

Applying human niche construction theory to study settlement choice in southwest Madagascar, 16th-19th centuries CE

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Abstract

Anthropologists coined the term human niche construction theory (HNCT) to apply the ecological concept of niche construction to the study of human society. Most of the work done on HNCT focuses on the biological and economic aspects of human niche construction. This paper aims to integrate HNCT in the archaeological study of settlement choice. I incorporate not only the economic aspects of settlement choice but its sociopolitical and ideological dimensions as well. To do so, geospatial analysis, archaeology, paleoclimatic proxies and ethnohistorical records have been integrated to provide multiple lines of evidence as to whether the proximity of a site to resources and/or its defensibility influenced community settlement choice in the face of unpredictable climate conditions and intergroup conflicts.

While the geospatial analysis demonstrated the influences of environmental and sociopolitical pressures on the settlement choice of archaeological communities, ethnohistorical reports showed that the decisions of people in southwest Madagascar have been heavily influenced by belief in cosmological values and divination. To choose where and when to settle, people consulted a diviner and acted upon the insight and prediction of the divination, even if the decision was not beneficial to their economic and sociopolitical lifeways. The slight contrast between these lines of evidence demonstrates the importance of integrating both environmental, sociopolitical, and ideological aspects into the study of human niche construction.

Key words: human niche construction, settlement choice, social memory, decision-making, southwest Madagascar

Résumé détaillé

Les écologistes ont développé le concept de construction de niche pour décrire le processus

par lequel un organisme modifie une ou plusieurs caractéristiques de son environnement ou celui d'autres organismes pour répondre à ses besoins en ressources. Cette modification peut se faire soit en perturbant certains caractères physiques de cet environnement dans le temps et dans l'espace, soit en se déplaçant vers un autre milieu pour s'exposer à différentes conditions. Les anthropologues ont adopté ce concept écologique pour étudier des phénomènes sociaux et culturelles, d'où la théorie de la construction de niche humaine (TCNH).

Bien que la nature des humains et les phénomènes sociaux soient compliqués, la plupart des recherches anthropologiques utilisant la TCNH se concentrent seulement sur les aspects biologiques et économiques de la construction de niche humaine. Par exemple, la plupart des recherches en archéologie utilisant la TCNH se concentre notamment sur la procuration des aliments chez les chasseurs-cueilleurs, ou les transitions vers l'élevage et l'agriculture (c'est-à-dire la domestication des animaux et des plantes). La présente étude considère non seulement les aspects économiques de la niche humaine, mais aussi ses dimensions sociopolitiques et idéologiques. Dans cette compréhension élargie, le terme « niche » se réfère non seulement au rôle joué par les communautés vis-à-vis de la vie sociopolitique et idéologique de la région, mais aussi du type d'institutions, de matériaux technoculturels, et de ressources culturelles qu'elles utilisent, telles que les liens sociaux, la technologie, les matériaux culturels, la mémoire sociale, etc.

De surcroît, les anthropologues ont négligé le concept de déplacement contre-actif en faveur des trois autres concepts de construction de niche qui mettent l'accent sur l'initiative des organismes pour modifier leur milieu. Cependant, ce concept de déplacement contre-actif offre une excellente opportunité aux anthropologues d'explorer les causes et les processus derrière la mobilité et la migration de groupe. Cet article a intégré ce concept négligé de déplacement contre-actif dans l'étude archéologique du choix de peuplement. Aussi, il nous importe de savoir pourquoi certaines communautés préféraient s'installer dans des parties spécifiques de la moyenne vallée de la Sakamarekely, dans le

Sud-ouest de Madagascar, spécifiquement sur les sites archéologiques de Keliangebo et d'Ankilivalo, durant un régime climatique imprévisible et une période d'insécurité due aux conflits intergroupes du 16^{ème} au 19^{ème} siècle de notre ère. Quels facteurs environnementaux, sociopolitiques et idéologiques ont influencé le choix de ces communautés ?

Basé sur le concept de déplacement contre-actif, nous présumons que les occupants des deux sites étudiés étaient déjà conscients de la disponibilité de ressources naturelles exploitables avant de décider de s'installer sur ces sites. Cette connaissance préalable devrait se refléter sur 1) le positionnement des sites vis-à-vis du paysage, 2) l'interaction entre les communautés et l'environnement et/ou la société environnant(e) et 3) la culture matérielle enregistrée dans les sondages archéologiques.

Différentes techniques et méthodes ont ainsi été intégrées, à savoir, l'analyse géospatiale, l'archéologie, la paléoclimatologie et l'ethnohistoire, pour fournir des évidences révélant si la proximité d'un site aux ressources naturelles et/ou sa position défensive aurait influencés le choix de la communauté de s'y installer.

La méthode d'analyse de proximité du logiciel ArcGIS a été utilisée pour déterminer la distance entre les sites et les ressources naturelles telles que les points d'eau, les terres arables, les prairies et les forêts. Pour déterminer si un site aurait été vulnérable ou défendable face à une attaque, le logiciel ArcGIS a été utilisé pour évaluer trois critères de défendabilité, à savoir la visibilité, l'accessibilité et l'élévation topographique. Pour comprendre les conditions climatiques dans lesquelles vivaient les occupants des sites, les données climatiques enregistrées sur les coraux au cours des 400 dernières années ont été consultées. Des données ethnohistoriques ont été également consultées pour mieux comprendre comment les anciens habitants du Sud-ouest ont choisi où s'installer pendant les périodes de stress climatique et d'insécurité due aux conflits entre groupes.

L'analyse géospatiale a suggéré que les pressions environnementales et sociopolitiques ont influencé les choix de peuplement des communautés archéologiques. Cependant, les sources ethnohistoriques ont révélé que les décisions des habitants du Sud-ouest de Madagascar étaient également fortement influencées par la croyance en la cosmologie et la divination. Pour choisir où et quand s'installer, les gens consultaient des

devins et prenaient des décisions en fonction de ce qu'ils apprenaient de la divination, même lorsque la décision ne correspondait pas à leurs intérêts économiques et sociopolitiques.

Le contraste entre les résultats de l'analyse géospatiale et l'enquête ethnohistorique démontre l'importance d'intégrer différentes sources de données pour comprendre les aspects environnementaux, sociopolitiques et idéologiques de la construction des niches humaines.

Mots clés : construction de niche, choix d'établissement, mémoire sociale, prise de décision, Sud-ouest de Madagascar

Introduction

This paper aims to incorporate Niche Construction Theory (hereafter NCT), a theoretical framework with roots in the field of ecology, in the archaeological study of settlement choice. Anthropologists and archaeologists have applied NCT to the study of human society and coined the term human niche construction (HNC) (Odling-Smee *et al.*, 2003; Smith, 2009; Laland & O'Brien, 2010; Gerbault *et al.*, 2011; Kendal *et al.*, 2011; Flynn *et al.*, 2013; Wallach, 2016) and cultural niche construction (Boyd *et al.*, 2011; Kendal, 2011). Human niche construction theory (hereafter HNCT) 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 a community's lifeways (cultural niche) and the natural resources available to them (physical niche), such as water, arable lands, prairies, forests, etc. (Sutton & Anderson, 2010: 46). Most of the work done so far on HNCT, however, has focused on the biological and economic aspects of HNC (Smith, 2009; Laland & O'Brien, 2010; Riel-Salvatore, 2010; Gerbault *et al.*, 2011; Vining, 2017). HNCT scholars are mostly interested in how people as organisms change the selective pressures on themselves and on other organisms through their subsistence practices. In archaeology, for instance, HNCT has been used to investigate processes of foraging (O'Brien & Laland, 2012), the domestication of plants and animals (Smith, 2016; Zeder, 2016), and other aspects of food production (Crawford, 2014). This interest in the biological and economic aspects of HNC runs parallel to the practice of proponents of NCT in ecology who treat people as biological organisms interested only in their subsistence and health needs. Meanwhile, the non-biological and non-economic aspects of the

human niche, such as sociopolitical and ideological processes, have been overlooked. These play an essential role in human decision-making (past and present), however, and should be considered in the study of HNC. To address the under appreciation of non-economic factors in HNCT, this paper considers not only the economic aspects of settlement choice but its sociopolitical and ideological dimensions as well.

