Title
A Sense of Space: A GIS Viewshed Analysis of Late Intermediate Period Sites in Moquegua Peru

Author
Gay, Brandon

Publication Date
2018

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA SAN DIEGO

A Sense of Space: A GIS Viewshed Analysis of Late Intermediate Period Sites in Moquegua Peru

A thesis submitted in partial satisfaction of the requirements of a Master of Arts

in

Anthropology

by

Brandon Gay

Committee in charge:

Professor Paul S. Goldstein, Chair

Professor Guillermo Algaze

Professor Thomas E. Levy

2018

The thesis of Brandon Gay is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California San Diego

2018

DEDICATION

To my family and friends who provided the support network that pushed me as I worked long hours in solitude.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to acknowledge the Moquegua Archaeological Survey (MAS) for providing the original dataset that was the foundation for this thesis. Without their notes and field reports this project would have never come to fruition.

I would also like to acknowledge Professor Paul Goldstein, whose advice and guidance helped me push this research to completion.

ABSTRACT OF THESIS

A Sense of Space: A GIS Analysis of Viewsheds of Late Intermediate Period Sites in Moquegua Peru

by

Brandon Gay

Master of Arts in Anthropology

University of California San Diego, 2018

Professor Paul Goldstein, Chair

This study investigates geospatial relationships among Late Intermediate Period (1000-1400 CE) settlement patterns within the Moquegua River drainage of southern Peru which were first identified in the 1990s by the Moquegua Archaeological Survey (MAS). A prevalence of walls and defensive locations and a largely vacant no-mans-land between down valley Chiribaya

and up valley Estuquiña settlements likely evidences an increased level of inter-cultural conflict in the region during the LIP that may have continued in the Late Horizon. Using viewshed analyses in ARC-GIS, this study proposes and compares two possible chronologies to explore how Chiribaya, Estuquiña, and Estuquiña -Inca settlements interacted or competed for the surrounding river valley through their direct or indirect control of resources, and their ability to defend against each other. Through the identification of these prime factors, this study aims to understand how the placement of settlements corresponds to the larger web of social interactions.

Introduction

The effects of warfare on societies is a major theoretical concern in social sciences (Arkush and Stanish 2005; Bridges 1996; Cohen 1984; Ferguson 1990; Otterbein 1999; Reichel 2009). There is debate to whom the definition of warfare applies. Ronald Cohen considers warfare to refer "to publicly legitimized and organized offensive and/or defensive deadly violence between polities" that may be caused for a number of social reasons (Cohen 1984, 330). This definition considers war as a form of "public policy" where the goal is victory over another polity and is reserved for higher forms of cultural complexity. What of the smaller localized forms of violence that may lack the structural complexity of a state-like institution? Under this definition all other violent actions are categorized as "warlike" violence and not strictly war. Cohen's definition fits those who are concerned with solving how warfare is related to the state and state formation and development therefore reserves the term warfare to highly political units (Carneiro 1970; Cohen 1984; Webster 1975).

Others provide a broader definition of warfare. Keith Otterbein considers warfare to manifest itself differently at all levels of social complexity that have some form of violence present. Otterbein provides two categorical groups for warfare: "internal war" where warfare is fought within a cultural unit, and "external war" where warfare occurs "between culturally different political communities (Otterbein 1968, 277). By broadening the types of violence that are under the theoretical purview of warfare Otterbein allows archaeologists to recognize what Lawrence Keeley describes (1996) as 'primitive warfare' as a set of violent, deadly and effective forms of war.

One region that was shaped by internal and external warfare was the pre-Hispanic Peruvian Andes. Elizabeth Arkush and Charles Stanish have convincingly outlined that the ancient Andean region was one of warfare and conflict (Arkush and Stanish 2005). In the Andes, conflict seemed to come in waves, and one such period followed the collapse of the Wari and Tiwanaku states of the Middle Horizon period (MH) and the beginning of the Late Intermediate Period (LIP) (1000-1400 C.E.) (Arkush and Tung 2013; Blom et al. 1998; Vranich and Stanish 2013; P. S. Goldstein 1993, 2000a, 2005; B. Owen 1994; Williams 2002). What caused the collapse of the Wari and Tiwanaku is often debated, putting primacy onto either sociopolitical or environmental causes (etc. Kennett and Marwan 2015; Ortloff and Kolata 1993; Williams 2002). Despite the controversy, after the collapse starts, in the LIP cultural landscape is fractured, as decentralized polities vied for power and resources through the consolidation of small regional spaces.

One prominent feature of this fractured landscape was increased prevalence of conflict, often evidenced by destruction of a site, use of fortifications, defensive settlements, and presence of skeletal trauma (Arkush and Tung 2013; Stanish and Levine 2011). The LIP marks a regional adoption of hilltop settlements, and prevalence of fortifications such as walls indicative of warfare during this period. Mortuary studies have shown a correlation between these settlement patterns and increased amounts of skeletal trauma further corroborating the conclusion of warfare (Arkush and Tung 2013). How communities responded to warfare in the Southern Peruvian Coast during the LIP were to move to more secluded defensible positions (Arkush 2008, 2011; Arkush and Stanish 2005; Bermann et al. 1989; McCool 2017). For example, the Colla of the Titicaca region congregated into large social groups to create sizable fortified positions on hilltops called *pukaras*, which used their large populations to construct large perimeter walls to defend themselves (Arkush 2011). On the other hand, the communities in the Nazca region of Central Peru, fortifications tended to be used by smaller groups who moved to the hillsides to protect their small populations (McCool 2017).

This project expands on this line of research by investigating settlement patters created by the convergence of two cultural groups, the Chiribaya and Estuquiña, along the Moquegua valley during the LIP (see table in P. S. Goldstein 2005, 123) (Table 1). Like much of the LIP, both the Chiribaya and Estuquiña settlements are located on elevated positions, often on top of hills and are considered defensible positions (Conrad and Webster 1989; Conrad 1993; Rice 1993). Further, occupation of the valley appears quite polarized with a majority of Estuquiña settlements congregated towards the northern edge of the river valley and the Chiribaya to the south (Figure 1). This leaves the middle region of the Moquegua valley sparsely occupied with few examples of settlements dating to the LIP. This pattern resembles possible buffer zones and other defensive use of settlements found elsewhere in southern Peru (Arkush 2008; Arkush and Stanish 2005; LeBlanc 1999). However, how these sites relate to one another and this buffer zone has not been extensively investigated, beyond brief recognition of these associations (B. D. Owen 1995, 3). This study attempts to explore these relationships and investigate how Chiribaya and Estuquiña settlements are situated in a period of warfare through a GIS analysis of viewsheds.

