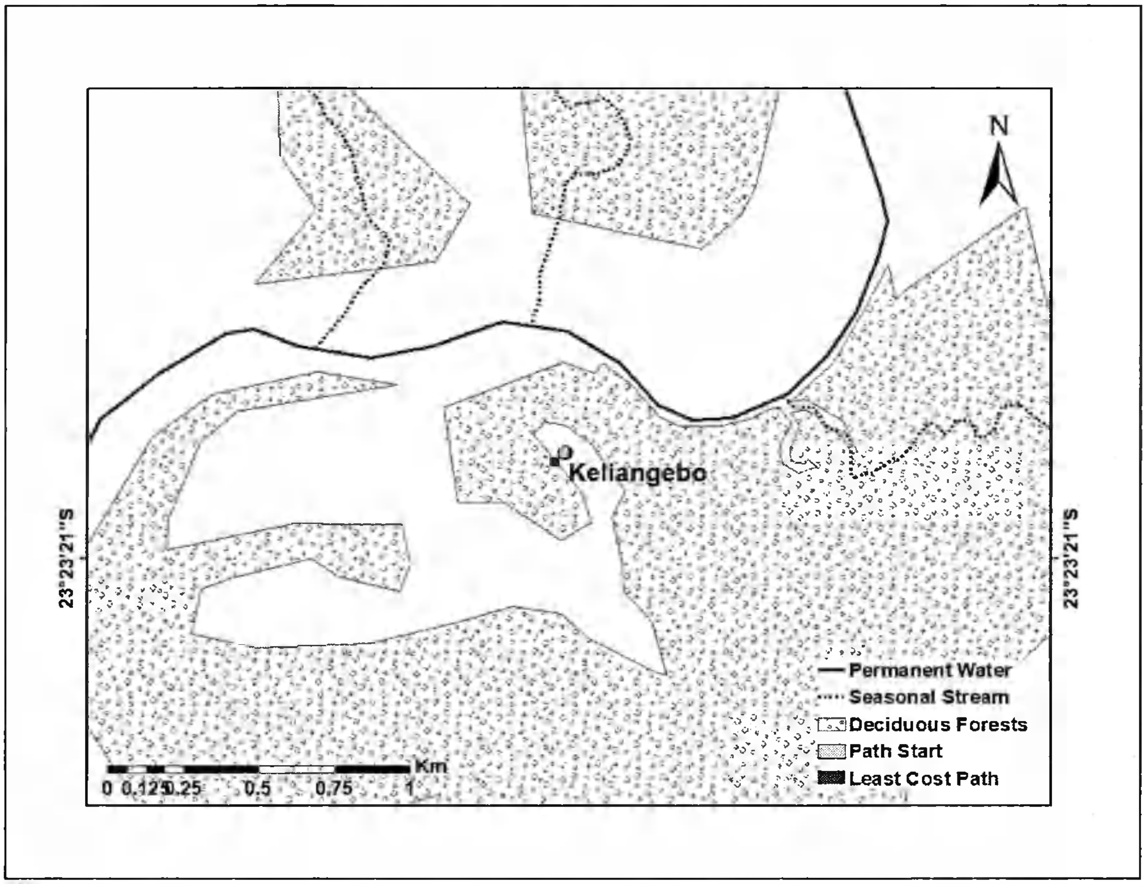

Figure 7.16: Least Cost Path from Keliangebo to Deciduous Forests

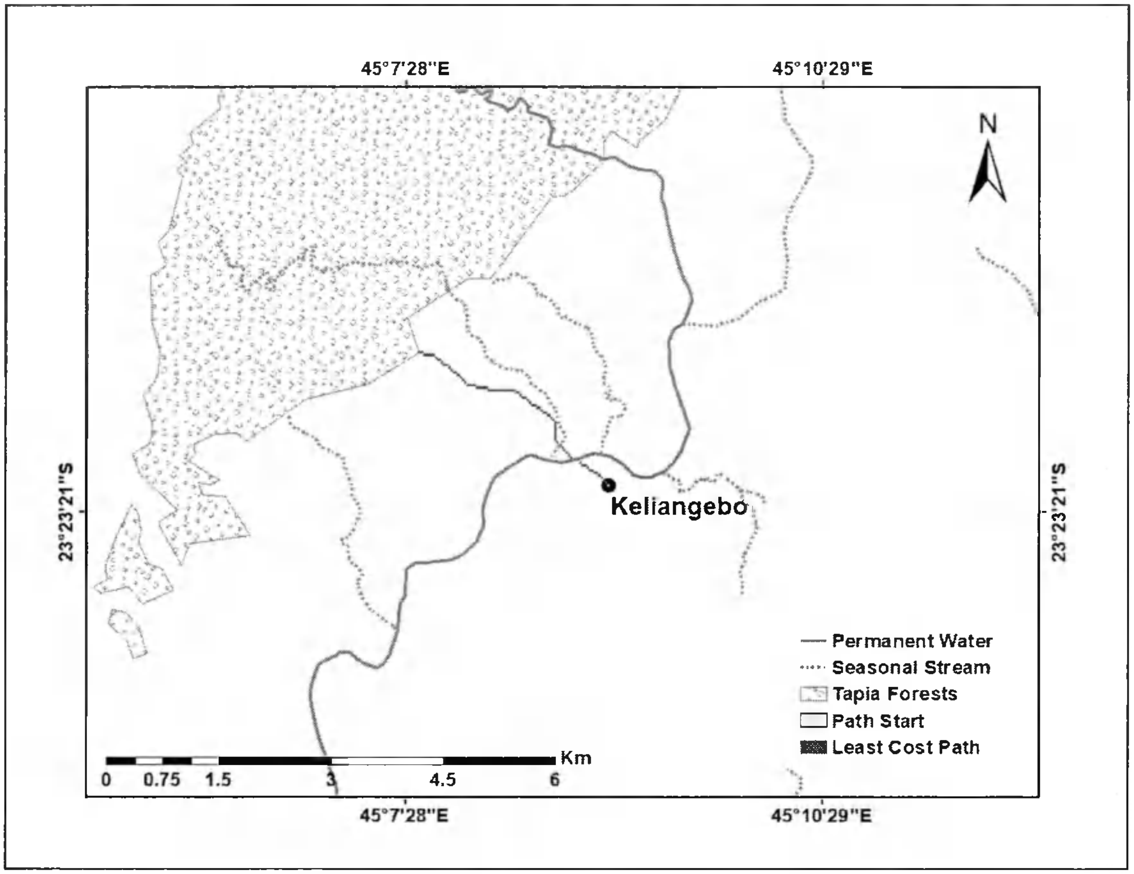

Figure 7.17: Least Cost Path from Keliangebo to the Tapia Forests

Table 7.13: Proximity of Random Sites to Deciduous Forests

Random Site #	Number of Near Patches	Minimum Distance (m)	Maximum Distance (m)	Mean Distance (m)	Total Shape Areas (Ha)
Random Site 1	4	2289.767804	3519.392994	3153.352955	4227.95
Random Site 2	5	1618.397602	2754.049184	2195.572125	4865.34
Random Site 3	3	0	3871.595249	2417.967027	4183.89
Random Site 4	6	0	4659.803565	1674.062316	5055.35
Random Site 5	1	1631.142799	-	-	3100.02
Random Site 6	6	1995.423854	4951.341172	3784.80123	4920.82
Random Site 7	8	0	4148.903956	2312.055396	6017.63
Random Site 8	5	0	3953.06697	2517.103851	4283.96
Random Site 9	5	200.303494	1983.467587	1121.986065	4283.96
Random Site 10	8	609.199955	4876.803832	2838.213444	6017.63
Random Site 11	4	87.980811	4990.203091	2907.566073	3339.81
Random Site 12	10	0	4988.359768	2788.519764	6168.6
Random Site 13	6	295.274985	4363.187498	2220.553883	4926.97
Random Site 14	5	0	3677.546364	2216.563223	4283.96
Random Site 15	8	0	3063.288398	1960.375983	5181.65
Random Site 16	5	0	3996.682647	2288.815647	4283.96
Random Site 17	8	656.448818	4991.711929	2857.671514	5122.9
Random Site 18	9	0	4157.231977	2437.725462	5224.45
Random Site 19	7	466.104154	4595.513945	2499.834278	5073.49