Based on HNCT, I use geospatial methods to investigate whether the proximity of a site to resources (waterpoint, arable land, pastureland, and forest) and/or its defensibility influenced community settlement choice in the face of unpredictable climate conditions and intergroup conflicts. In addition, I consulted ethnohistorical reports to look at how people socio-politically and ideologically selected where to settle in the past. Although this interest in sociopolitical and ideological perspectives is not new in archaeology and geospatial studies (Allen, 1996; Hasenstab, 1996; Llobera, 1996, 2001; Maschner, 1996; Jones, 2010), it represents a novel application of HNCT, as explained below.

The study area

This study is situated on the riverine landscape of the middle Sakamarekely River (hereafter MSV), a 15 km long section of a tributary of the upper Onilahy River, in the Isalo region of arid southwest Madagascar (Figure 1). The area has been *terra incognita* for archaeological research. Recent research by the author (Rasolondrainy, 2012, 2019) suggests a rich archaeological record with the potential to address a range of questions relating to human-environment interaction, mobility, land use, rock art, just to name a few.

The MSV lies in a depression in the Sakamena geological layer bounded by the Horombe Plateau to the east and the tabular massif of southern Isalo to the west (Battistini & 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 hydrological networks, including the Sakamarekely

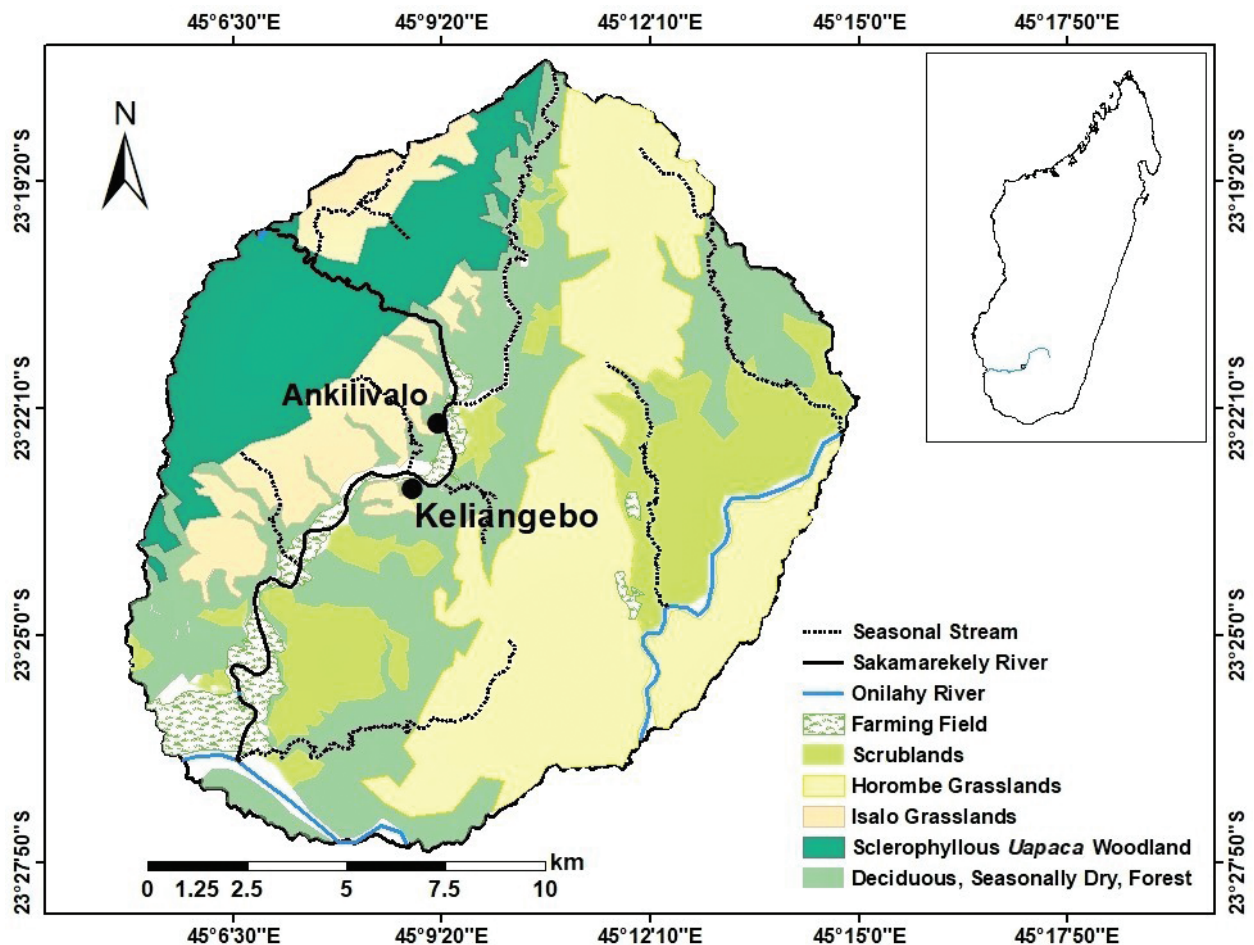


Figure 1. The study area.

River, the unit of interest in this paper (Sourdat, 1970: 107; Petit, 1996: 79). 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 alluvium derived from ferruginous soils that envelope the sandstone massif of the Isalo (Sourdat, 1970: 106). The river follows the eastern escarpment of the Isalo (Battistini & Doumenge, 1966: 84, 92), and expands into an alluvial marsh along which the Bara Vinda people have established their settlements since the 19th 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 frequently causes damage to livelihoods. Upstream, it erodes riverbanks and agricultural fields, while downstream it inundates agricultural fields with sand and obstructs irrigation canals (Faublée, 1942: 157-158). These constitute yearly challenges for farmers occupying the valley.

In this paper, I specifically focus on the sites of Ankilivalo and Keliangebo, two major archaeological sites among the 42 sites I recorded along the MSV during my summer fieldwork in 2014, 2015, and 2016 (Figure 1). Ankilivalo is a piedmont site of 0.5 ha, while Keliangebo is a hilltop site of about 1.5 ha. The first has been dated to the late 17th-19th centuries CE, while the latter is dated to the 16th-17th centuries CE (Rasolondrainy, 2019: 238-240, 299-300). Both sites are important and well suited for investigating whether the proximity of sites to resources and/or their defensibility influenced settlement choice in the face of variable climate and intergroup conflicts: 1) ethnohistorical studies of the southwest during the 16th-19th centuries CE are available and suggest that the occupants of both sites faced a regime of unpredictable climate and intergroup conflicts (Flacourt, 1661; Grandidier & Grandidier, 1903, 1904, 1906). This allows a comparative analysis between ethnohistorical records and archaeological data; 2) 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; and 3) a resource-rich mosaic of microenvironments is found in the study area, including the Sakamarekely Valley with its water and arable land, 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 (Figure 1)

Human niche construction theory and settlement choice

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). 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 (Sutton & 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 environment and community. 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). NCT holds that 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 and/or other's niches (Odling-Smee *et al.*, 2003; Laland & O'Brien, 2010: 305, 310). 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 1).