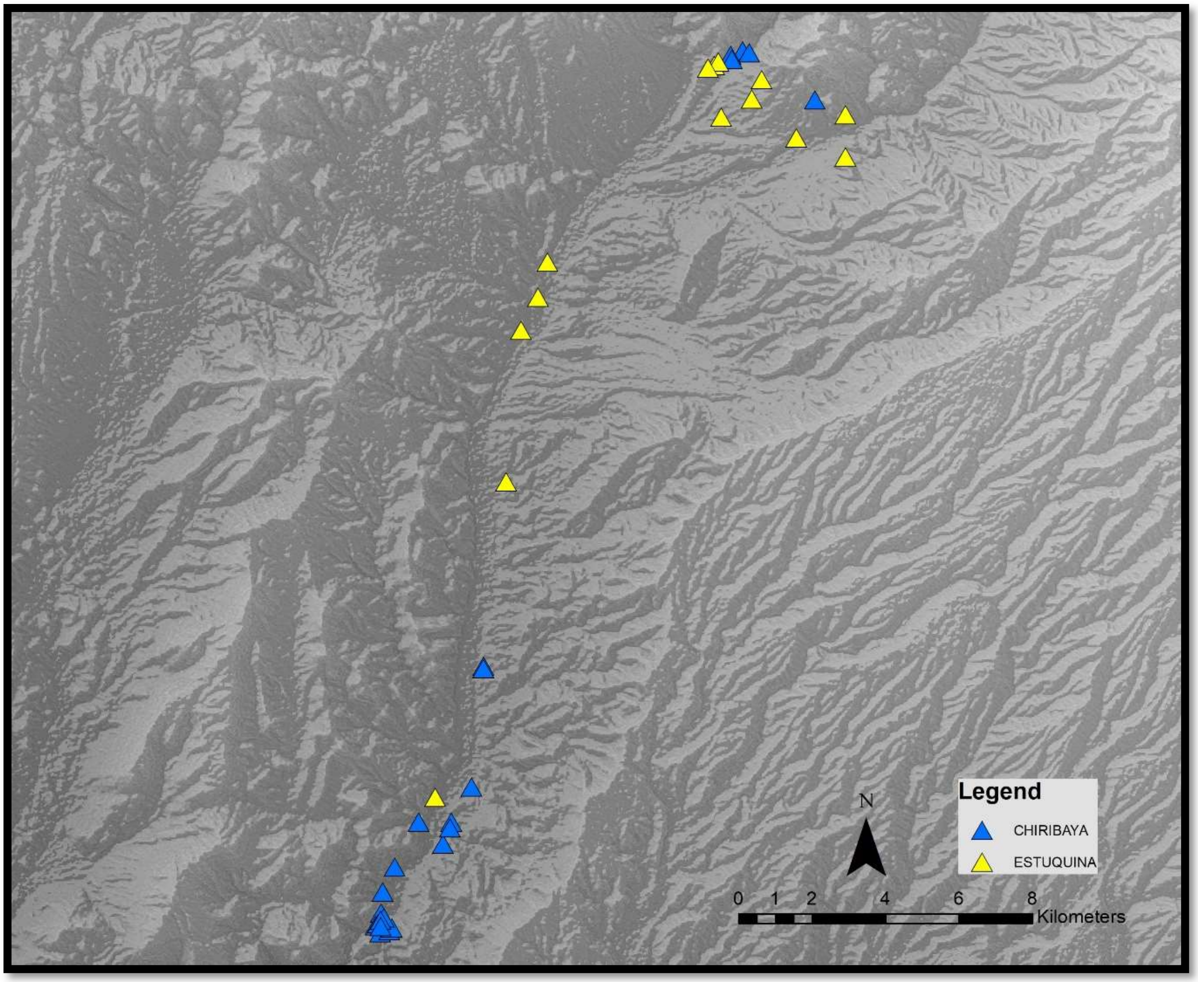

Figure 1: **Chiribaya and Estuquiña Settlement Locations** within the Middle Moquegua valley. Blue indicates Chiribaya settlements, and yellow indicates Estuquiña settlements.

Description of Study Area

The South American Andes form a spine along the western extent of the South American continent and create a compressed region of elevational extremes. The change in elevation is intense where within 400 km one can travel from sea level to the highest peaks of Peru up to 5,000 meters above sea level (m.a.s.l.) (Rice 1989, 23-29). This study is focused on the Middle Moquegua valley of southern Peru, in the Atacama Desert. Though the western South American coast tends to be arid, the Atacama Desert of southern Peru and Northern Chile (between 15 degrees south and 25 degrees south latitude) is notably more so, as it receives a minimal precipitation that averages 20-55 mm a year (Magilligan et al. 2008; Rice 1989). Despite this hyper-aridity, there are several river valleys, like the Moquegua valley, that act like agricultural oases dispersed throughout the Atacama Desert.

The Moquegua valley is a midland formation of the Osmore drainage system that creates a narrow habitable space (Rice 1989). The Osmore drainage system carries water from its headwaters in the Highland peaks of the Chuquiananta and Arundane mountains (5100 m.a.s.l.) and joins three tributaries, Rio Tumilaca, Rio Torata and Rio Huaracane in the northern Moquegua valley forming the Moquegua River. This river valley is situated within a wide arid expanse known as the Atacama Desert (Rice 1989, 19). The Middle Moquegua valley is situated between the confluence of three rivers at the northern extent of the valley at around 1500 m.a.s.l. and runs south west to 1000 m.a.s.l where it then narrows into a steep canyon that is difficult to navigate by foot or boat (Rice 1989). The valley itself provides enough flat land that river water can be diverted to produce agriculturally viable land. These river valleys have provided the only habitable areas within this heavily circumscribed space, and were a place where people migrated to throughout prehistory (Goldstein 2015, 2005).