Random Site 20	4	837.710173	4792.289035	3612.34784	3376.89
Random Site 21	9	209.793472	4667.306805	2764.301279	5166.97
Random Site 22	6	2097.374212	4825.65598	3104.380565	4096.52
Random Site 23	4	43.198505	4553.907855	2694.105476	4227.95
Random Site 24	1	2683.394342	-	-	3100.02
Random Site 25	6	249.784327	4101.719008	2785.895399	4947.58
Random Site 26	6	0	4204.122801	2714.299242	4337.61
Random Site 27	8	316.498449	4728.095909	3527.309793	4994.4
Random Site 28	5	529.36426	3320.343711	1778.778982	4283.96
Random Site 29	6	368.412625	4772.062366	2480.101114	5030.68
Random Site 30	3	522.053454	4736.335932	3077.037529	3308.69
Random Site 31	9	0	4359.83882	2313.587777	5224.45
Random Site 32	5	0	2329.495981	1491.252999	4283.96
Random Site 33	3	48.301863	4683.496398	2698.847289	1127.93
Random Site 34	7	0	4185.930076	2030.890489	4516.7
Random Site 35	7	202.036908	4709.138118	2315.909739	4950.34
Random Site 36	7	385.989042	4236.248919	2174.507967	5073.49
Random Site 37	8	0	4695.8041	2532.304382	4994.4
Random Site 38	8	152.838603	4904.381301	3059.122478	6017.63
Random Site 39	8	553.429857	4856.392294	2755.553853	5181.65
Random Site 40	5	1095.342576	2764.135783	1952.255816	4053.72
Random Site 41	7	877.037724	4911.72588	2667.944883	4516.7
Random Site 42	5	0	4161.119186	2849.555446	4283.96
Random Site 43	8	805.334203	4914.013859	2407.592231	5181.65
Random Site 44	7	1483.564337	4563.098627	3477.620742	5073.49
Random Site 45	6	999.213826	4276.295146	2689.59316	4920.82
Random Site 46	5	1610.642208	3700.107217	2503.525797	4889.7
Random Site 47	3	2701.556656	4647.487905	3567.504159	3226.32
Random Site 48	5	0	4024.565439	2118.29684	4283.96
Random Site 49	4	3433.356869	4219.071923	3843.707812	1789.67
Random Site 50	6	0	3727.810544	1899.52494	4337.61

Table 7.14: Proximity of Random Sites to Tapia Forests

Random Site #	Number of Near Patches	Minimum Distance (m)	Maximum Distance (m)	Mean Distance (m)	Total Shape Areas (Ha)
Random Site 2	1	2258.160237	-	-	3381.82
Random Site 4	1	177.420448	-	-	3381.82
Random Site 6	3	0	4446.868508	2546.029228	3455.09
Random Site 7	1	3719.508652	-	-	3381.82
Random Site 9	3	3994.036284	4563.49007	4318.020308	3455.09
Random Site 12	1	1143.458171	-	-	3381.82
Random Site 13	1	3381.82	-	-	3381.82
Random Site 14	3	778.662889	1897.839245	1363.757558	3455.09
Random Site 15	1	1433.385596	-	-	3381.82
Random Site 17	1	0	-	-	3381.82
Random Site 18	1	490.455062	-	-	3381.82
Random Site 21	1	137.477399	-	-	3381.82
Random Site 22	1	189.511899	-	-	3381.82
Random Site 25	1	4114.154411	-	-	3381.82
Random Site 26	3	492.463467	2364.00548	1479.493196	3455.09
Random Site 28	2	4076.416358	4727.819902	4402.11813	73.27

Random Site 31	1	2578.385323	-	-	3381.82
Random Site 32	3	2228.75329	3144.398912	2731.504041	3455.09
Random Site 34	3	2678.212992	3107.581433	2941.458142	3455.09
Random Site 35	3	607.012269	4349.340767	2874.996392	3455.09
Random Site 36	1	4549.207436	-	-	3381.82
Random Site 37	1	3669.135645	-	-	3381.82
Random Site 39	1	3781.83268	-	-	3381.82
Random Site 40	1	0	-	-	3381.82
Random Site 41	3	4370.510327	4603.749852	4485.679778	3455.09
Random Site 43	1	2050.864055	-	-	3381.82
Random Site 45	3	0	3868.031733	2265.06586	3455.09
Random Site 46	1	0	-	-	3381.82
Random Site 49	1	0	-	-	3381.82
Random Site 50	3	1159.27319	2496.737955	1884.439324	3455.09

7.2. SITE DEFENSIBILITY ANALYSES

This section analyzes the possible influence of site defense, in the context of intergroup conflict on a community's choice of location. Chapter 4 discussed how intergroup conflicts may have driven communities to relocate to more defensible locations during the 16th -19th centuries CE. This chapter, focused on site defensibility (see Bocinsky 2014; Jones 2006; 2010; Martindale and Supernant 2009), is based on the assumption that, if intergroup conflicts influenced decisions about settlement location, then sites will be positioned in a defensible location.

7.2.1. Site Elevation

The assumption underlying this analysis is that a habitation site located at a higher location is more defensible than one located at a lower place (Bocinsky 2014; Jones 2010; Martindale and Supernant 2009). See Chapter 5 for methods used.

7.2.1.1. Elevation of Ankilivalo

The site of Ankilivalo is situated at 286m above sea level. The elevation advantage analysis, however, showed that the elevation values of its surroundings, within a 100m-500m radius, range from 257 to 374, with a mean elevation of **291.28** (Figure 7.28). After subtracting this mean elevation from the height of Ankilivalo, the result shows that there is a **-5.28** (286 – 291.28) difference in elevation value between the archaeological site's height and the mean elevation of the buffered area (Table 7.15). This suggests that the immediate surrounding landscape is slightly higher than the archaeological site. The elevation index for Ankilivalo is thus 0 (i.e. lower than its immediate surroundings).

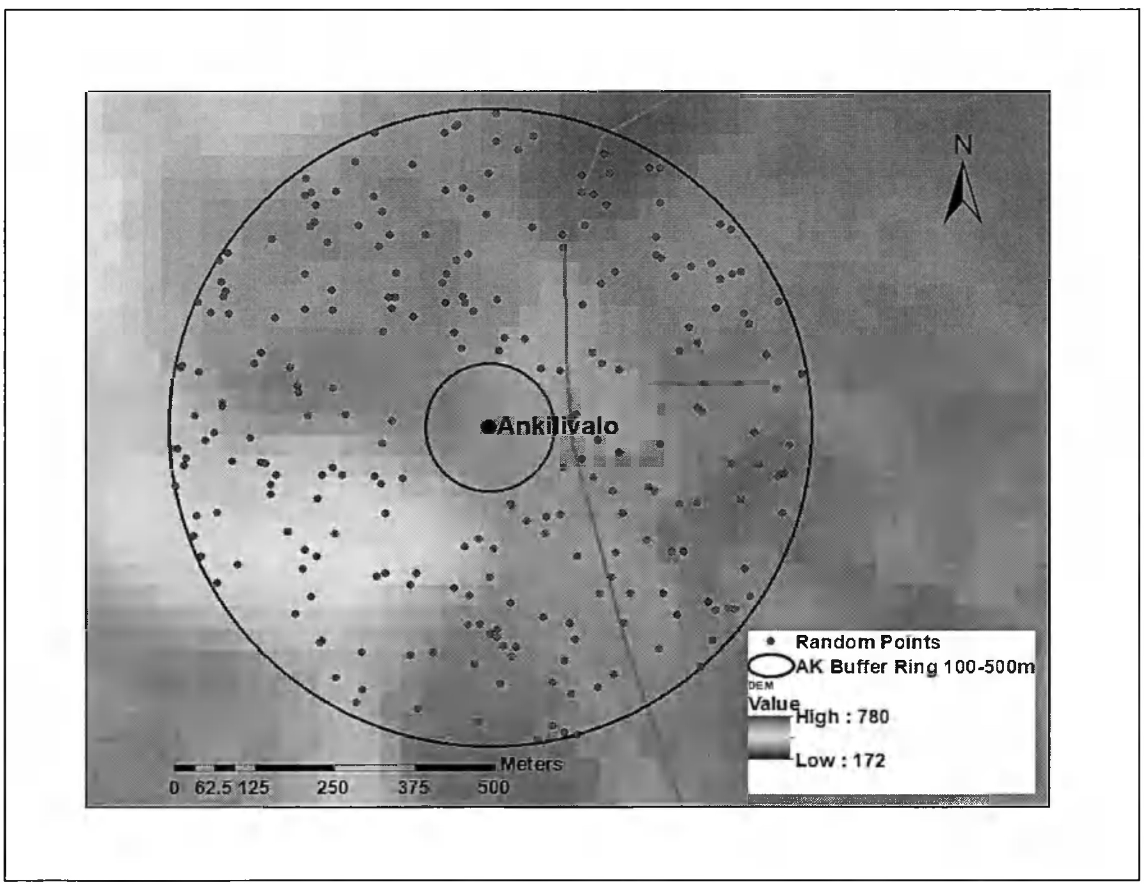

Figure 7.28: 100-500m Buffer and 250 Random Points around Ankilivalo

7.2.1.2. Elevation of Keliangebo

The site of Keliangebo is situated at 378m above sea level. The site elevation analysis, however, showed that the elevation values of its surroundings, within a 100m-500m radius, range from 243m to 396m, with a mean elevation of **283.87m**. (Figure 7.29). After subtracting this mean elevation from the height of Keliangebo, the result shows that there is a **94.13m** (378m – 283.87m) difference between the archaeological site's height and the mean elevation of the immediate surrounding landscape. This high positive value indicates that the site of Keliangebo is located higher than its immediate surrounding areas (De Reu *et al.* 2011: 3438). The elevation index for Keliangebo is, thus, 1 (i.e. higher than its immediate surroundings).