In the application of NCT to archaeology, researchers mostly focus on the economic and

Table 1. A summary of four categories of niche construction (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.

environmental aspects of the human niche (O'Brien & Laland, 2012; Crawford, 2014; Dortch *et al.*, 2014; Smith, 2015, 2016; Stiner & Kuhn, 2016; Zeder, 2016). This paper aims to expand archaeological investigations of HNC by incorporating sociopolitical and ideological aspects of the human niche. Within an expanded understanding, 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, warfare paraphernalia, ideology, and so on.

Furthermore, despite drawing from ecological theory, HNCT scholars have overlooked counteractive relocation in favor of the other three niche construction categories (O'Brien & Laland, 2012; Crawford, 2014; Smith, 2016; Zeder, 2016). They promote 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 & O'Brien, 2010: 315). They also complement the anthropological concept of human agency. By stressing the inceptive and perturbatory nature of niche construction, however, 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 to explore drivers and processes of group mobility and migration. Both inceptive and counteractive relocation consider a community moving and settling in a new location. Inceptive relocation implies that the relocating community moves to a new place without knowing about the sustainability of its resources, 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 of settlement choice.

Using the concept of counteractive relocation, this paper aims to establish a narrative of settlement choices in the face of unpredictable climate and intergroup conflicts in arid southwest Madagascar. This is pertinent to the anthropological question of

how small-scale societies respond to environmental and sociopolitical challenges. Specifically, I investigate why riverine communities preferred to occupy specific parts of a valley over others in the face of unpredictable climate during the 16th–19th centuries CE in southwest Madagascar. What environmental or economic factors influenced their choice? This paper is the first to address this issue for Madagascar. Although studies have increased our understanding of this topic (Gunderson & Holling, 2002; Berkes *et al.*, 2003; Redman, 2005; Liu *et al.*, 2007; Sutton & Anderson, 2010; Brondízio & Moran, 2013), 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, 1984; Llobera, 1996, 2001; Maschner, 1996; Hatch & Bondar, 2001; Tilley & 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 (Maschner & Stein, 1995; Jones, 2010: 2; Bocinsky, 2014: 38).

Based on the counteractive relocation concept, I assume that the occupants of the two sites under study had a fair judgment of the suitability of the landscape of the MSV before they chose to settle these sites. This judgment should be reflected in 1) the positioning of the sites vis-à-vis the landscape, 2) the interaction between the relocating community and the surrounding environment and society, and to some extent 3) the material objects left in the archaeological record (Odling-Smee *et al.*, 2003; Laland & O'Brien, 2010: 313). As communities moved to these locations, there are two relevant concepts to consider, namely social memory and decision-making.

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; Kendal, 2011; Flynn *et al.*, 2013), indigenous knowledge (Schieffelin, 1990; Minar & Crown, 2001; Boyd *et al.*, 2011), traditional ecological knowledge (Berkes *et al.*, 2000), and traditional knowledge systems (Sutton & Anderson, 2010: 102–115), and

so forth. It includes people's beliefs, worldview, ecological and social knowledge (Knapp & Ashmore, 1999: 10-13; McIntosh, 2000).

Within a society without written documents, social memory 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 & O'Brien, 2010: 308). Social memory helps communities make informed decisions to face and survive challenges in their livelihood (Brunger, 1982 in Stone, 1996: 143; Fritz-Vietta *et al.*, 2017). 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-Gimenez, 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-Gimenez, 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 NCT 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 or livestock rustling (Ingold, 1984; Anthony, 2007). Thus, thanks to social memory, herders become resilient to environmental and social challenges, and 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 social structure (McIntosh, 2000: 144).

To encourage people to implement and maintain social memory, societies without written records back it up with ideology, beliefs, and rituals (Sutton & 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 & Henry, 2017: 2). Dedicated professionals such as the griots of West Africa or other artists may play an important role in keeping and transmitting social memory (Jones *et al.*, 1989; McIntosh, 2000). In southern Madagascar, for instance, 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).

Indeed, social memory, either knowledge of objective matters or cognitive worldviews, is at the heart of people's decision-making in the face of challenges such as climate uncertainty or intergroup conflicts (McIntosh, 2000: 143, 2005: 89; Adger 2006; Berkes, 2007: 287; Laland & O'Brien, 2010: 307; Bocinsky, 2014: 33; 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.

I therefore consulted ethnohistorical records to investigate social memory of how people in the southwest chose where to settle in the past. Appreciation of ethnohistorical data helps to understand ideological aspects of the landscape and material culture (Whitley, 2004), and to some extent develop models of decision-making in the face of unpredictable climate and intergroup conflicts.

Decision-making

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

Based on the NCT counteractive relocation concept, this research explores why people relocate to a new place due to selective challenges. Specifically, it looks at how people chose to settle 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 push factors such as the unpredictable climate and/or intergroup conflicts, to pull factors such as the bountifulness of the environment and/or the defensibility of the location (Bocinsky, 2014: 59).

Based on a functionalistic standpoint, I first assumed that the choice of where to settle in a valley was conditioned by the disposition of natural resources on the landscape. Especially when prolonged unpredictability of climate puts stress on a community, its members might 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).

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 (Grandidier & Grandidier, 1906: 299; McGovern, 1994; Allen, 1996; Maschner, 1996; McIntosh, 2005; Berkes, 2007: 283; Parker Pearson, 2010: 259; Sakaguchi *et al.*, 2010: 1172-1173). In such a situation, sociopolitical or ideological 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 (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 in the archaeological record (Laland & O'Brien, 2010: 308, 314).

Table 2 summarizes expected scenarios of counteractive relocation in the MSV during the 16th-19th centuries CE.

Methods

I combined geospatial analysis (site proximity to resources, hillshade analysis, and site defensibility), isotopic analysis, ethnohistory, and paleoclimatology to provide multiple lines of evidence of past settlement choices.

Geospatial analysis

I used proximity analysis to determine the proximity of sites to resources (Jones, 2006: 523). The prime mover of proximity analysis is the assumption that the disposition and condition of environmental variables on the landscape affect the settlement decisions of people, and that they basically choose an "optimal" location close to natural resources such as water points, arable lands, grasslands, and forests (Volkman, 2018: 30).

It is assumed that the presence of permanent water points encourages people to settle nearby (Jones, 2017: 12; Staudt, 2017: 197). I produced such permanent water sources by extracting high flow accumulation data from a digital elevation model (DEM) using the Hydrology geoprocessing tool in ArcMap (Chang, 2008: 310).

As high concentrations of organic carbon and clay are indications of soil fertility (Campbell, 1978; Six *et al.*, 2002; Fließbach *et al.*, 2007), I combined raster

Table 2. 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 resource-rich 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 resource-rich microenvironments.	Site proximity to resourceful ecozones, and defensive site.

maps of soil organic carbon and clay contents from the open-source database SoilGrids (Hengl *et al.*, 2014, 2017) to determine the distribution of arable lands (For more details, see Rasolondrainy, 2019: 171-179).