Table 1: LIP sites from Moquegua Archaeological Survey (MAS)

Site Name	Sector Area hectares	Primary Culture	Secondary Ceramic	Fortification
M6	4.12	Estuquiña		Fortified
M8A	.43	Chiribaya		
M8B	1.93	Chiribaya		
M8C	1.27	Chiribaya		
M8D	1.54	Chiribaya		
M8E	1.44	Chiribaya	Tumilaca	
M8F	.20	Chiribaya	Tumilaca	
M18	.84	Estuquiña		Fortified
M20B	.95	Estuquiña	Huaracane	Fortified
M21A	.93	Estuquiña		
M57B	.10	Chiribaya		
M59A	1.08	Chiribaya	San Miguel	
M59B	.23	Chiribaya	San Miguel	
M59E	1.68	Chiribaya	San Miguel	
M66A	.008	Chiribaya	Tiwanaku	
M66B	.02	Chiribaya		
M68G	.12	Chiribaya	Inka	
M71D	.13	Chiribaya	Huaracane	
M71E	.003	Chiribaya		
M110A	.61	Chiribaya	Tumilaca	Fortified
M115	.01	Chiribaya	Tumilaca	
M120	.06	Chiribaya	Colonial	
M123	.37	Estuquiña	Colonial	Fortified
M166	.70	Estuquiña	Huaracane	
M188A	.07	Estuquiña	Huaracane	Fortified

Table 1: LIP sites from Moquegua Archaeological Survey (MAS), continued

Site Name	Sector Area hectares	Primary Culture	Secondary Culture	Fortification
M190	.05	Estuquiña		Fortified
M191C	.63	Estuquiña		
M209	1.11	Estuquiña		Fortified
M213	.74	Estuquiña	Huaracane	
M217	.11	Chiribaya	Tumilaca	
M219B	.06	Estuquiña		
M221	.66	Estuquiña		
M222	.08	Estuquiña		
M223B	.40	Chiribaya	Tumilaca	Fortified
M224A	.08	Chiribaya	Tumilaca	
M224B	.19	Chiribaya		

Local Cultural Timeline of the LIP (1000-1400 C.E.)

To contextualize the discussion of the Chiribaya and Estuquiña it is important to recognize the LIP spans 400 years during which the Moquegua valley experienced movements of people into, through and out of the valley. As stated previously, archaeologists have interpreted the LIP as a period of socio-political decentralization and increased levels of warfare (Arkush and Stanish 2005; Arkush 2011; McCool 2017; Sims 2006), after the collapse of the Tiwanaku and Wari states at the terminus of the Middle Horizon (MH).

Within the Moquegua valley and throughout the coastal southern Andes, archaeological data evidences a local rise of material cultural practices referred to as the Tumilaca period 900-1000 C.E. (Bermann et al. 1989; Sims 2006; Sutter and Sharratt 2010). The Tumilaca material culture resembles the preceding Tiwanaku culture but lacks state iconography and is stylistically more variant (P. S. Goldstein 1989, 243–53, 2005, 170–77; Sharratt 2011). Along with this change in ceramics, settlements close to the valley were abandoned and new settlements were established away from the valley floor into a more defensible location on top of hills (Bermann et al. 1989; Owen 2005; Sims 2006).

The Tumilaca period ended with the arrival of the coastal Chiribaya moved inland and began colonizing the river valley approximately 1000 C.E. (Rice 1993, 72). Chiribaya origins are uncertain, though the depth of cultural materials along the coast may indicate an independent coastal community that had inhabited the Ilo region well before the decline of the Tiwanaku (Bawden 1989, 51; Owen 1992, 6-8). Chiribaya material culture is identifiable through the use of distinctive white dot pattern, that differentiates itself from other styles (Bawden 1989, 45). The Chiribaya type site is Chiribaya Alto, a 36 ha site six km inland from the coast, north of the modern day town of Ilo (Rice 1993, 69). Don Rice describes the approach to Chiribaya Alto as a "ditch and mound fortification" that prevents access from easily traversed terrain and butted against a "dramatic natural drop to the river bellow"(Rice 1993, 69). The sites size and complexity have led some to consider Chiribaya Alta the regional center for a hierarchical Chiribaya polity (Rice 1993, 70).

After the decline of the Tiwanaku and Tumilaca, the Chiribaya began to expand outward occupying sites along the coast line between Osmore and Tambo rivers (Zaro et al. 2010), inland into the Osmore drainage (Rice 1993), and south where Maityas/Chiribaya are found in the Azapa valley of northern Chile (Rivera 1991). Within the Moquegua valley itself, the site of La Yaral (M8) is a Chiribaya settlement with a large central plaza and hillside residential terracing along the northern slope (Rice 1993; Buikstra 1995). There are some differences in carbon dates of La Yaral's occupation, but with dates between A.D. 950-1302 (Stanish and Rice 1989, Table One; and Rice 1993, 72). Beyond La Yaral, there are several Chiribaya settlements throughout the Moquegua valley with the most settlements to the south, and some near the northern extent of the valley (M224A, M224B, M223B, M217) (Figure 1). These northern sites are small and their affiliation is currently unclear, as is discussed below. Current archaeological research has not identified any developed fortifications like walls but some Chiribaya sites appear defensive by their hilltop position. Stable isotope analysis showed that Chiribaya people in the Moquegua valley had a diet that consisted of agricultural products such as maize, and marine resources such as shellfish and fish; which may indicate a connection to the coast (Langsjoen 1996; Tomczak 2003).

The Estuquiña cultural group likely originated from the highland with many of their sites further inland from Moquegua, in the Torata valley (Burgi 1993, 32–40). Within the Moquegua valley, Estuquiña settlements occupied primarily the northern extent of the valley, with early carbon dates from Estuquiña (M6) placing occupation from A.D. 1280-1488 (Stanish and Rice 1989, table 1; and (Conrad 1993, table 5.1). The Estuquiña type site is the site of Estuquiña (M6) which like many Estuquiña sites is placed on a defensible hill with a large external wall (Conrad 1993; Burgi et al. 1989, 332; Borstel, Conrad, and Jacobi 1989). The wall is .5 meters wide and 2 meters tall and is constructed by local unshaped stone (Conrad 1993). The interior of the site is divided into square rooms, a pattern that is replicated with some variation at other Estuquiña sites (Conrad 1993, 58-60). Estuquiña ceramics are predominantly unpainted with certain characterizable forms such as the boot pot and Estuquiña bowl (Burgi 1993; Stanish 1991).

The political economy of the Estuquiña has been difficult to assess. The lack of complex artistic ceramic styles and other elite level goods has led to the common interpretation that

Estuquiña settlements were "nucleated [and] relatively autonomous" during the LIP (Burgi 1993, 148). Further, despite similarities of ceramic goods and structures, variations in style have led some to argue that the Estuquiña may have been a multiethnic polity (Conrad 1993). This argument has left open the question concerning who the fortifications of these settlements were meant to keep at bay? Did Estuquiña have internal or external kinds of warfare?