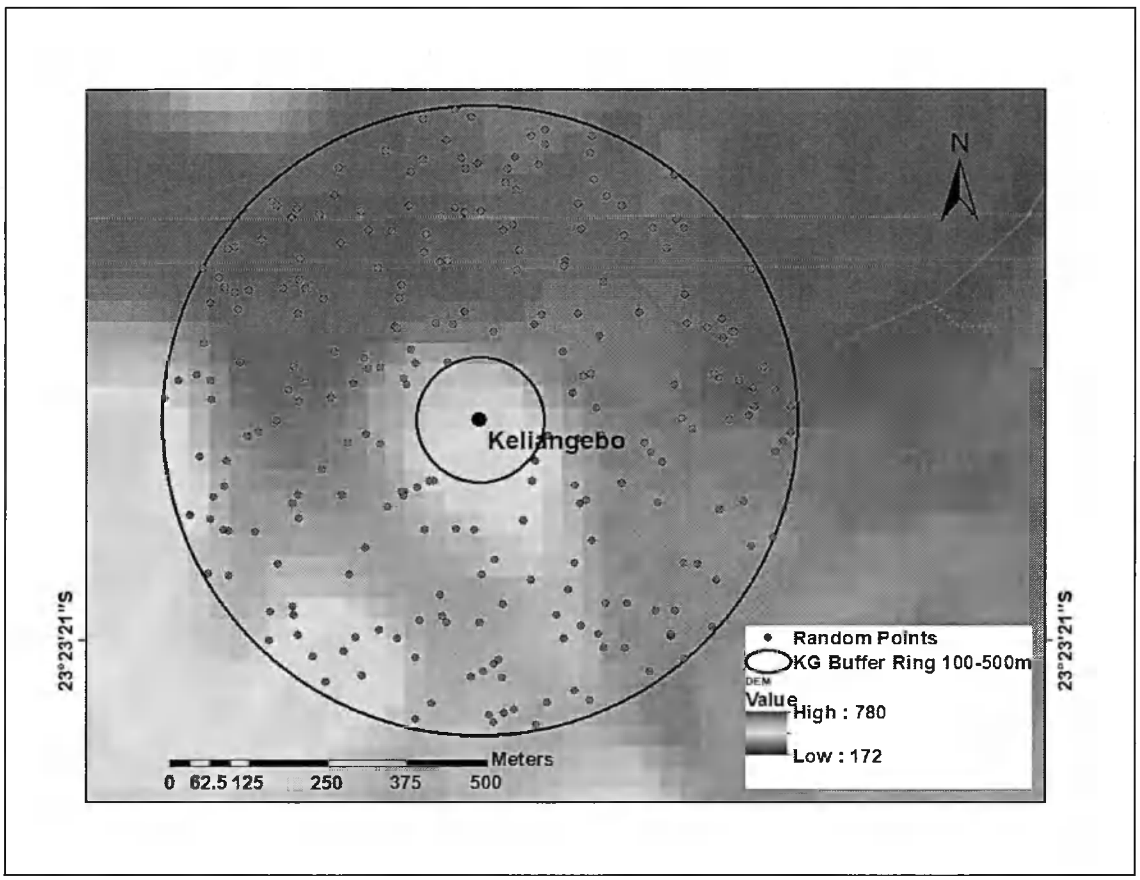

Figure 7.29: 100-500m Buffer and Random Points around Keliangebo

Table 7.15: Elevation Advantage/Disadvantage of Archaeological Sites

Sites	Site Elevation (m)	Mean Elevation (m)	Elevation Advantage/Disadvantage (m)	Binary Index
Ankilivalo	286	291.28	-5.28 (286 – 291.28)	0
Keliangebo	378	283.87	94.13 (378 – 283.87)	1

7.2.1.3. Elevation of Random Sites

The results of the site elevation analysis showed that 22 out of 50 random sites are located higher than their immediate surroundings (Figure 7.30). Their elevation indexes are therefore 1, while the remaining 28 random sites have elevation indexes of 0 (Table 7.17).

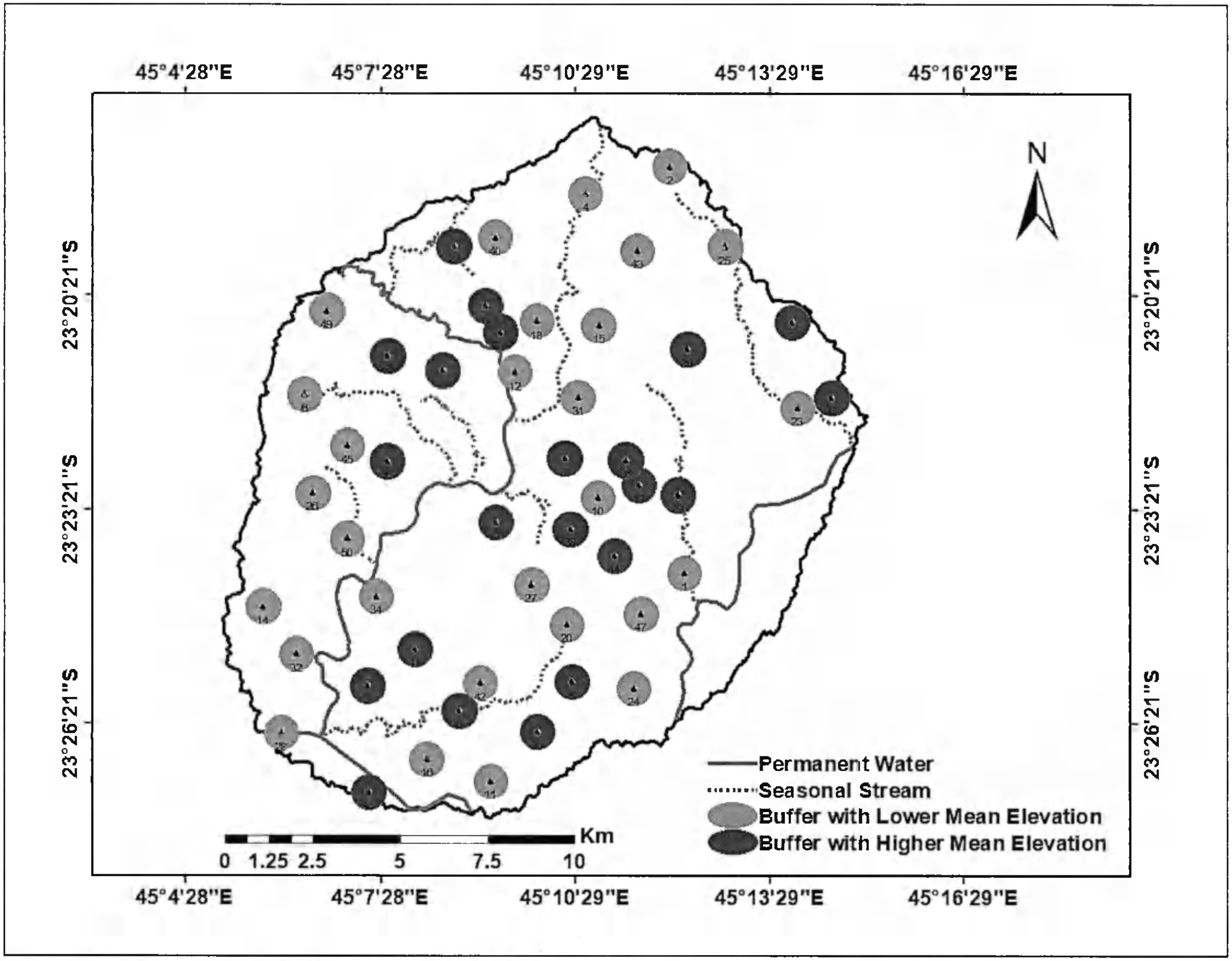

Figure 7.30: Random Sites Buffer and their Mean Elevation

Table 7.17: Elevation Analysis of Random Sites

Random Sites #	Random Site Elevations	Mean Elevation	Elevation Advantage/Disadvantage	Binary Index
Random Site 1	297	302.31	-5.31	0
Random Site 2	462	484.6	-22.6	0
Random Site 3	335	333.06	1.94	1
Random Site 4	322	356.06	-34.06	0
Random Site 5	327	324.78	2.2	1
Random Site 6	393	400.8	-7.8	0
Random Site 7	335	325.15	9.85	1
Random Site 8	249	242.39	6.61	1
Random Site 9	242	235.4	6.6	1
Random Site 10	418	432	-14	0
Random Site 11	285	285.7	-0.7	0
Random Site 12	293	308	-15	0
Random Site 13	503	458.67	44.33	1
Random Site 14	247	254.48	-7.48	0
Random Site 15	310	343.6	-33.6	0
Random Site 16	242	264.92	-22.92	0
Random Site 17	456	431.68	24.32	1
Random Site 18	313	358.02	-45.02	0
Random Site 19	374	371.15	2.85	1
Random Site 20	381	409.4	-28.4	0
Random Site 21	510	447.31	62.69	1
Random Site 22	409	383.59	25.41	1
Random Site 23	306	318.32	-12.32	0
Random Site 24	308	316.26	-8.26	0
Random Site 25	428	435.5	-7.5	0
Random Site 26	367	380.03	-13.03	0
Random Site 27	551	608.28	-57.28	0
Random Site 28	182	198.06	-16.06	0
Random Site 29	330	319.9	10.1	1
Random Site 30	300	293.01	6.99	1
Random Site 31	296	308.59	-12.59	0
Random Site 32	229	236.47	-7.47	0
Random Site 33	318	315.59	241	1
Random Site 34	248	255.36	-7.36	0
Random Site 35	371	354.6	16.4	1
Random Site 36	440	424.57	15.43	1
Random Site 37	303	300.7	2.3	1
Random Site 38	553	532.96	20.04	1
Random Site 39	455	435.24	19.76	1
Random Site 40	472	487.32	-15.32	0
Random Site 41	280	276.06	3.94	1
Random Site 42	233	257.86	-24.86	0
Random Site 43	473	478.48	-5.48	0
Random Site 44	371	367.13	3.87	1
Random Site 45	387	399.9	-12.9	0
Random Site 46	422	416.3	5.7	1
Random Site 47	300	307.65	-7.65	0
Random Site 48	244	236.4	7.6	1
Random Site 49	342	402.79	-60.79	0
Random Site 50	253	303.2	-50.2	0