As for the distribution of vegetation cover, I digitized different types of forests and grasslands from ArcMap's imagery basemap. Based on local land uses, I classified them in five categories, including deciduous forest, Tapia forest (sclerophyllous *Uapaca* woodland), scrubland, Horombe grassland, and Isalo grassland (Figure 1; For more details, see Rasolondrainy, 2019: 180-187).

To determine the proximity of an archaeological site to a given natural resource, I used the Generate Near Table geoprocessing tool in ArcMap 10.4.1 (*ArcToolbox > Analysis Tools > Generate Near Table*; GEODESIC option selected). This analysis provides a list of environmental variables close to archaeological sites at a determined distance. 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 understand more about the proximity of archaeological sites to pasturelands, I assessed how long livestock stays in ecozones such as grassland or gallery forest. To do so, nitrogen isotopic values of collagen extracted from cattle remains from excavations at Ankilivalo were measured to determine whether the animals usually consumed tree/scrub leaves (i.e. forest-dweller) or grasses (i.e. grassland-dweller) (Pate & Noble, 2000). Sean Hixon conducted this analysis at the Penn State University Department of Anthropology Isotope Geochemistry Lab.

In addition, 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° from the horizon to

90° overhead, while azimuth is the angle along the horizon from 0° in the north, 90° in the east, 180° in the south, and 270° 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 determined the altitude and azimuth of the sun at midday during the winter (June selected) and the summer (January selected) in the MSV. At noon during the austral summer (January selected), the altitude of the sun is at 89°, while the azimuth is at 280°. On the other hand, at noon during the austral winter (June selected), the altitude of the sun is at 45°, while the azimuth is at 359°.

I used these values to estimate the hillshade of my study area during the winter and summer. 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*).

On the other hand, I used defensibility analysis to determine how vulnerable or defensible the site is vis-à-vis attackers (Jones, 2006: 523). It aims to assess whether intergroup conflicts influenced the community to choose a defensible site location. In this paper, I assessed three defensibility criteria, including visibility, accessibility, and elevation advantage/disadvantage. Visibility analysis calculates viewshed size from a site. It is based on the assumption that the occupants of a site with larger viewsheds can see enemies approaching and can therefore defend it more easily (Jones, 2010: 3, 6; Bocinsky, 2014: 165); Accessibility analysis counts the number of least cost paths accessing the site and assesses the degree of slope at its access points. It is based on the assumption that a site with easy access is vulnerable to attackers, while a site with difficult access can be defensible (Martindale & Supernant, 2009: 195; Llobera *et al.*, 2011; Bocinsky, 2014: 164); Site elevation compares the height of an archaeological site with its immediate surroundings. It assumes that a site located at higher locations is more defensible than those located at lower places. I assigned the results of each defensibility analysis to 0 (not defensible) or 1 (defensible) and summed up 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) (Jones, 2006: 527; Bocinsky, 2014: 166).

I tested the significance of proximity to resources and site defensibility in settlement choices by

exploring decisions that would have been made if proximity to bountiful resources and/or site defensibility were unimportant (Bocinsky, 2014: 166). To do so, I compared the actual archaeological sites with random sites within the same landscape, thereby testing the causal relationship between the decision and the bountifulness of the landscape and/or the defensibility of the site (Maschner & Stein, 1995; Jones, 2010; Staudt, 2017). I generated 50 random site locations within the study area boundary (Figure 2) using the Generate Random Points tool in ArcMap 10.4.1 (*ArcToolbox > Data Management > Sampling > Generate Random Points*). I set the minimum distance between random points at 2 km. If the significance level of the p-values is equal to or less than 0.05 ($\alpha = 0.05$), then the relationship is strong. Otherwise, the relationship is weak.

Climate proxies

Climate proxies have uncovered a long history of unpredictable climate in southwest Madagascar, especially since the late 16th century CE (Zinke *et al.*, 2004; Dewar & Richard, 2007, 2012; Virah-Sawmy *et al.*, 2010, 2016). Historical documents and oral traditions mention cyclical droughts and unpredictable rainfall regimes that caused crop

failures and episodic famines (Faublée, 1942: 165, 167, 1947). Based on the counteractive relocation concept, I investigated whether such unpredictable climate influenced the decision of people to settle along the MSV.

To understand the climate conditions under which occupants of the sites lived, I consulted coral proxies for the last 400 years (Zinke *et al.*, 2004). From these, I estimated climatic regimes in the MSV during the 16th-19th centuries CE (Bocinsky, 2014: 35). It should be noted, however, that climate proxies are estimates. They are not an accurate measure or record of actual climatic events (McIntosh, 2005: 73). To validate the use of proxies, I cross-checked the 400 year-long coral proxies with decades-long instrument weather data, and ethnohistorical records of droughts.

The earliest date remembered for drought/famine in the southwest was in 1928. This was reportedly caused by low rainfall and the introduction of cochineal insects that ate/destroyed the prickly pears all over the region (Kaufmann, 2004). 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 in 2016 with Mbaiaho, a 75-year-old elder from

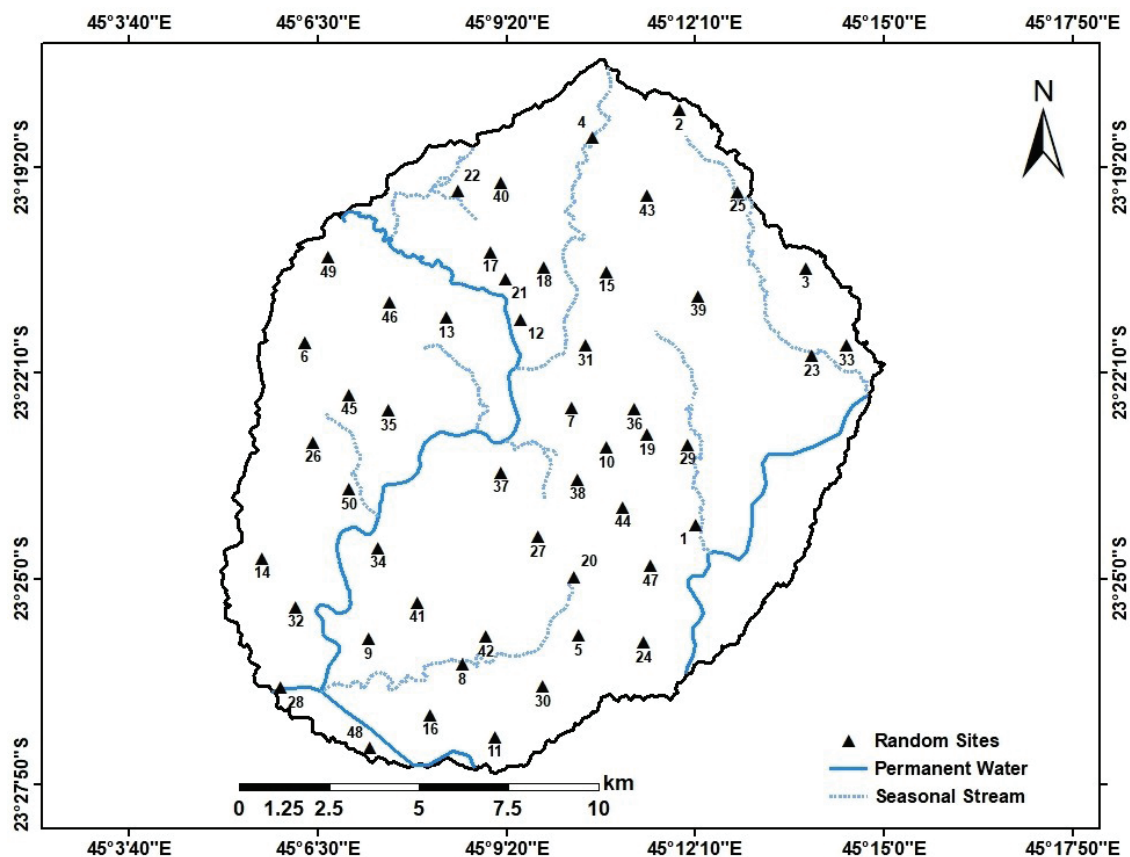


Figure 2. Distribution of random sites.