Though there is a general chronology in place, the length of contact in the valley is difficult to assess. There are painted Tumilaca and Chiribaya wares within Estuquiña contexts in the Torata valley, and that may appear to signify contemporaneity. However, it is also likely that these ceramics are indicative of earlier occupations that were resettled by later Estuquiña (Burgi 1993, 154–64). Relative dating is also made difficult due to the lack of sedimentation outside of the flood plain. There are absolute dates within the valley for both cultural groups, but the confidence intervals indicate either contemporaneity or a gap in time between occupations of the river. Within the Moquegua valley, dating by Rice and Conrad for the sites of La Yaral and Estuquiña makes it probable that Estuquiña occupation of the Moquegua valley occurred while Chiribaya were still in the valley (Rice 1993; Conrad 1993; B. D. Owen 1995, 3).

Goal of Research

This project sets out to assess this interaction by investigating settlement patterns of these archaeological cases. All of the settlement data compiled in this project is thanks to the Moquegua Archaeological Survey project (MAS) directed by. Paul Goldstein with multiple field seasons from 1993-1995 and 1998-2005 (P. S. Goldstein 2000b, 341, 2005, 119–23). This systematic survey of the middle Moquegua valley identified over 400 sites from all periods of occupation with sites identified to have existed throughout the timeline of the occupation of the valley. Some sites were previously known (M1-M43). Most sites (M44-M226) were first identified by MAS through a systematic pedestrian survey, with field analysis of ceramic styles that allowed for relative dating and assignment of cultural affiliation, and subsequent mapping, collection and testing of some sites. This present thesis analyzes a subset of this expansive dataset limited to 21 Chiribaya and 14 Estuquiña habitation sites (P. S. Goldstein 2005, 123) (Figure 1).

To analyze these data Geographic Information Systems (GIS) are employed. GIS are computer programs used to manage, display, and analyze data that contain information referenced to a specific location on Earth. Originally, GIS were developed and designed for applications in urban planning, with many of the quantitative tools geared towards land tenure and urban planning (for a more comprehensive history of early GIS development see: Coppock and Rhind 2017). There is debate within the geographic community about what GIS is: either a tool for mass use or a science requiring its own theoretical grounding (for more on this debate see: Wright, Goodchild, and Proctor 1997; Pickles 1997; Yano 2000). Many academic and private fields such as public works agencies, historians, and, importantly for this thesis, archaeologists have benefited from the geospatial analytics provided by GIS software (Knoerl 1991; Ottensmann 1997; Sweeney 1997; Constantinidis 2009; Yano 2000).

This widespread use of GIS has been accelerated through programs such as Esri's ArcGIS suite, GRASS, and QGIS. With spatial analytics contained in GIS software, researchers can analyze the complex spatial relationships found in archaeological data (Conolly and Lake 2006). With a better understanding of these relationships, archaeologists have rapidly begun to reinterpret and quantify aspects of cultural landscape, such as viewscapes see below (Bernardini et al. 2013; Bongers, Arkush, and Harrower 2012; Llobera 1996; Rua, Gonçalves, and Figueiredo 2013; Sakaguchi, Morin, and Dickie 2010), proximity to resources, and least cost paths (Gustas and Supernant 2017; Schild 2016; Richards-Rissetto and Landau 2014). This allows for a rapid and quantifiable interpretation of how historic and prehistoric individuals may have interacted within their environment. As technology develops and researchers become more versed with geospatial analysis, archeologists can ask more complex spatial questions.

It is the design of this thesis to use the ArcGIS 10.5 viewshed tools to explore aspects of defensibility and resource control between Chiribaya and Estuquiña settlements during the LIP in Moquegua Peru. This project asks: does a convergence of cultures along a frontier solidify similar groups in the face of an opposition? To this question the present thesis proposes the following hypothesis based on defense patterns documented by Elizabeth Arkush in the Titicaca region (2011): warfare and threats of violence would force communities to seek defensible locations in higher elevations, at the expense of important resources. If this is true, then the following would occur within the viewshed. As settlements prioritize defensibility they would maximize distances away from possible threats while congregating near allies. This would result in a viewshed that has little visibility of enemies, as spaces between grew larger in the formation of buffer zones, and friendly groups would have higher rates of line of sight between settlements. Visual space over agriculture would result in a similar pattern where, areas of viable agricultural land would become less visible as a buffer zone would form between opposing groups, and there would be more visual overlap in areas of agricultural land between allies.

To contextualize this argument the subsequent section provides a background on the theoretical framework of landscape, decision domains, and GIS use as they pertain to the creation and testing of these hypotheses. How these hypotheses were approached is presented within a methods section that describes how data were collected, created, and analyzed through this project. The viewshed and data compiled in this thesis is presented in a results section. Then a discussion section covers how the viewsheds relate to agricultural land, communal defensibility, and the buffer zone. This paper concludes with a section that briefly synthesizes viewsheds, results of this project, and goals of future research.

Background

Archaeological Data of the LIP in Moquegua

The original spatial data for the LIP sites used in this study were provided by the Moquegua River Archaeological Survey (MAS). MAS was a systematic survey led by Paul Goldstein from 1993-1995 (P. S. Goldstein 2005, 123). They surveyed approximately 150 km^2 area with six individuals providing transects at 20-meter intervals. The survey was focused from the valley floor to the upper ridgeline to identify archaeological sites within the Moquegua valley. The results of this survey are the discovery and recording of over 400 archaeological sites, including 21 Chiribaya and 14 Estuquiña sites, along the valley. Their findings showed a general decline in settlement intensity within the valley following the Middle Horizon, with total Tiwanaku occupation totaling 141 hectares, and by the LIP occupation area declined to 28.5 hectares in total (Goldstein 2005, 134 and 176). There were some excavations carried out by MAS on certain LIP sites, for example at the site of El Ramadon, but were not published, and will be the focus of future projects.

Though survey provides a broad context for spatial relationship of settlements, much detailed information on settlement composition is through excavations of LIP sites in the 1980's and early 1990's. Excavations of the Moquegua valley Chiribaya site La Yaral (M8) by Don Rice in the 1980s and 90's procured carbon dates placing occupations between cal 1027 +/- 50 and 1252 +/- 50 CE (Rice 1993, 72) (Calibrated using the CALIB 2.0 radiocarbon calibration program). Though there was a wider Chiribaya influence on the valley it is apparent that La

Yaral is the largest Chiribaya settlement in Moquegua (Rice 1993, 66–70). Approximately 40 km from the coast, La Yaral is located at the bottom of a large hill with extensive residential terracing up the steep slope of the hill to the north. As at other Chiribaya sites, terracing seems to support domestic occupation with structures on the terracing built of cane and plastered clay. In addition, La Yaral is located where the Moquegua River could provide adequate water for its flood field agriculture (Rice 1993, 70–82). Between La Yaral and the Chiribaya coastal settlements, the Osmore River enters a steep canyon that is impossible to occupy. Despite this difficulty, the inhabitants of La Yaral seem to have had diets high in marine resources, indicating connections to the coast and the Chiribaya culture core despite the steep canyon (Knudson, Aufderheide, and Buikstra 2007).