7.2.2. *Accessibility Analysis Results*

This section presents the results of the site accessibility analysis based on the number of least cost paths accessing the site, and the degree of slope at its access points.

7.2.2.1. *Number of Least-Cost Paths Accessing Archaeological Sites*

The results showed that there are 3 LCPs accessing the site of Ankilivalo (Figure 7.24), and 5 LCPs accessing the site of Keliangebo (Figure 7.25).

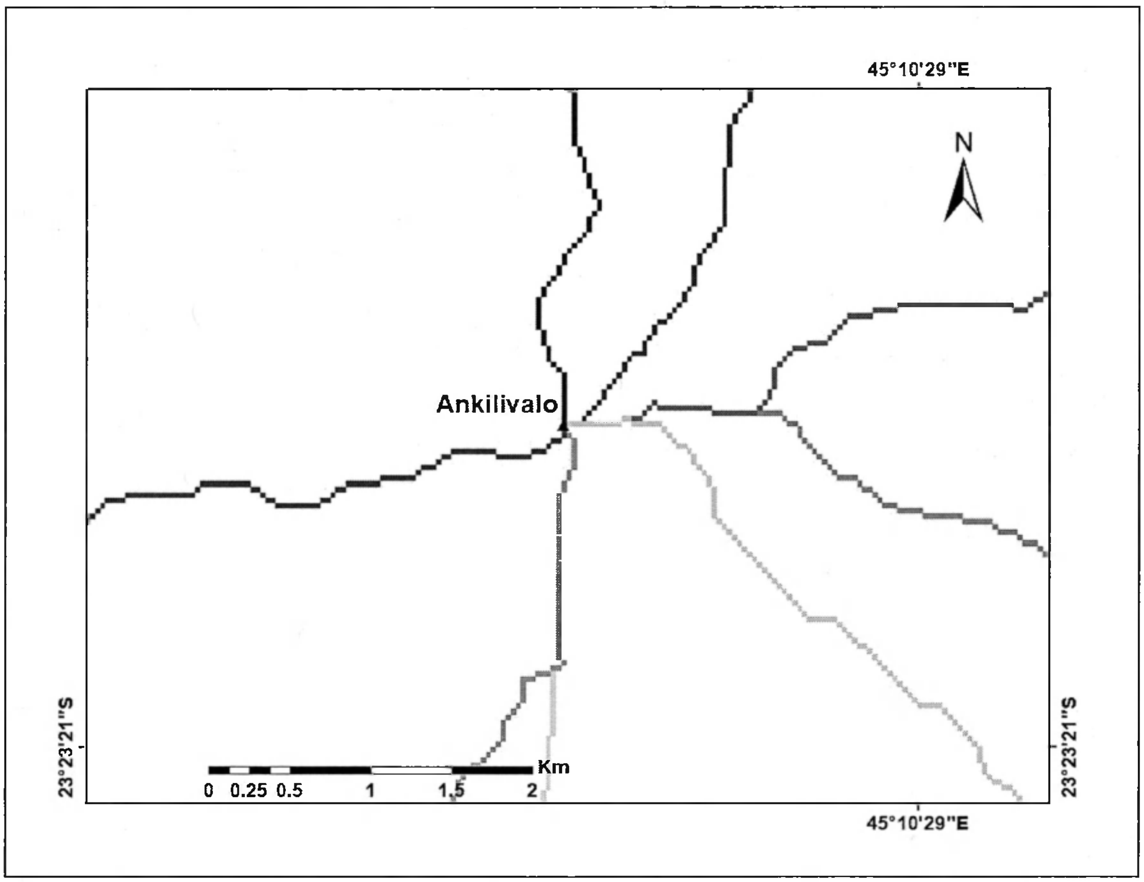

Figure 7.24: Least Cost Paths Accessing Ankilivalo

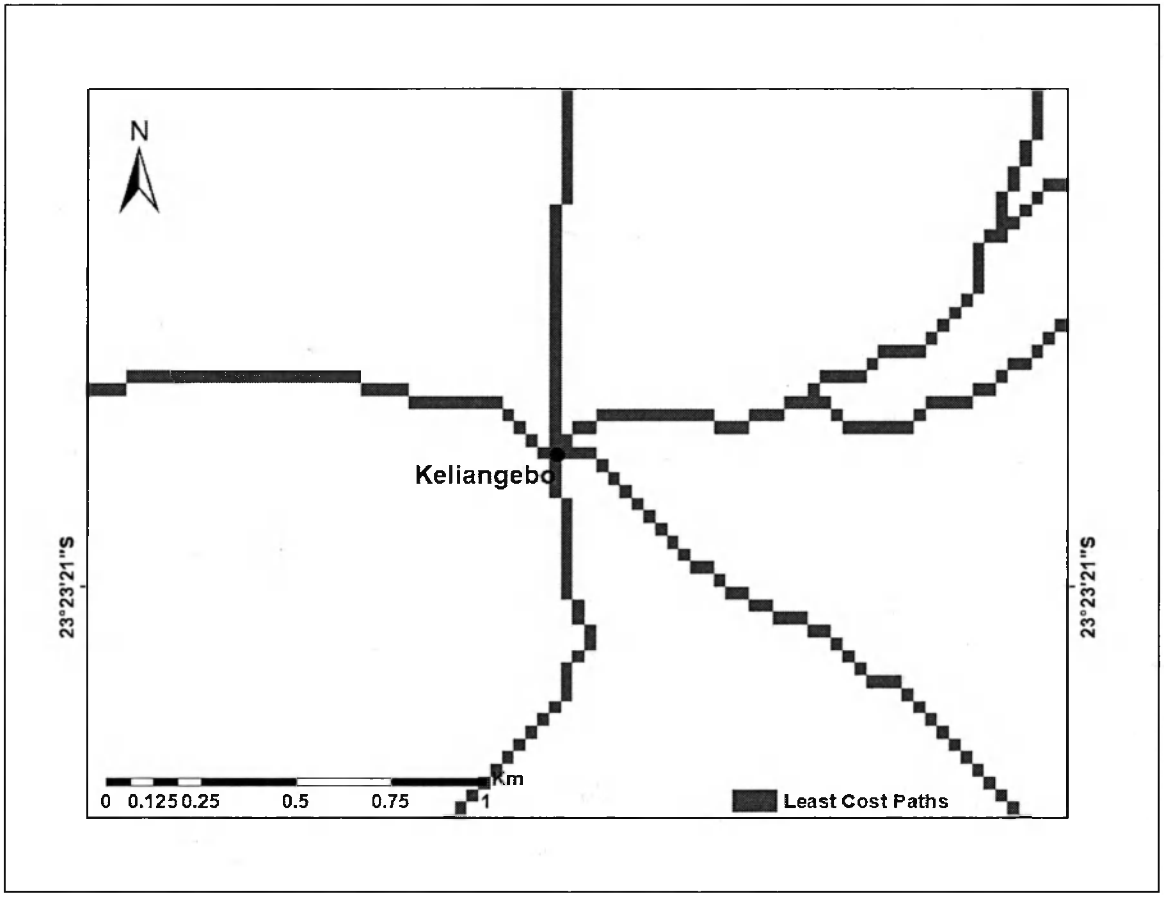

Figure 7.25: Number of LCPs Accessing Keliangebo

7.2.2.2. Number of Least Cost Paths Accessing Random Sites

The results of the LCP analysis also showed that the number of LCPs accessing random sites range from 2 to 5 (Table 7.12). There are 5 random sites that are accessed by 2 LCPs, 16 random sites accessed by 3 LCPs, 17 random sites accessed by 4 LCPS, and 12 random sites accessed by 5 LCPS (Table 7.12).