Amparimaiky, Rasolondrainy, unpublished data). Although the dates differ slightly, the occurrence of climatic events (wet or dry years) in the instrument weather data and ethnohistorical records correlates with those of coral proxies (Ferry *et al.*, 1998: 94; Zinke *et al.*, 2004: 182). This consistency validated the use of the coral proxies. Moreover, the temporal resolution (bimonthly) of the coral proxies is finer than the chronological resolution (centennial) of the archaeological dates, highlighting the potential of these climate proxies to strengthen our ability to interpret the geospatial pattern and archaeological record.

Ethnohistory

Ethnohistory explores the cultures and history of people by investigating historical records and oral traditions. Based on these sources, the 16th-19th centuries CE (i.e. during the occupation of Ankilivalo and Keliangebo) coincided with the emergence and development of inequality and social complexity in the southwest (Kent, 1970; Fagereng, 1971), documented by historical reports of intergroup conflicts (Duarte Barbosa, Diogo do Couto, and André Thevet in Grandidier & Grandidier, 1903: 54, 89, 99, 147, 152, 440). Based on the *counteractive relocation* concept, I investigated whether such conflicts drove people 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?

I also used ethnohistorical records to investigate how local people chose where to settle in the face of unpredictable climate and intergroup conflicts. 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, 2010), and to be

vital to the interpretation of landscape perception and models of land use during the past (Sutton & Anderson, 2010: 104; Tilley, 2010).

Results

Proximity analysis

The proximity analysis demonstrated that no random site was closer to a high flow accumulation than Ankilivalo (118 m) and Keliangebo (304 m) (Table 3). This gives us a probability value of 0, 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. This suggests that proximity to permanent water sources was an important factor influencing the decision of the occupants of Ankilivalo and Keliangebo to settle at these sites.

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 are closer than Keliangebo (Table 4). This gives p-values of 0.14 and 0.26, respectively, which are both statistically significant. The relationship between the location of archaeological sites and their proximity to arable lands is therefore weak, suggesting that proximity to arable lands did not strongly influence settlement choice.

In terms of pastures, several random sites are located closer to pasturelands than Ankilivalo and Keliangebo (Table 5). These give p-values higher than the significance level ($\alpha = 0.05$), suggesting that there is a weak relationship between the location of archaeological sites and the proximity to pasturelands. However, if I consider the size of pasturelands available to archaeological sites and random sites within a 5 km search radius (the average distance between village and places where herders take their livestock daily), I observed that the relationship between the location of Ankilivalo and

Table 3. Recapitulation of proximity of archaeological sites and random sites to high flow accumulation. AK = Ankilivalo and KG = Keliangebo.

	Distance from AK (m)	LCP from AK	Distance from KG (m)	LCP from KG	Number of RS Closer than AK	Number of RS Closer than KG
Permanent water point	118	0.05	304	0.36	0 (p-value = 0)	0 (p-value = 0)

Table 4. Recapitulation of proximity of archaeological sites and random sites to arable lands. AK = Ankilivalo and KG = Keliangebo.

	Distance from AK (m)	LCP from AK	Distance from KG (m)	LCP from KG	Number of RS closer than AK	Number of RS closer than KG
Arable lands	118	0.26	319	0.46	7 (p-value = 0.14)	13 (p-value = 0.26)

Keliangebo and the availability of scrublands was strong (Table 6). The same applied to the location of Ankilivalo and the availability of Isalo grasslands within a 5 km search radius (Table 6).

Several random sites are also located closer to forest patches than Ankilivalo and Keliangebo (Table 7). These give p-values higher than the significance level ($\alpha = 0.05$), suggesting that the relationship between the locations of archaeological sites and their proximity to forests was weak. Proximity to deciduous and Tapia forests was not therefore influential to the placement of Ankilivalo and Keliangebo.

Isotopic analysis

The isotopic analysis demonstrated that the nitrogen isotopic values of cattle remains from Ankilivalo were

7.2 (Table 8). This is the same values as of those of extant mammal browsers elsewhere in the southwest (Crowley & Godfrey, 2012). That is, they fed on shrubs, leaves of trees within reach, and woody materials, suggesting that throughout their lifespan, these livestock fed more on trees than on grasses. In another word, people herded these cattle more in the forest gallery in the valley than on the open grasslands.

Hillshade analysis

The hillshade analysis demonstrated that the hillshade value for Ankilivalo is 4 during the summer and 17 during the winter (Table 9). For Keliangebo, the hillshade value is 1 during the summer, and 179 during the winter (Table 9). Therefore, Ankilivalo

Table 5. Recapitulation of proximity of archaeological sites and random sites to pasturelands. AK = Ankilivalo and KG = Keliangebo.

	Distance from AK (m)	LCP from AK	Distance from KG (m)	LCP from KG	Number of RS closer than AK	Number of RS closer than KG
Scrublands	292	0.37	225	0.19	10 (p-value = 0.2)	9 (p-value = 0.18)
Horombe grassland	2206	14.65	1403	5.92	32 (p-value = 0.64)	26 (p-value = 0.52)
Isalo grassland	119	0.05	230	0.17	5 (p-value = 0.1)	7 (p-value = 0.14)

Table 6. Recapitulation of areas of pasturelands available to archaeological sites and random sites within 5 km search radius. AK = Ankilivalo and KG = Keliangebo.

	Areas for AK (ha)	Areas for KG (ha)	# RS having access	Range of areas (ha)	# RS having access \geq AK	# RS having access \geq 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)

Table 7. Recapitulation of proximity of archaeological sites and random sites to forests. AK = Ankilivalo and KG = Keliangebo.

	Distance from AK (m)	LCP from AK	Distance from KG (m)	LCP from KG	# RS closer than AK	# RS closer than KG
Deciduous	0	0	42.83	0.006	17 (p-value = 0.34)	17 (p-value = 0.34)
Tapia forest	2288.57	18.76	2851.63	28.5	19 (p-value = 0.38)	19 (p-value = 0.38)

Table 8. Stable isotopic information for Ankilivalo cattle remains (Source: Penn State University Isotopic Lab, January 2018).

Sample ID	Weight	$\delta^{15}\text{N}_{\text{AIR}}$	$\delta^{13}\text{C}_{\text{VPDB}}$	%N	%C	C:N	%C/12/%N/14
AK/F1	1.600	7.2	-8.6	9.9	27.2	2.8	3.22
AK/F2	0.930	7.2	-11.0	9.5	25.9	2.7	3.18

Table 9. Seasonal hillshade for Ankilivalo and Keliangebo.