Other Chiribaya sites are located throughout the valley (Figure 1). A majority of Chiribaya sites are congregated near La Yaral towards the southern edge of the river valley where the valley narrows. MAS did discover four Chiribaya occupations towards the northern extent of the valley recorded as M224A, M224B, M223B, M217. Not only do these four sites lack any stable architecture and are marked as a dispersion of both Tumilaca and Chiribaya ceramics, they are also considerably smaller (average area .17 hectares) than Chiribaya sites further south (average area .61 hectares). The northern sites are well within what would be considered Estuquiña territory and will be a topic of discussion later in the thesis.

On the northern end of the Moquegua valley are the Estuquiña who came to the valley from the highlands around 1200 AD (Conrad 1993, 55). Estuquiña settlements are notably more defensive then Chiribaya settlements. Estuquiña settlements are located on hill tops, often with steep slopes, that limit access to one or two routes making them difficult to access, in addition to their placement there are several with perimeter walls of unaltered stones (Owen 1993, 4).

Estuquiña settlements were also generally larger (average .81 hectares) than Chiribaya settlements (average .53 hectares)

The site of Estuquiña (M6), which is located on the northern end of the Moquegua valley at 1500 m.a.s.l., is a large settlement at 4.1 hectares located on an elongated hill along the valley floor. This site of Estuquiña is a highly defensive residential site with a large external peripheral wall that was approximately 50 cm wide and two meters tall (Conrad 1993). Carbon dates collected by Conrad place occupation of the site between A.D. 1280-1640 (Conrad 1993, 56). The internal composition of the site has major rooms outlined by large walls with internal subdivisions demarcated by cane walls (Conrad 1993, 59–62). Most archaeologists agree that these subdivided areas were private homes (Conrad 1993; Stanish 1989). This site also has several mortuary sectors located inside and around the residential areas indicating a long-term investment in the site. Other Estuquiña settlements in the Moquegua valley resembled this general composition of M6, but differed from upper valley Estuquiña sites like San Antonio. This differentiation has lead Conrad to put forth a hypothesis that the Estuquiña were comprised of two ethnic groups he called Estuquiña-Tumilaca and San Antonio-Otora group, though future research is needed to substantiate that claim (1993, 64).

How did the Chiribaya and Estuquiña interact during this brief period? Most consider the defensive structures of the Estuquiña to be indicative of violence though there is minimal osteological evidence (Arkush and Tung 2013, 341; Owen 1995; Williams 1990). Paul Goldstein argues that the Estuquiña use of canals in the upper end of the valley could cause water shortages down river (2005, 178). Inca influence in the river valley is associated with some Estuquiña sites, as is the presence of Inca ceramics at site M21A. The presence of Inca ceramics complicates relative dating and an Estuquiña-Inca subphase cannot be clearly ruled out in the relative chronology of settlement (Stanish 1991). Though a majority of Estuquiña sites are located towards the northern half of the valley, site M21A, M123, and M18 are all settlements that occupy an area where the valley narrows and are relatively close to the Chiribaya (Figure 1).

Landscape Theory and Settlement Placement

To interpret how Chiribaya and Estuquiña settlements may have shaped interactions between Chiribaya and Estuquiña communities, this thesis employs the concept of landscape. How humans relate to the environment is of theoretical importance to anthropology in general (Low 1996, 2003) and archaeology in particular, which is limited to physical remains (Moore 2004; Wernke 2007; Fowles 2010; L. Goldstein 1981; Hodder 1972; McCoy and Ladefoged 2009). One way that this relationship has been studied is through the theoretical lens of landscape. Archaeologist John Walker recognizes that the concept of landscape has many definitions with little consensus on its application (Walker 2012). Walker provides a definition of landscapes as "the product of interactions between communities of people and nonhuman entities that is geographically defined and historically specific" (Walker 2012, 210). Anthropologist Tim Ingold provides a similar definition for landscapes as " the world as it is known to those who dwell therein, who inhabit its places and journey along the paths connecting them" (Ingold 1993). Recognizing that there is disagreement on the definition, "landscape" is used here to represent the relationship between humans and the environment, where through human interaction with the physical environment individuals attribute cultural *significance* to aspects of that physical environment. 'Significance' is deliberately vague and is meant to encapsulate both human wants or needs of natural resources (such as food, water, stone, and ores) and the subjective human experience based on cultural symbolic values.

One important aspect of the landscape is the places humans construct to use and live in. Architect Amos Rapoport recognized that buildings are not only a byproduct of the physical world, both in terms of the laws of physics and local resources, but instead, architecture is the result of a complex balance between the physical world and human desires (1977). Rapoport termed these considerations of the architect as a series of decision domains. Though not completely transparent even to the members of the society, the social decision domains help mold how humans decide to situate and contextualize themselves within the complex landscape of the world around them (Ryden 2006). Where decision domains recognize how the beginning of a structure is based in social goals, it does not consider how a built structure can continually shape future interactions. Archaeologist Elizabeth Arkush terms this future interactions between society and the constructed spaces as part of "landscape patrimony" (Arkush 2011, 12–13). Her primary example is the creation of a fortification. Though a fortification is initially developed based on the community need to defend itself from some outside force, after construction the fortification then provides the means for the community to plan an offensive without fear of reprisals. In other words, aspects of the built landscapes then shape the future social landscape.

Through the concepts of decision domains and landscape patrimony, settlements become an intersection of social needs that then impact future interactions. Placement of a settlement within the landscape then is not an arbitrary interaction with just the physical environment, rather it is an intersection of mediating factors both environmental and social. Regional projects such as the MAS, provide a wider context towards understanding archaeological prehistory (Goldstein 2005). Through the identification of factors, such as visibility, settlements' positions then allow researchers to interpret the social landscape in which communities were situated in. In turn through the identification of social domains of settlements, we can discover more about how these communities interacted and shaped each other during the LIP.