Table 7.12: Number of LCPs Accessing Random Sites

Random Site #	Number of LCPs
Random Site 1	4
Random Site 2	3
Random Site 3	3
Random Site 4	4
Random Site 5	4
Random Site 6	2
Random Site 7	5
Random Site 8	3
Random Site 9	2
Random Site10	5
Random Site 11	2
Random Site 12	5
Random Site 13	5
Random Site 14	4
Random Site 15	5
Random Site 16	4
Random Site 17	3
Random Site 18	3
Random Site 19	5
Random Site 20	3
Random Site 21	4
Random Site 22	5
Random Site 23	2
Random Site 24	3
Random Site 25	3
Random Site 26	4
Random Site 27	4
Random Site 28	4
Random Site 29	5
Random Site 30	3
Random Site 31	3
Random Site 32	4
Random Site 33	2
Random Site 34	5
Random Site 35	4
Random Site 36	4
Random Site 37	3
Random Site 38	3
Random Site 39	5
Random Site 40	3
Random Site 41	4
Random Site 42	4
Random Site 43	4
Random Site 44	5
Random Site 45	3
Random Site 46	4
Random Site 47	5
Random Site 48	3
Random Site 49	4
Random Site 50	3

7.2.3. Degree of Slopes at the Site's Access Points

The above number of LCPs analysis is susceptible to error and can produce a mistake since the ArcGIS may sometimes make least cost paths access steep slopes that would have been taken as inaccessible. To straighten out this, I assessed the degree of slope at the site's access point. See Chapter 5 for methods used.

7.2.3.1. Degree of Slope at Ankilivalo Access Points

All three access points to Ankilivalo have slope value less than 57.79630221, suggesting that the site can be easily accessible (Figure 7.26; Table 7.13). The accessibility index for Ankilivalo is thus 0.

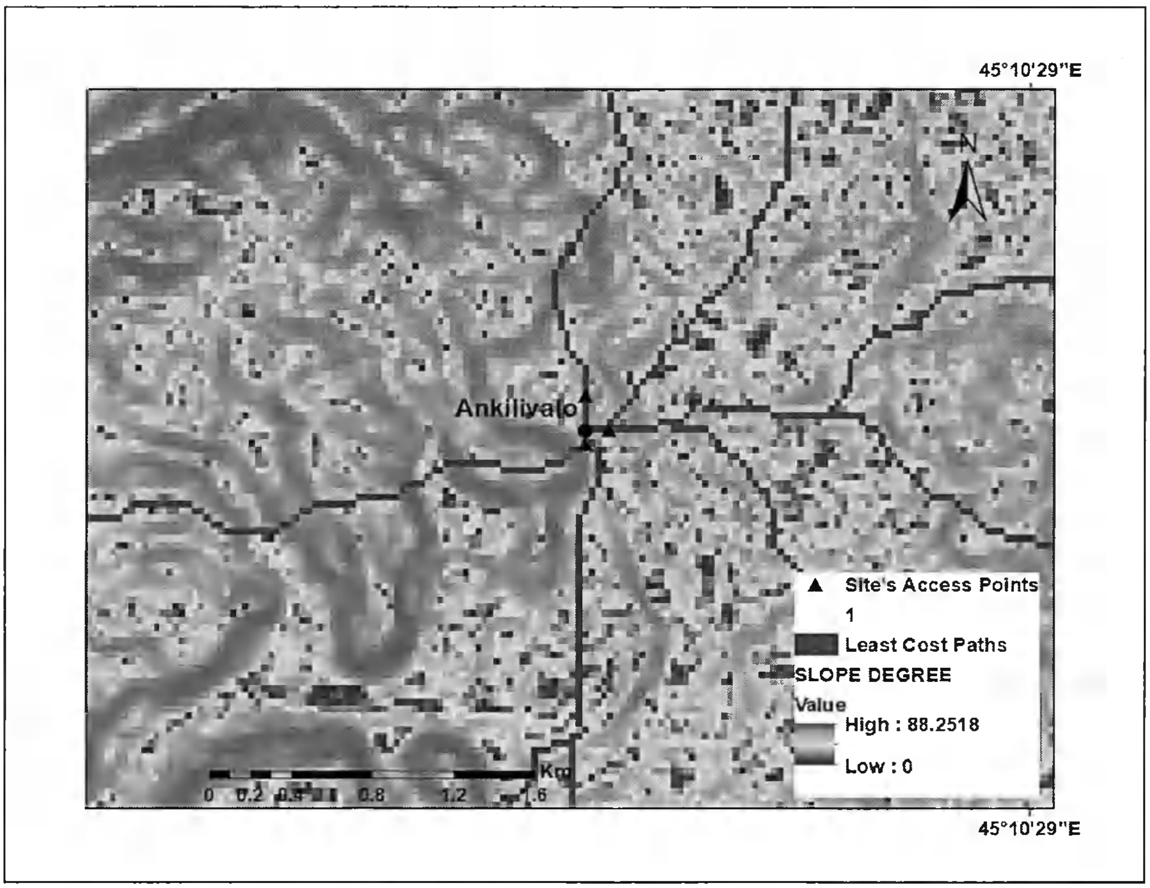

Figure 7.26: Degree of Slopes around Ankilivalo

Table 7.13: Slope Value at the Access Points of Ankilivalo

Access Points	Longitude (X)	Latitude (Y)	Slope Value
1	45.155005	-23.373215	21.654264
2	45.156054	-23.372666	46.855736
3	45.154993	-23.371257	52.730045

7.2.3.2. Degree of Slope at KG Access Points

All five access points to Keliangebo have slope value greater than 57.79630221, suggesting that the access to the site is very restricted (Figure 7.27; Table 7.14). The accessibility index for Keliangebo is thus 1 (i.e. inaccessible).

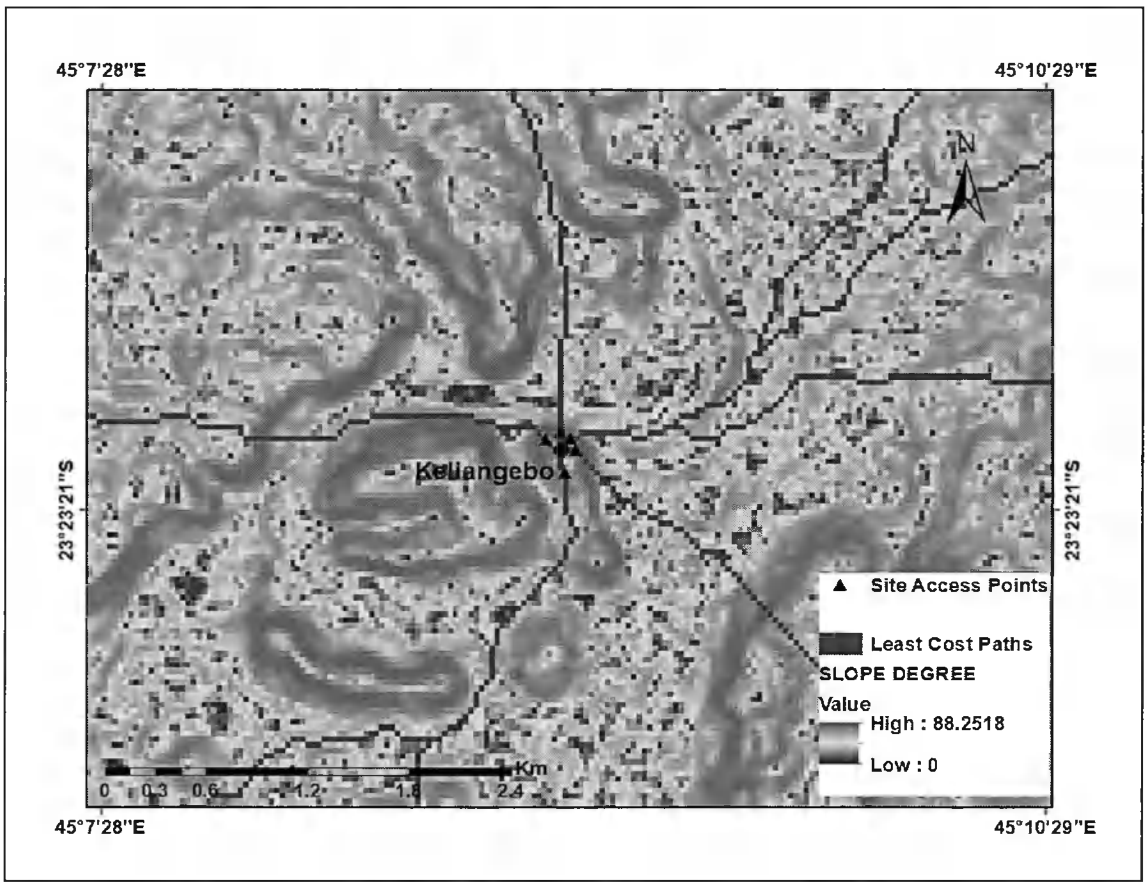

Figure 7.27: Degree of Slopes around Keliangebo

Table 7.14: Slope Degree Value at the Access Points to Keliangebo

Access Points	Longitude	Latitude	Slope Value
1	45.149704	-23.386272	85.623535
2	45.14943	-23.385701	83.704735
3	45.1489	-23.385387	82.488487
4	45.148118	-23.385748	76.968079
5	45.149174	-23.38734	85.735741