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

is shadier almost throughout the year (2.2% of insolation during the summer, and 9.4% of insolation during the winter). Ankilivalo is suitable for summer settlement, but less desirable in winter. Keliangebo, on the other hand, is shady (0.5% insolated) during the summer, and highly exposed to sun (70.5% insolated) during the winter, making the site ideal for settlement throughout the year.

Defensibility analysis

Alongside the above economic interests, the results of the defensibility analysis also demonstrated that the relationship between the location of Keliangebo and its total defensibility was very strong (Table 10), suggesting the defensibility of the site influenced the settlement decision of its occupants (Bocinsky, 2014: 48). The site was situated at an elevated location with difficult access and had a good view of the confluence of the Onilahy and Sakamarekely Rivers (Table 10). On the other hand, the relationship between the location of Ankilivalo and its total defensibility was very weak (Table 10).

Ethnohistorical information on settlement choice

According to ethnohistorical records for the last 400 years, people in the southwest made decisions based

on the dynamism of cosmic forces (Flacourt, 1661: 173; Luis Mariano in Grandidier & Grandidier, 1904: 230; Cauche in Grandidier & Grandidier, 1909: 101). Space is perceived cosmologically as rectangular (Kus, 1990: 46; Vérin and Rajaonarimanana, 1991), and this perception has been applied to many places such as a landscape, village, house, cattle pen, or tomb. Cardinal directions regulate the spatial arrangements of these spaces (Vérin & Rajaonarimanana, 1991: 55-56). Each cardinal direction has its own value (Figure 3). In addition, there are also perceived 12 cosmological directions (Figure 3) that have been assigned values related to cardinal and astrological values. These cosmological directions are believed to regulate the spatial arrangements of a place and situate the place of people vis-à-vis the cosmological orders (Hébert, 1965; Kus, 1990; Verin & Rajaonarimanana, 1991: 55).

Although people recognize the power of cosmic forces, they still want to manipulate it. A healer-diviner *ombiasy* has the ability to realize this (Urbain-Faubleé & Faubleé, 1969). An *ombiasy* has good knowledge of divination and astrological techniques (Faubleé, 1951: 127; Vérin & Rajaonarimanana, 1991: 54). Using the art of divination, an *ombiasy* can see maledictions pre-determined by cosmic forces and soften/correct them with charms.

Table 10. Total defensibility of archaeological sites.

Sites	Viewshed size	Accessibility	Elevation advantage	Total defensibility	# of RS having \geq TD value
Ankilivalo	0	0	0	0	50 (p-value = 1)
Keliangebo	1	1	1	3	2 (p-value = 0.04)

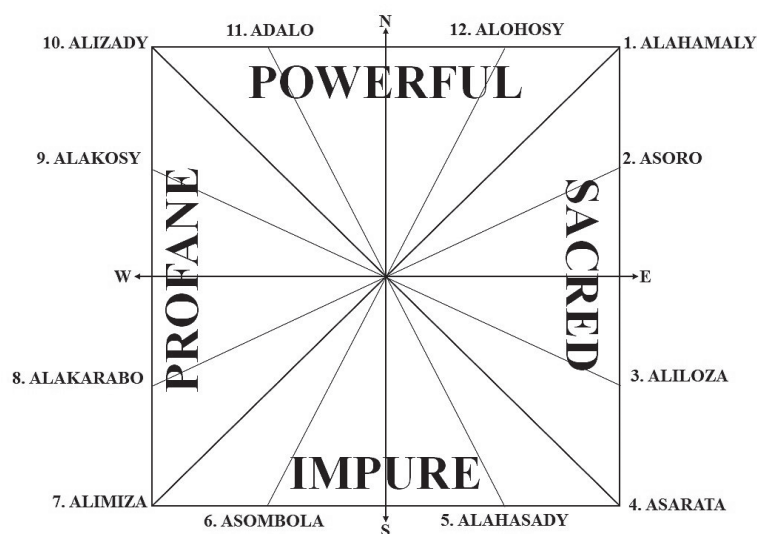


Figure 3. Model of cardinal and cosmological orientations recorded from oral traditions in the Middle Sakamarekely Valley (Fieldwork, 2016).

For the last 400 years, therefore, community members have always consulted an *ombiasy* before making any decision or initiating any enterprise (Grandidier & Grandidier, 1904: 8). The Portuguese Priest Luis Mariano first reported this 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 & 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 & Grandidier, 1909: 101)

"The *ombiasy* 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." [my translation]

Further, 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 malades les consultent pour leur guérison, les autres pour leurs affaires ; il y en a beaucoup qui ne sortent point de chez eux sans squiller.* » (Flacourt, 1661: 173).

"The *ompitsiquili* (*mpisikily* = diviner) are usually Negroes or *Anacandries* (*anakandria* = noble group) who work 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. Sick persons consult them for a cure; others for their business affairs, many do not leave their homes without consulting them." [my translation].

For a community to choose where and when to settle, they had to consult an *ombiasy* to see whether the proposed location is favorable for the community (Belrose-Huyghues, 1983: 143; Kus, 1990: 50; Verin & Rajaonarimanana, 1991: 55). The *ombiasy* uses his divination skill to unravel the will of supernatural beings embodied in the cosmic orders. As long as the *ombiasy* gives a green light, the group would relocate to the area even if it is hazard prone. This foreknowledge about places before relocating, though instructed by the *ombiasy*, conforms very well with the NCT counteractive relocation concept.

Discussion

The results of geospatial analysis can be correlated with the climate proxies and ethnohistorical records. Paleoclimatic records from the southwest confirm the unpredictability of the climate and the recurrence of anomalies such as droughts and abundant rainfall that could have caused flooding during the 16th-19th centuries CE (Zinke *et al.*, 2004). These anomalies might have frustrated people whose subsistence strategies depended on rainfall. Oral traditions recorded in the MSV allege the emergence of social inequality and social complexity due to crop failure and famine that occurred after a flooding event (Faublée, 1947: 204-207). This likely refers to the first polity *Grand Pays Machicores*, ruled under the Masikoro chief Andriambaloale, that unified a vast area in southwest Madagascar from around the end of the 16th century CE or the beginning of the 17th century CE (Flacourt, 1661: 44; Kent, 1970: 139-140; Firinga, 1971). Unpredictable flooding followed by crop failure and famine could therefore influence not only economic but also sociopolitical decisions in the community. The site of Keliangebo was occupied during this period (Rasolondrainy, 2019: 299-300).

With regard to the economy, the results of proximity analyses demonstrated that immediacy to permanent water sources and scrublands in the valley were important factors influencing community settlement choice at Keliangebo in the 16th-17th centuries CE. Proximity to arable lands and grasslands seemed to have been less important. This might be due to the fact that people were hiding from enemies and did not sow the land during this period (Flacourt, 1661). This correlation between proximity analyses and historic documents demonstrates that the occupants of the site were aware of the resource potential of the landscape before selecting the site location, supporting the NCT *counteractive relocation* concept.