Viewsheds

One aspect of landscape is human experience and one aspect of that experience is the ability to visually experience it. This idea of visibility and how it relates to a social landscape is nothing new. Since Foucault's discussion of the panopticon, visibility has fascinated social sciences (1995, 195–200). There are multiple methods to explore how vision interacts with the cultural landscape in an archaeological dataset. Methods sometimes focus on subjective experience, employing personal perspectives to understand sites. For example, archaeologist Christopher Tilley proposed a phenomenological approach to exploring landscape, where a researcher can physically walk through the archaeological site and through personal experience glean some cultural meaning from it (Tilley 1994). Interpretations using this method have been criticized for their primary assumption on the universality of the human shared experience and leading to problematic results (Fleming 2006). To avoid this, other archaeologists enacted more quantitative methods to interpret the landscape using statistical analytical techniques, such as k-means and nearest neighbor analysis, to understand distribution of data across a site (Kintigh and Ammerman 2008; Moore 1992). Now, with computer-based GIS approaching, these questions are easier to explore.

One approach to interpret visibility is through the implementation of a GIS viewshed analysis. Viewsheds are a GIS tool that allow for a quick comparison of surrounding elevations to discern areas visible from a defined location (Conolly and Lake 2006, 228-33). As such, viewsheds have become a prominent feature in archaeological literature that deals with vision of the subjective and physical landscape (McEwan and Millican 2012). Currently many archaeologists have used viewsheds to investigate areas of high cultural concern such as monumental architecture (Bongers, Arkush, and Harrower 2012), settlement power dynamics (Wernke 2007)), ritualized experiences (Llobera 1996, 2007, McCool 2017), and defensibility (Rua, Gonçalves, and Figueiredo 2013). The conceptual argument between each study is simple: an area of high visibility either from or to a specified location has a value to the society that picked the location to begin with. A modern example are viewpoints off United States of America highways, that are selected specifically because the area that is visible is considered "beautiful" from that exact point.

Within archaeological literature, vision is often considered a part of defensive strategies during times of conflict. In the Mid-Fraser River region of Canada, archaeologists used viewsheds to argue that hunter-gatherer sites within the Canadian plateau maintained line of sight (LOS) with other sites as part of a defensive suite to allow for visual response to allies being attacked (Sakaguchi, Morin, and Dickie 2010). A similar LOS defensive network was shown through a viewshed analysis of the fortification system of the Lines of Torres Verdas of the Peninsular War. Each defensive LOS of this military trench formation maintained visual contact to another trench, to communicate with each other and relay messages to their commanders (Rua, Gonçalves, and Figueiredo 2013). Within the Lake Titicaca region of Peru Elizabeth Arkush used viewshed analysis to determine line of sight between pukaras to identify possible coalitions among the Colla in the altiplano (Arkush 2011,159-61). Thus, a defensible site would have greater field of vision that would assist in its defense.

Viewsheds produce a raster that determines only what can be seen, not what individual agents might have looked for. Though this may be considered a general weakness of the tool, it also allows patterns to emerge beyond the researcher's original beliefs. On this note, this thesis looks for regions that are within view of every site and where multiple viewsheds would intersect with known resources, and other settlement locations. By comparing multiple site viewsheds as a heuristic this thesis hopes to discern a pattern in the data that can illuminate decision domains that went into the selection of a settlement locations.

Methodology

This section discusses the processes and methods in creation and analysis of data for this project. Section One is the methodology on the procurement and creation of initial datasets that was used in this project. Section Two focuses on what methods and parameters were implemented on the original datasets.

Settlement Spatial Data

The original spatial data for the LIP sites used in this study were provided by the Moquegua Archaeological Survey (MAS) which carried out a systematic survey of the Middle Moquegua valley over multiple field seasons in 1993-1995 (P. S. Goldstein 2005, 119-123). The results of this survey documented over 400 archaeological sites, including 22 Chiribaya and 14 Estuquiña sites, along the valley (Figure 1, Table 1 and 2). Site locations were initially recorded in a series of pace maps and field notes that recorded site dimensions and locations. Survey results showed a dramatic reduction in occupation with the Middle Horizon Tiwanaku maintaining occupation of approximately 141 hectares, and after the LIP occupation never grew past 28.5 hectares till colonization (Goldstein 2005:175-178).

The MAS survey recorded these data through a series of sitemaps either done with Brunton and pacing, or in several cases, total station and plane table, showing the general dimensions of the sites (typically in 1:250 or 1:500 scale), and 1: 10,000 agricultural maps that recorded approximate location of all settlements. Sites M18, M21, and M59 were produced through a combination of unpublished plane table or total station maps, and M8 and M6 were corrected by referencing unpublished MAS maps, and published maps (Rice 1993, 73; Williams et al 1989, 331). Sites were classified by identifying ceramic style, surface artifact dispersal, and the presence of architectural features on standardized forms. The numerical and descriptive data were digitized previously into a site database that was projected in ARCIS settlement maps, using the southwest corner of the site recorded in Provisional South American Datum (PSAD56) projection (Goldstein 2005, 2015).

For this study, the spatial data set was digitized and operated on within ESRI's ArcGIS versions 10.4 and 10.5. First, all-southwest corner PSAD56 points were transformed into the WGS_1984_19S projection of the Universal Transverse Mercator (UTM) coordinate system. These spatial points were displayed in GIS to provide initial northing and easting of each site. Pace maps, and published or unpublished total station or plane table maps were digitized and georeferenced as shapefiles within ArcGIS, through a visual comparison of ESRI's satellite imagery (ESRI default imagery), Google Earth imagery, and SAN aerial photography from 1947 and 1970. The process is to identify general features visible in the imagery that are indicative of the site maps. Once identified, control points are created on the feature visible in the imagery and the map, these control points rescale the map to resemble the dimensions set by the control points.

Two scales of maps were georeferenced, first the MAS created a regional summary map recorded on a series of 1: 10,000 agricultural maps, that recorded site location and basic perimeters of sites along the Moquegua valley. This map was used to develop a shapefile that marked the approximate perimeter of sites along the Moquegua valley. Due to the focus of the base map on agricultural features, many of topographic lines were focused along the valley and agricultural developments. The small scale made these locations approximate and the disparity in detail, caused sites near the valley floor to have accurate spatial location and sites further away less so. To remedy this issue with the summary maps, larger scale, more accurate, and highly detailed aerial photography and site maps were georeferenced prior to the creation of shapefiles.

A perimeter of each site was recorded as shape files that was produced through a comparison of the 1:10,000 maps, field notes, site maps, satellite imagery, and aerial photography. As with any georeferenced mapping there are inherent inaccuracies, that may be improved by ground positioning systems (GPS) in future field surveys. There are several archaeological sites found during the original survey that are damaged to modern development.