7.2.3.3. Degree of Slopes at Random Site's Accessing Points

Since the random sites are represented by points, one cannot have actual access points at their boundaries. I therefore arbitrarily set their access points to 100 m away from the random site locations and along the least cost paths accessing it. The results are in the following table (Table 7.15):

Random Site #	Number of LCPs	Point 1	Point 2	Point 3	Point 4	Point 5
Random Site 1	4	10.600774	23.309862	20.521769	7.538791	-
Random Site 2	3	36.206963	46.987053	30.238039	-	-
Random Site 3	3	30.744192	12.045897	35.476704	-	-
Random Site 4	4	73.051628	57.399811	27.895191	47.500156	-
Random Site 5	4	21.654264	41.3428	57.059166	54.947372	-
Random Site 6	2	39.500443	77.125786	-	-	-
Random Site 7	5	50.629307	41.66087	57.230831	20.521769	65.272057
Random Site 8	3	46.317673	10.600774	62.177182	-	-
Random Site 9	2	33.49287	7.538791	-	-	-
Random Site10	5	47.203178	70.025581	7.538791	66.057686	64.456993
Random Site 11	2	37.899151	4.784504	-	-	-
Random Site 12	5	51.799541	47.500156	12.045897	38.834095	50.629307
Random Site 13	5	83.954224	81.252541	83.967384	85.744768	85.457375
Random Site 14	4	51.212162	54.877491	57.891323	53.724129	-
Random Site 15	5	67.010155	75.900291	61.457851	75.301788	64.120529
Random Site 16	4	55.968498	75.597633	10.068197	38.45126	-
Random Site 17	3	62.002487	30.744192	76.308189	-	-
Random Site 18	3	39.427795	39.929333	82.178368	-	-
Random Site 19	5	62.002487	66.360039	57.979904	55.667347	79.309097
Random Site 20	3	38.45126	70.105965	77.101807	-	-
Random Site 21	4	41.848549	78.639511	73.113647	75.255814	-
Random Site 22	5	61.037487	66.582848	63.304245	57.455551	71.23761
Random Site 23	2	33.49287	61.642937	-	-	-
Random Site 24	3	16.48476	14.095546	31.712244	-	-
Random Site 25	3	26.014721	34.711926	17.678125	-	-
Random Site 26	4	45.175423	62.714867	41.148705	42.095203	-
Random Site 27	4	76.097992	65.826904	76.361298	53.724129	-
Random Site 28	4	35.476704	13.713607	37.899151	19.550409	-

Random Site 29	5	25.50877	10.600774	19.039757	41.59779	23.112206
Random Site 30	3	65.009132	4.784504	77.1632	-	-
Random Site 31	3	20.755098	26.665804	14.095546	-	-
Random Site 32	4	34.613743	36.990715	36.206963	45.614647	-
Random Site 33	2	26.981884	31.355841	-	-	-
Random Site 34	5	29.176748	31.355841	42.095203	53.170029	29.313194
Random Site 35	4	52.645744	35.845966	52.389297	41.3428	-
Random Site 36	4	17.678125	52.273579	34.011909	49.594933	-
Random Site 37	3	40.75293	53.928619	41.59779	-	-
Random Site 38	3	64.891418	56.527317	78.218201	-	-
Random Site 39	5	35.476704	48.155624	57.381165	35.383057	41.59779
Random Site 40	3	61.256355	48.314651	71.974648	-	-
Random Site 41	4	20.521769	39.427795	34.711926	32.175781	-
Random Site 42	4	55.313042	20.521769	21.654264	57.154873	-
Random Site 43	4	54.004398	73.457542	62.13092	26.014721	-
Random Site 44	5	42.811691	70.669708	29.313194	40.27787	16.48476
Random Site 45	3	76.312302	80.706039	79.303879	-	-
Random Site 46	4	75.022903	77.836533	66.52774	37.15979	-
Random Site 47	5	10.600774	60.800167	10.068197	49.843769	35.476704
Random Site 48	3	43.100334	34.613743	59.099697	-	-
Random Site 49	4	41.848549	79.373062	69.037392	74.280884	-
Random Site 50	3	26.665804	35.383057	65.712807	-	-

Table 7.15: Slope Degree Value of Points Accessing Random Sites

Among the random sites having 2 LCPs, there are 2 random sites having one access point with slope degree greater than 57.19630221 (Table 7.16).

Among the random sites having 3 LCPs, there are 4 random sites with 1 access point, 5 with 2 access points, and 1 with 3 access points having slope degree greater than 57.19630221 (Table 7.16).

Among the random sites having 4 LCPs, there are 3 with 1 access point, 1 with 2 access points, and 4 with 3 access points having slope degree greater than 57.19630221 (Figure 7.16).

Finally, among the random sites having 5 LCPs, there are 3 with 1 access point, 2 with 3 access points, 1 with 4 access points, and 2 with 5 access points having slope degree greater than 57.19630221 (Figure 7.16).

Table 7.16: Random Sites Access Points Having Slope Degree >57.19630221

Number of LCPs Accessing the Site	Number of access point > 57.19630221	Random Site # Involved
2	1	RS6, RS23
3	1	RS8, RS18, RS48, RS50
	2	RS17, RS20, RS30, RS38, RS40
	3	RS45
4	1	RS4, RS16, RS26
	2	RS43
	3	RS21, RS27, RS46, RS49
5	1	RS7, RS44, RS47
	3	RS10, RS22
	4	RS19
	5	RS13, RS15

To reconcile the number of least cost paths accessing the site and the slope degree at site's access point, I combined them to generate an index of accessibility/defensibility. I consider a site inaccessible if more than 50% of its LCPs have access points with slope degrees greater than 57.79630221. The results are presented in a binary fashion from 0 (Accessible) to 1 (Inaccessible) (Table 7.17). The results showed that 15 out of the 50 random sites (30 %) have a restricted access (Table 7.17).

Table 7.17: Accessibility Index of Random Site Locations

Sites	Number of LCPs Accessing the Site	Number of access point with > 57.19630221 Degree	Accessibility Binary Index
RS1	4	0	0
RS2	3	0	0
RS3	3	0	0
RS4	4	1	0
RS5	4	0	0
RS6	2	1	0
RS7	5	1	0
RS8	3	1	0
RS9	2	0	0
RS10	5	3	1
RS11	2	0	0
RS12	5	0	0
RS13	5	5	1
RS14	4	0	0
RS15	5	5	1
RS16	4	1	0

RS17	3	2	1
RS18	3	1	0
RS19	5	4	1
RS20	3	2	1
RS21	4	3	1
RS22	5	3	1
RS23	2	1	0
RS24	3	0	0
RS25	3	0	0
RS26	4	1	0
RS27	4	3	1
RS28	4	0	0
RS29	5	0	0
RS30	3	2	1
RS31	3	0	0
RS32	4	0	0
RS33	2	0	0
RS34	5	0	0
RS35	4	0	0
RS36	4	0	0
RS37	3	0	0
RS38	3	2	1
RS39	5	0	0
RS40	3	2	1
RS41	4	0	0
RS42	4	0	0
RS43	4	2	0
RS44	5	1	0
RS45	3	3	1
RS46	4	3	1
RS47	5	1	0
RS48	3	1	0
RS49	4	3	1
RS50	3	1	0

7.2.4. Viewshed Analysis

This section presents the results of the viewshed analysis.

7.2.4.1. Viewshed Analysis of Ankilivalo

The *Viewshed* tool generated 3291 viewsheds for the site of Ankilivalo. After clipping the viewshed layer with the study area boundary, there remains **2598** visible cells from Ankilivalo, including 393 of highly visible, 108 visible, 829 somewhat visible, and 1268 less visible (Figure 7.22). Since Ankilivalo has viewshed sizes less than 11,897, then its viewshed binary index is 0.

7.2.4.2. Viewshed Analysis of Keliangebo:

The *Viewshed* tool generated a 34,241 viewsheds for Keliangebo. After clipping the viewshed layer with the study area boundary layer, there remains **19,477** visible cells, including 4864 most visible, 6818 visible, 4292 somewhat visible, and 3503 less visible (Figure 7.23). Since Keliangebo has viewshed sizes greater than 11,897, then its viewshed binary index is 1.