The climate proxies also show that in 1650-1675 CE (i.e. right before the Late Maunder Minimum), the southwest experienced warm periods (Zinke *et al.*, 2004). Historic texts report that there was a shift from herder-forager communities to raiding polities. This change contributed to the fragmentation of the *Grand Pays Machicores* and the formation of new sociopolitical organizations (Kottak, 1980: 52). This period saw the emergence of various chiefdoms in southwest Madagascar (Kent, 1970; Fagereng, 1971). Historic documents show that one of these polities, the *Zafindravola*, occupied the MSV during this period (see map of Sanson-le-Fils, 1667 in Flacourt, 1661). The timing suggests that the occupants of Keliangebo were part of this polity. During this period, groups in the southwest raided each other constantly (Grandidier & Grandidier, 1904). Even Europeans who were relatively acquainted with the area participated in this violence as Flacourt reported:

« *Le Sieur Le Roy avec vingt-deux Français à l'issue des Ampatres, fut à la guerre contre les Zafean Renavoulou vers la rivière d'Onghlahe 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.* » (Flacourt, 1661: 290).

"Le Sieur le Roy and 22 Frenchmen beyond the *Ampatres*, were at war against the *Zafean Renavoulou* around the *Onghlahe* River for *Dian Raval*, where they obtained 2000 oxen and cows, and many goods, among others, they found good amount of precious stones in the land they passed by on their way." [my translation].

This land where the French found precious stones was the upper Onilahy River, including the MSV. The MSV was already known for its precious stones during this period and remains an important mining region today.

Due to contact with foreigners, local rulers in the southwest during the 17th century CE started to use blunderbuss (*basy*) and muskets as weapons (da Costa, Freire and Mariano quoted in Grandidier & Grandidier, 1904: 9; Kottak, 1980: 51). The defensibility analysis showed that there is a strong relationship between the location of Keliangebo and its high defensibility. This demonstrates that due to intergroup conflicts, its occupants chose the site knowing in advance its potential for defense. This a priori knowledge of the landscape conforms with the NCT concept of counteractive relocation. Nevertheless, I did not find any evidence to prove that Keliangebo occupants used either blunderbuss or muskets. Future research might prove otherwise.

Despite the intergroup conflicts of the 17th century CE, the archaeological record suggests ongoing trade and exchange in the region (Rasolondrainy, 2019: 238-240). A tradition of graphite-burnished pottery with triangle-impressed decoration has been found in many regions of the southwest and beyond (Arnaud, 1970; Raharijaona, 1986; Rakotoarisoa, 1998: 89-91; Wright, 2007: 42-49; Parker Pearson, 2010: 262-267, 305-315). Keliangebo was part of this complex. The presence of this pottery tradition suggests that people in the MSV shared some cultural and ideological values and/or practices with communities elsewhere in Madagascar. They must have been connected to a broader culture system (Sauer, 2015: 40). In the southeast, Rakotoarisoa (1998: 98) described communities occupying fortified settlements bordering the Efaho River and using the same graphite-burnished pottery tradition between 15th-17th centuries CE. In the deep south, Parker Pearson (2010: 258-259) reported a profound social and political change between the 16th-17th centuries CE. During this period, communities using the same graphite-coated pottery tradition moved to more defensive locations and abandoned agricultural lands in the valleys. In the southwest, a few sites during the 16th-17th centuries CE were located in caves (Ramilisonina & Rakotoarisoa, 1971) and bordering streams or along the coast with no apparent defensive posture (Vérin, 1971; Douglass, 2016). It is striking to find that the positioning and context of Keliangebo was more like those of the deep south than those of the southwest. This might be because

Keliangebo was located within the *Grand Pays Machicores* cultural system that encompassed the areas between the Fiherena and Mandrare Rivers as reported by historic documents (see maps of Flacourt, 1661; Sanson-le-Fils, 1667). I argue that this connection either through kinship or alliance or partnership was an important social niche for the inhabitants of Keliangebo during its occupation. Oral historical records from the Velondriake area of southwest Madagascar, for instance, demonstrated that people constructed different social ties, such as kinship, marriage, trade partnerships, and so on, to access natural and social resources (Douglass & Rasolondrainy, 2021). The participation of Keliangebo occupants in the regional exchange of the graphite-burnished pottery with triangle-impressed decoration during a period of intergroup violence, thus, shows that they constructed a social niche that strengthened their resilience to the ongoing sociopolitical pressure.

The advent of the Late Maunder Minimum in the late 17th century CE (McIntosh, 2000: 156; Zinke *et al.*, 2004: 177-178; Mann *et al.*, 2009) brought the coldest period in the southwest for the last 400 years (Zinke *et al.*, 2004: 182). This marked the end of the occupation of Keliangebo, and the beginning of the occupation of Ankilivalo (Rasolondrainy, 2019: 299-300).

With regard to the economy, the relationship between the location of Ankilivalo and its proximity to arable lands is weak (Table 4), suggesting that people did not choose a site based on its proximity to arable lands. Robert Drury, an English sailor/slaver who became enslaved in Madagascar, was in the south and the southwest from 1701-1717 (Grandidier & Grandidier, 1906). He reported groups were still attacking each other during this period (Drury in Grandidier & Grandidier, 1906: 299). Because of the insecurity, people sometimes hid and did not cultivate the land. The internecine warfare exposed the inhabitants of the southwest to famine. People relied only on tamarind fruits, and other wild resources during this period of famines (Flacourt, 1661; Drury in Grandidier & Grandidier, 1906: 299).

The occupants of Ankilivalo might have been influenced by this pressure for they chose a place that is far from arable lands (Table 4). The geospatial analysis showed that proximity to permanent water sources and scrublands in the valley were the economic factors influencing their settlement choice (Table 3; Table 6). This demonstrates that Ankilivalo occupants had prior knowledge of the resource potential of the landscape before relocating to the

site, supporting the NCT counteractive relocation concept.

It is counterintuitive, however, to learn that, despite the ongoing intergroup violence, the relationship between the location of Ankilivalo and its total defensibility was very weak. The defensibility index of the site is very low (Table 10). Perhaps a powerful polity was already well established, so there was no need to settle at a defensible site. Historical documents of this period reported a situation where some chiefs under the authority of a king required the consent of the king to make decisions (Grandidier & Grandidier, 1907: 8). This, however, does not necessarily mean that the occupants of Ankilivalo were not interested in defending their habitation. Seclusion might have been used to hide from attackers (Jones, 2006: 536). Drury in Grandidier and Grandidier (1906: 299) reported that during the early 18th century CE, people hid in the woods due to internecine violence. The location of Ankilivalo might have conformed with this statement. The site is hidden by the hills surrounding it from the south, west, and north. Let alone, excavations at Ankilivalo uncovered a few gunflints and a large seashell bead, locally known as *fela* (Figure 4), that corroborated the presence of warriors. If so, then the Ankilivalo occupants might have chosen the seclusive position of the site to hide from enemies in the face of intergroup conflicts. This prior knowledge of the convenience of the landscape confirms the NCT concept of counteractive relocation.

In addition, both the seashell bead *fela* and gunflints recovered at Ankilivalo originated from the southwest coast, demonstrating the connection between the coast and inland areas. Kottak (1980: 52, 61) argued that intergroup violence during this period might have been fueled by the trade of slaves and firearms from the coast. The Onilahy River could have facilitated the movement of people during this period. This tie shows that the Ankilivalo occupants were constructing social niche either through kinship or trade partnerships with people outside of the MSV (Douglass & Rasolondrainy, 2021).

Between 1750 and 1800, the climate in the southwest warmed. Then a cold period returned in 1825-1850 CE, followed by another warm period between 1880-1900 CE (Zinke *et al.*, 2004: 177, 182). It is still not yet clear, however, how the occupants of Ankilivalo responded to these climate shifts.