Most of the tools and analytics (discussed in greater detail below) required the data to be converted from a polygon shapefile to point feature format. To obtain these coordinates, the shapefiles were converted into point files based on the shapefiles' centroids, or middle points. The centroid method was selected because it allowed for quick conversion of each shapefile into a point feature and would provide a decent summary of vision of the site location.

Digital Elevation Model

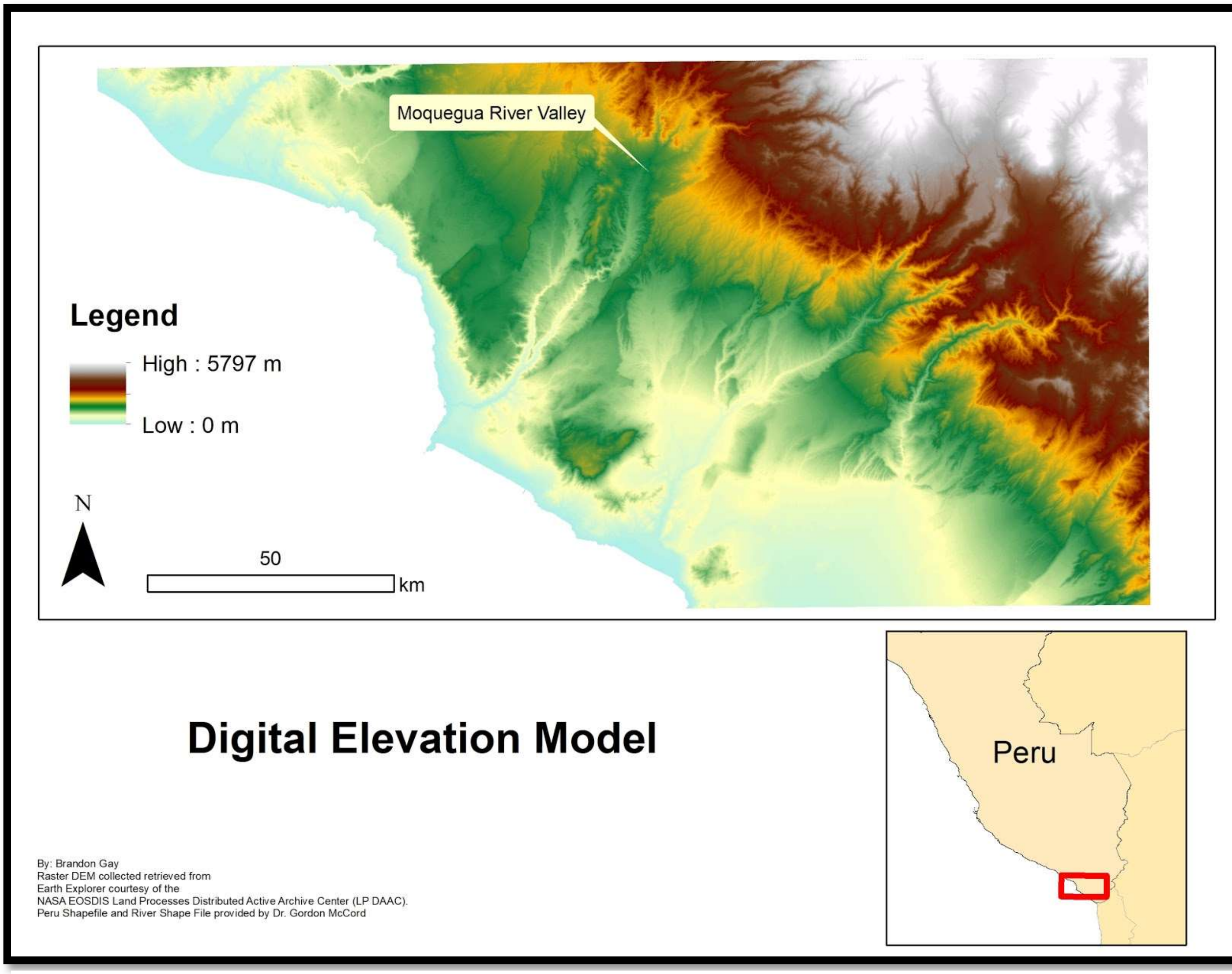

Figure 2: **The Digital Elevation Model** ASTER DEM of the study area which provides the base elevation values used within this thesis. Note that any values equal to or below zero are not depicted.

A viewshed analysis requires an accurate digital elevation models (DEM). DEMs are, as the name suggests, elevation data that are recorded in two-dimensional space. Currently there are many DEMs available through third party sources that are collected through a variety of methods (McCoy and Ladefoged 2009); however as one moves to more remote areas; such as the Moquegua valley; the selection becomes quite limited. A popular format to record DEMs is within a raster data set. A raster is a grid-based data summary system for a single variable where each grid cell has a numeric value of that specified variable. This allows for the recording and display of this variable for a wide area. In the case of a DEM the variable recorded of the cell is elevation.

Resolution is a crucial factor in selecting DEMs and must be weighed based on each individual project. Lower resolution provides quick processing and are relatively smaller file sizes that are easier to store, and ideal for national or continental projects. But, with these lower resolution DEMs smaller features, such as trees or walls, are likely missed. At higher resolutions, these features become more detectable, but processing requires more time and computer power and generates exponentially larger files (for some examples of resolution effects on general studies refer to Bamber, Ekholm, and Krabill 2001; Wolock and Price 1994; Zhang and Montgomery 1994), and sometimes archaeological features are still not detected (Crutchley 2006). In the end it is left to the researcher to decide what costs, both fiscal and processing time, and benefits would be necessary for their study.

For this thesis, selection of a raster was limited to an Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model (ASTER GDEM) (Figure 2) due to its affordability, free from United States Geographical Survey (USGS), and the survey area's remoteness. ASTER GDEMs are a product of NASA and METI, and part of the Shuttle Topography mission which recorded global elevation at a sample rate of 1-degree intervals (approximately 30 m x 30 m cells) with a .02 m vertical accuracy. This large dataset is of moderate resolution and has been used in multiple scales of study to great effect (Schild 2016; Kosiba and Bauer 2013; McCoy and Ladefoged 2009). One issue present in ASTER GDEM is that sampling gaps can be caused by areas of steep topography and result in missing data. Thankfully this issue did not affect the study.