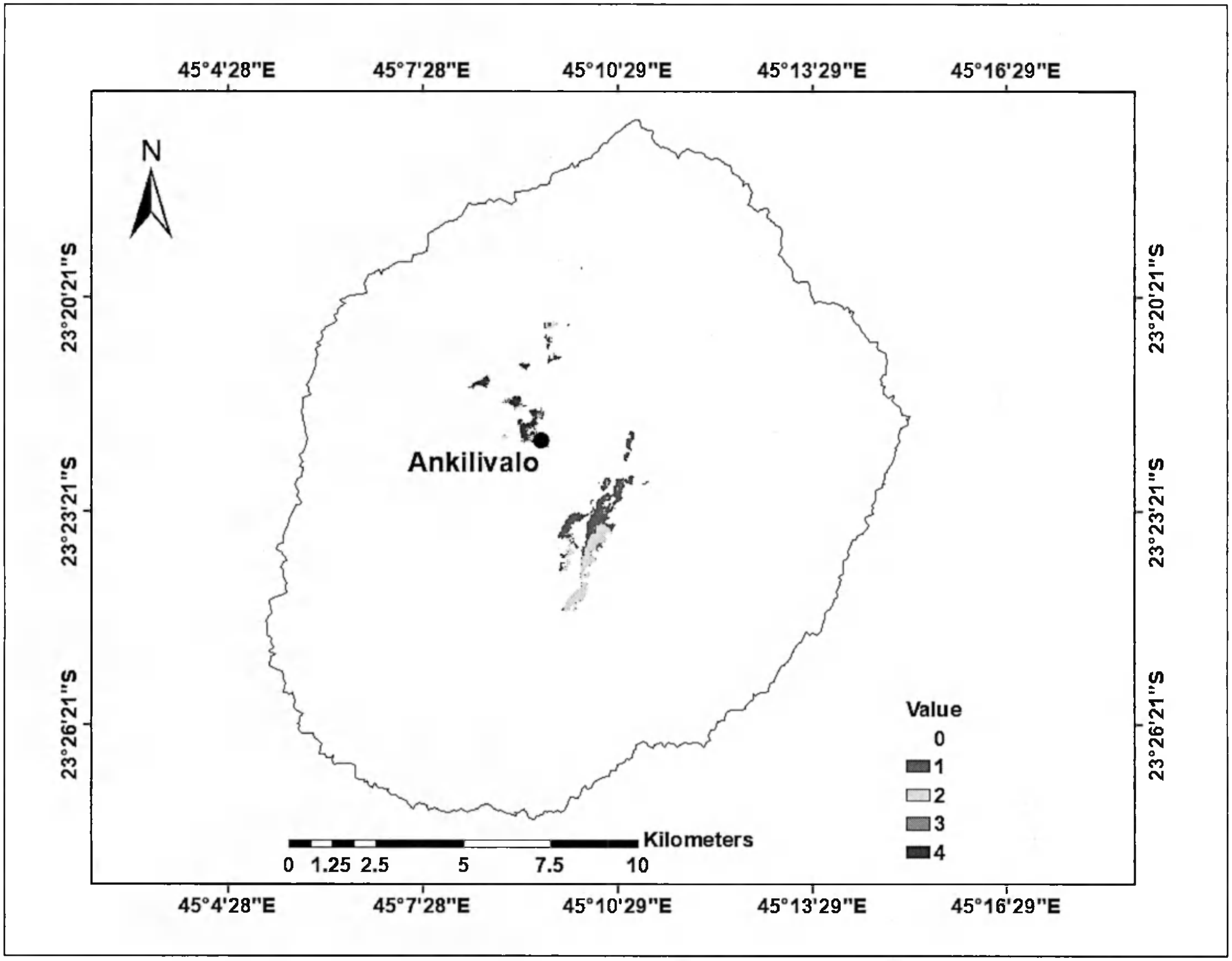

Figure 7.22: Viewshed Values from Ankilivalo

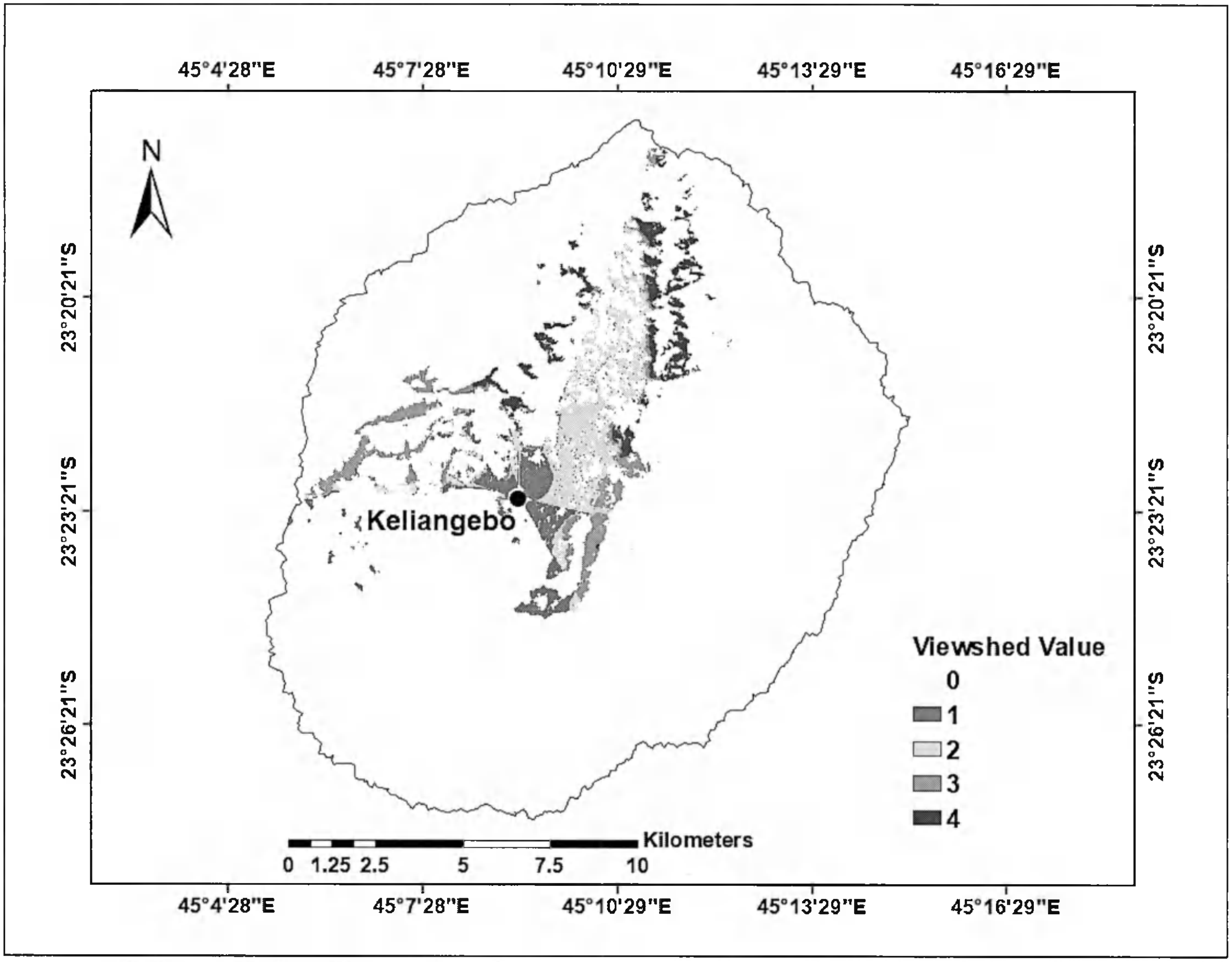

Figure 7.23: Viewsheds from Keliangebo

7.2.4.3. *Viewshed Analysis of Random Sites*

The viewshed analysis showed that viewshed sizes from random sites range from 139 to 24802 (Table 7.11). Only 3 random sites (RS21 = **16,805**; RS27 = **11,957**; and RS38 = **24802**) have viewshed sizes greater than 11,897 (5% of the study area) (Table 7.11). These random sites have viewshed binary index of 1.

Table 7.11: Viewshed Sizes from Random Sites and their Binary Indexes.

Random Site	Visible Cells Count	Viewshed Size > 11,897 Cells
Random Site 1	573	0
Random Site 2	215	0
Random Site 3	2211	0
Random Site 4	2164	0
Random Site 5	4307	0
Random Site 6	612	0
Random Site 7	3623	0
Random Site 8	3475	0
Random Site 9	5687	0
Random Site 10	1396	0
Random Site 11	581	0
Random Site 12	1577	0
Random Site 13	1204	0
Random Site 14	2240	0
Random Site 15	2393	0
Random Site 16	3019	0
Random Site 17	1302	0
Random Site 18	3685	0
Random Site 19	2486	0
Random Site 20	245	0
Random Site 21	16805	1
Random Site 22	3589	0
Random Site 23	1386	0
Random Site 24	523	0
Random Site 25	139	0
Random Site 26	2521	0
Random Site 27	11957	1
Random Site 28	2696	0
Random Site 29	5401	0
Random Site 30	6469	0
Random Site 31	5065	0
Random Site 32	1133	0
Random Site 33	4355	0
Random Site 34	3008	0
Random Site 35	2754	0
Random Site 36	461	0
Random Site 37	6569	0

Random Site 38	24802	1
Random Site 39	2521	0
Random Site 40	263	0
Random Site 41	4565	0
Random Site 42	1331	0
Random Site 43	1099	0
Random Site 44	1944	0
Random Site 45	1128	0
Random Site 46	1817	0
Random Site 47	2222	0
Random Site 48	9232	0
Random Site 49	845	0
Random Site 50	3000	0

7.2.5. Site Total Defensibility

Site defensibility was assessed with three main criteria including (1) site elevation advantage/disadvantage vis-à-vis the immediate surrounding landscape, (2) site accessibility (including the number of LCPs accessing the site, and the slope degree at the site's access points), and (3) viewshed sizes. Each of these criteria were assigned a binary value of 0 (Not Defensible) and 1 (Defensible). To generate a total defensibility for a site location, thus, I summed up these binary values (elevation advantage/disadvantage + accessibility + viewsheds). The total defensibility value ranges from 0 (vulnerable) to 3 (highly defensible). The results showed that Keliangebo has a total defensibility value of 3 (i.e. highly defensible site), while Ankilivalo has 0 (i.e. vulnerable site) (Table 7.18). Meanwhile, only 2 out of the 50 random sites (p-value = 0.04) have the same total defensibility value as Keliangebo (i.e. highly defensible site). This suggests a strong relationship between the location of Keliangebo and the defensibility of the site. On the other hand, 50 out of 50 random sites (p-value = 1) have equal or higher defensibility value than Ankilivalo (Figure 7.31; Table 7.18), suggesting there is no relationship between the location of Ankilivalo and its defensibility.