Considering the good amount of cattle remains encountered at Ankilivalo (Number of Individual Specimens or NISP = 947), the occupants of the

site are likely to have been herders. The weak relationship between the site and grasslands was thus an unexpected finding. It is noteworthy, however, that local communities in the southwest for the last 400 years have practiced transhumance, moving their herds from place to place following seasons and availability of fodder (De Bry, De Constantin, and François Martin de Vitré cited in Grandidier & Grandidier, 1903: 145, 197, 284). Archaeological sites in the MSV might have been seasonal habitation sites during the lean season when fodder in the grasslands was not edible to livestock. The nitrogen isotopic values for the cattle samples from Ankilivalo conform with this (Table 8) in that they have the same values as those of extant mammal browsers elsewhere in the southwest (Crowley & Godfrey, 2012). That is, cattle fed on shrubs, leaves of trees within reach, and woody materials, suggesting that people herded their livestock more in the valley than on the open grasslands. This might have something to do with the fact that there was a strong relationship between the location of archaeological sites and the availability of scrublands in the valley (Table 6), where herds were feeding during lean seasons. Ethnohistorical data indicates that people typically kept their livestock in the valley only during a lean season or period of drought (Faublée, 1954: 33, 39; Rakotomanana, 2002: 14). This suggests that occupants of Ankilivalo experienced periods of climate upheaval. The coral proxies confirm this (Zinke *et al.*, 2004: 182). The

climate stresses of the 18th-19th centuries CE most likely influenced Ankilivalo occupants to choose a place in the valley to be near a water source and alternative fodder. This conforms very well with the NCT counteractive relocation concept. Although immediate proximity to grasslands was not important in choosing a site (Table 5), this does not mean the occupants of the site were not interested in the availability of pastures in the grasslands. They could always have moved there seasonally practicing transhumance such as described in historical documents (De Bry, De Constantin, and François Martin de Vitré cited in Grandidier & Grandidier, 1903: 145, 197, 284; Kent, 1970; Fagereng, 1971).

The relationship between the locations of archaeological sites and their proximity to forests also was weak (Table 7). Proximity to deciduous and *Tapia* forests was not therefore influential in the placement of Ankilivalo and Keliangebo. This analysis was based on the current size of the forests and is therefore susceptible to biases. Paleoenvironmental study might reveal a more accurate past area size of forests in the MSV. The MSV might have been densely vegetated in the past. Various resources in the forests would have been essential to archaeological communities. Resources of interest would have included firewood, hardwood for housing, medicinal plants, wild fruits, small game, etc. Furthermore, the proximity of these resources would have allowed people not to travel farther from



Figure 4. (Left and center) A *fe/a* recovered from Ankilivalo (Field Season 2015), and (Right) Bara warriors wearing *fe/a* on their foreheads (Credit: Postcard circa 1900 in Fee, 2004: 95).

the village to acquire these resources, which is good for easy transportation, but also for the safety of the members of the community during a period of intergroup conflicts (Engelbrecht, 2003: 103).

Superseding the above environmental and sociopolitical factors, however, was an ideological factor that heavily regulated all decisions made by people in the southwest in the past. According to ethnohistorical data, people believed that their lives were pre-destined by cosmic forces, and that they should live in harmony with the cosmological orders (Faublée, 1954). Infringements are believed to cause accidents and maledictions to the wrong-doer or the community(s) they belong to. Thus, for the last 400 years, community members have always consulted a diviner *ombiasy* before making any major decision or initiating any enterprise (Grandidier & Grandidier, 1904: 8). To choose where and when to settle, people had to consult a diviner to see whether the proposed location was favorable for the community (Belrose-Huyghues, 1983: 143; Kus, 1990: 50; Verin & Rajaonarimanana, 1991: 55). This ideological decision (divination) might not necessarily conform with the economic and sociopolitical interests of the relocating community. However, their social memory informed them to follow whatever instruction the *ombiasy* gave, even if the proposed location was hazard prone. This foreknowledge about places before relocating, though instructed by the *ombiasy*, conforms very well with the NCT counteractive relocation concept.

Although the divination *sikily* was instrumental to people's decisions, identifying remains of divination paraphernalia in the archaeological record is difficult. Most of the items used in the *sikily* are plant materials (grains and small wooden boards) that rarely survive in archaeological records. However, it is also known that to increase clairvoyance while reading the divination *sikily*, a diviner *ombiasy* usually puts a chunk of crystal or quartz in front of him/her (Rabedimy, 1976: 17, 39; Verin & Rajaonarimanana, 1991). I suggest a single chunk of crystal or quartz, if found within an archaeological context, especially within a house floor following cosmic orders, can be considered as evidence for the practice of *sikily* divination.

Conclusion

In sum, this paper demonstrates how people construct their niches not only based on biological and economic needs, but also on sociopolitical and ideological motivations. The niche construction here

does not involve any inceptive and perturbatory NCT categories that require organisms to modify their surrounding environments to survive (Table 1). It instead speaks to an NCT counteractive relocation that involves a repositioning of organisms from a pressured environment to a foreknown convenient location where they can improve their fitness (Odling-Smee *et al.*, 2003: 44-47). The paper looks essentially at the drivers (social memory and decision-making) behind a process of counteractive relocation (settlement choice and relocation).

The geospatial analysis showed that to respond to the unpredictability of climate, communities relocated to Ankilivalo and Keliangebo based on their foreknowledge that these sites are located near permanent water sources and alternative fodder in the valley (Tables 3 & 6). These resources likely helped them to survive during lean seasons and prolonged droughts. This demonstrates a case of counteractive relocation. In addition, the intergroup violence of 16th-17th centuries CE pushed the occupants of Keliangebo to move to a highly defensible site, while the inhabitants of Ankilivalo in the late 17th-19th centuries CE preferred to relocate to a secluded place and relied on their weapons to keep themselves safe. According to the geospatial and isotopic analyses, it is highly likely that social memory of the bountifulness and the defensibility of places along the MSV landscape informed people's decisions to relocate. Meanwhile, ethnohistorical records inform us that, for the last 400 years, social memory informed people in the southwest to make decisions primarily based on the dynamism of cosmic forces (Flacourt, 1661: 173; Luis Mariano in Grandidier & Grandidier, 1904: 230; Verin & Rajaonarimanana, 1991: 55). They had to consult a diviner *ombiasy* to unravel cosmic orders and inform them accordingly on their major decisions.

Indeed, there is a slight dichotomy between this ideology-based decision and the economic and sociopolitical decisions discerned by geospatial analyses. However, both are important evidence that help us understand more about settlement choice in the past. Without presenting the ideological factor, the geospatial analysis constrained us to believe that only proximity to resources and site defensibility influenced settlement choices in the 16th-19th centuries CE in southwest Madagascar. Meanwhile, the ethnohistorical reports reveal that in addition to economic and sociopolitical factors, the belief in cosmological order and instruction from a diviner heavily influenced settlement choices during this period. This ideological factor does not necessarily fit

with the economic and sociopolitical interests of the community. Therefore, we may not be able to discern it through a functionalistic analysis. There might still be a methodological limitation to demonstrating how far we can discern ideological information in the archaeological record and geospatial patterns. This, however, does not mean we should omit ideological information from our work when it does not fit the results of our geospatial and archaeological analyses. We still need to integrate different lines of evidence to study the past.

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