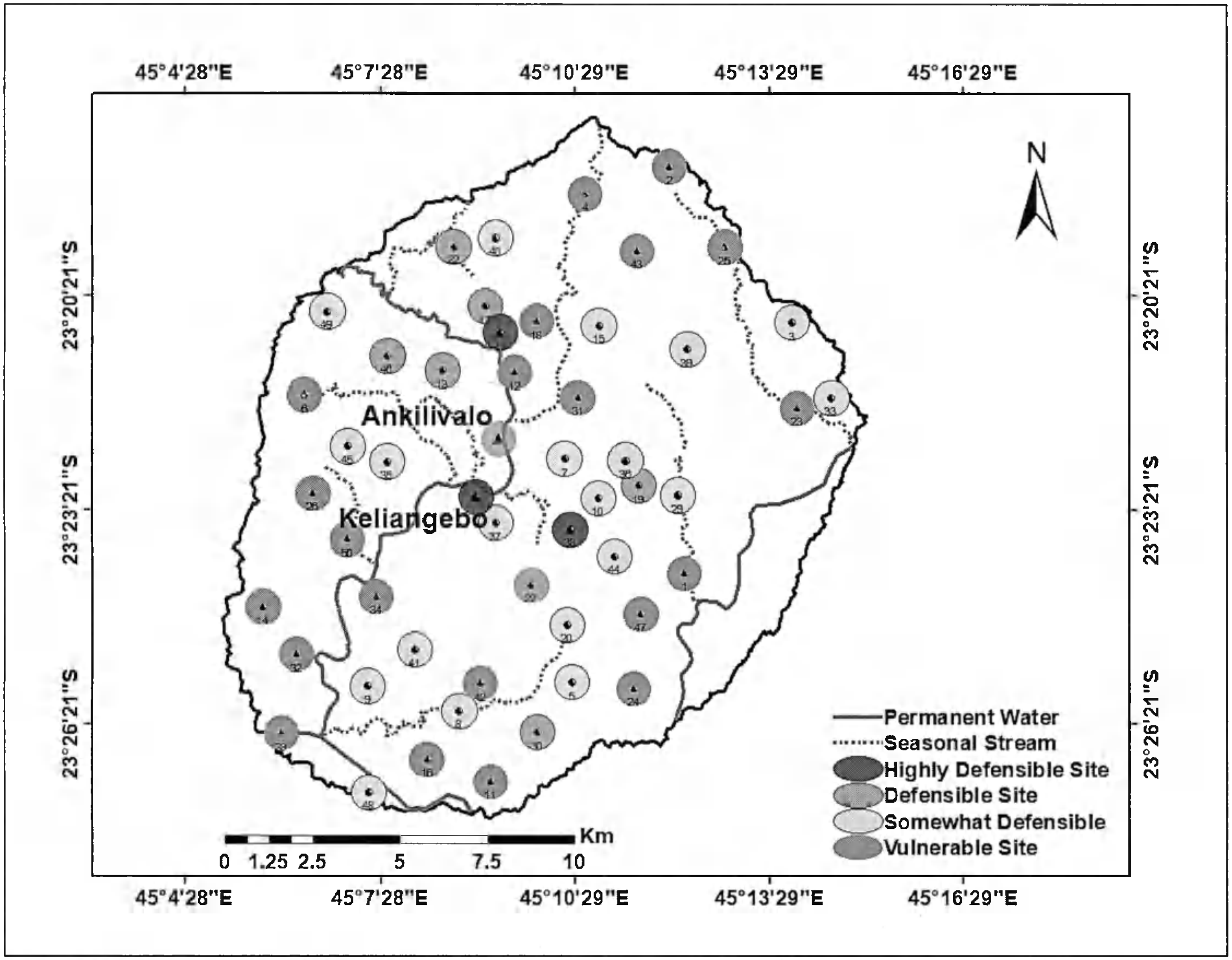

Figure 7.31: Total Defensibility of Archaeological Sites and Random Site Locations

Table 7.18: Total Defensibility of Archaeological Sites and Random Site Locations

Sites	Viewshed Size	Accessibility	Elevation Advantage	Total Defensibility
AK	0	0	0	**0**
KG	1	1	1	**3**
RS1	0	0	0	**0**
RS2	0	0	0	**0**
RS3	0	0	1	**1**
RS4	0	0	0	**0**
RS5	0	0	1	**1**
RS6	0	0	0	**0**
RS7	0	0	1	**1**
RS8	0	0	1	**1**
RS9	0	0	1	**1**
RS10	0	1	0	**1**
RS11	0	0	0	**0**
RS12	0	0	0	**0**
RS13	0	1	1	**2**
RS14	0	0	0	**0**
RS15	0	1	0	**1**
RS16	0	0	0	**0**
RS17	0	1	1	**2**
RS18	0	0	0	**0**
RS19	0	1	1	**2**
RS20	0	1	0	**1**
RS21	1	1	1	**3**
RS22	0	1	1	**2**
RS23	0	0	0	**0**
RS24	0	0	0	**0**
RS25	0	0	0	**0**
RS26	0	0	0	**0**
RS27	1	1	0	**2**
RS28	0	0	0	**0**
RS29	0	0	1	**1**
RS30	0	1	1	**2**
RS31	0	0	0	**0**
RS32	0	0	0	**0**
RS33	0	0	1	**1**
RS34	0	0	0	**0**
RS35	0	0	1	**1**
RS36	0	0	1	**1**
RS37	0	0	1	**1**
RS38	1	1	1	**3**
RS39	0	0	1	**1**
RS40	0	1	0	**1**

RS41	0	0	1	**1**
RS42	0	0	0	**0**
RS43	0	0	0	**0**
RS44	0	0	1	**1**
RS45	0	1	0	**1**
RS46	0	1	1	**2**
RS47	0	0	0	**0**
RS48	0	0	1	**1**
RS49	0	1	0	**1**
RS50	0	0	0	**0**

CHAPTER EIGHT: DISCUSSIONS, CONCLUSIONS, AND FUTURE PROSPECTS

'Mena tany, mena koa trandraky'

At a red soil, tenrecs are red [My translation]

'Ze tany mahavelo ka tanindraza'

Wherever you can make a living is your ancestor's land [My translation]

These two Malagasy sayings are known among different groups in southwest Madagascar. They are especially well-known among people experiencing rural exodus. These are remainders of social memory from the past. They reflect how people were always on the move (De Bry, De Constantin, and François Martin de Vitré cited in Grandidier and Grandidier 1903: 145, 197, 284), and tried to adapt to a new location whenever they settled in.

This kind of situation encouraged me to investigate factors influencing decisions on where to settle in. I chose riverine communities in arid southwest Madagascar to study.

It has been always puzzling to imagine the decisions of people in the face of unpredictable climate and internecine violence. What kind of subsistence strategies were adopted during a period of unpredictable climate and episodic droughts? How did people recover from a climatic stress such as droughts or flooding? How could people exchange goods during a period of insecurity? And the questions continue on and on.

My limited time and means did not allow me to investigate all of these questions. And the results of my work could not answer all these questions. Instead it created more questions. However, some findings are pertinent and noteworthy. Nothing was known about the history of the area before my study. And I am the first to introduce new methods of analysis to Madagascar archaeology. I also am the first to compile diverse historical sources and to compare them to archaeological record of the southwest.

The paleoclimatic proxies and ethnohistorical records from the southwest corroborated the unpredictability of the climate and the recurrence of anomalies such as droughts and abundant rainfalls that could have caused flooding (Ferry *et al.* 1998; Randriamahefa and Reason 2017; Zinke *et al.* 2004). The uncertainties of the climate might have influenced people whose subsistence strategies depended on rainfall to respond. But ethnohistorical records also reported that some of these climatic events affected the sociopolitical life of people in the southwest.

Intergroup violence was expected to influence the decisions of people to choose defensive location. But historic documents reported that such events also caused famines in the past.

Nevertheless, ethnohistorical records from the last 400 years demonstrated that the decision-making of people in the southwest has been influenced by the belief on the cosmological orders.

These are my preliminary conclusion.

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