The Global DEM is broken down into smaller regional data sets known as ASTER DEMs and two of these DEMs that cover the Moquegua valley regional DEM were selected for this study. The moderate resolution of this ASTER DEM is ideal for this project as it provides a balance between higher resolution accuracy and lower resolution process ability. Further, issues with lower resolutions are mitigated due to the arid nature of the region; which limits the development of trees and other vegetation that may obfuscate the viewshed analysis.

The original ASTER DEM was projected in WGS_1984 which is a geographic projection system that displays information in unit degrees. This data had to be re-projected into WGS_1984 UTM 19s which displays data in a meter system so subsequent distance tools could be accurately implemented. To perform this transformation the ArcGIS 10.5 projection tool was used and the WGS_1984 to WGS_1984 Zone 19s projection transformation was selected. Since the study area is located so far inland, sea-level was not an issue for this study and no conversions beyond this were required on the original data set.

Agricultural Land

Recently, modern agricultural land use has expanded to a much larger extent than in the past due to industrial pumps. To avoid overestimating agricultural extent, a Normalized Difference Vegetation Index (NDVI) was run on regional LANDSAT imagery to identify regions with higher plant productivity. NDVI is a simple calculation that compares near infrared light (NIR) to the visible spectrum to determine plant life in imagery (Carlson and Ripley 1997; Gamon et al. 2016). Mathematically it is written as:

$$NDVI=(NIR-VIS)/(NIR+Vis)$$

Healthier vegetation will absorb more solar radiation and in turn emit larger quantities of near infrared radiation compared to unhealthy plants and the surrounding landmass. After running an NDVI, areas near the natural river system appeared to have a much denser vegetation area then modern developments. The resulting map was visually compared to black and white aerial photography from 1947, a time before the industrial pumping project began in the region. The air photos available for this study did not cover the entire valley and the NDVI allowed for a quick and efficient check to verify the agricultural land use. This comparison was by eye and resulted in a shapefile of valley-bottom agricultural land likely to have been irrigable in the LIP.

Viewshed Analysis

A viewshed tool simulates the areas visible to an observer based on specified vantage point. To do this it takes an elevation of the vantage point, either given to the program or inferred from a provided DEM; and compares it to surrounding elevation values. When there are areas with a higher elevation relative to the original vantage point the program treats everything behind it as not-visible. The tool computes these results and generates a binary raster of visibility with visible cells given a value of one and not-visible cells given a value of zero (Connolly and Lake 2006, 230). There are many viewshed tools available for use, and this thesis used the ArcGIS 10.5 viewshed tool to determine these viewsheds. This tool was selected due to its expediency and capability to sustain operation over the large dataset. To determine the size of visible areas the raster was converted into shapefiles and compute geometry tool was used.

This analysis was run independently on each settlement of the sample to produce site level visibility. Though this was useful to determine visibility from settlements, the results of visibility often overlapped and resulted in an overestimate of visible areas when considering total visibility by community and total visibility in the resulting shape file. To lower the likelihood of such occurrences, additional viewshed analysis were run. First, a viewshed analysis was run on the entire sample of LIP settlements to determine the total viewshed area during the LIP. Second, analysis was divided based on cultural affiliation to determine visible area by cultural affiliation. Other viewshed analyses were run with and without four Chiribaya sites (M224A M224B, M223B, and M217), because each of these Chiribaya sites were well within the Estuquiña territory and required some consideration discussed in greater detail in the following subsection to assist in the production of Figures 3-6.

All the viewshed rasters were then compared to the agricultural land shapefile to determine visible agriculture. To do so, the agricultural land shapefile was converted into a raster grid file at a 30-meter resolution. A raster calculator was used to determine areas that were simultaneously visible and part of the agricultural land raster. The resulting combination recorded the visible agricultural level, or number of sites that can see that area of agriculture, of each cell. To determine the area of visible agriculture in each new raster, the raster was converted into a shapefile using the raster-to-shapefile tool and area was then calculated. It was quickly noted that there were areas of micro-gaps within visible agriculture caused by local topography such as hills that may have brought the area of visible agriculture lower than actual visible land. Since this may be the case, comparisons of viewsheds were based on total visible agriculture that produced percentages to compare sizes of agriculture while accounting for this possible error.

Finally, settlement visibility was determined based on a comparison of settlement location and the rasters of cultural viewsheds. Since multiple viewshed analysis totaled the number of individual settlements that had visibility to each cell. For example, a raster cell that two sites can see provides an output with the value two in the viewshed analysis. A zonal statistics tool then was used to determine the raster value at each site to provide the number of other settlements that could see a site.

Chronological Categories for Interpretation

One issue that this thesis had to grapple with is one of chronology. One ubiquitous issue with survey data is it does not provide the chronological accuracy present in more extensive excavations. Though, as discussed previously, the general chronology of occupation is well evidenced and provides a general outline of habitation of the valley, a fine grained chronology of occupation in the Moquegua valley is still incompletely understood (Bermann et al. 1989).

Within this LIP dataset alone there are inconsistencies of the ceramic chronology. First, many northern sites, M223B, M224A, M224B, and M217 were recorded as Chiribaya sites though each site had evidence of both Chiribaya and Tumilaca ceramics. Since the Tumilaca period is evidenced to have ended around the time the Chiribaya occupation began, it makes it difficult to assess when these sites were occupied. It is difficult to assess chronologies based on ceramics alone, but with the presence of Tumilaca ceramics two possibilities are explored here. First, these sites may have been a Chiribaya site placed on a previous Tumilaca site, making age of the settlement uncertain. Second, some sites may be early Chiribaya or late Tumilaca sites that traded with the other. This problem of chronology is further exacerbated by the lack of permanent structures at some sites. The sites M223B and M217 are noted as dispersion sites, or as habitation sites without any structures, with both Chiribaya and Tumilaca ceramics (MAS survey data). M224A is a hilltop site with a light scatter of Tumilaca and Chiribaya wares (MAS survey data), and M224B has a light scattering of wares of unknown type along with Chiribaya.

Similar issues, but at the other end of the time spectrum, arose for the Estuquiña settlement M21A due to the presence of Incan artifacts within the ceramic assemblage. In other contexts similar issues have made it difficult to assess the relative chronology at other Estuquiña sites site (Stanish 1991, 13). This means that M21A was either occupied by the Estuquiña prior to the Inca arrival, or was a site that had Inca occupation or influence after the Inca have expanded into the valley.

Due to these issues this thesis employs two possible chronologies based on ceramic styles detected during the MAS field surveys to interpret the original hypothesis. Chronology A is a static chronology and holds that all sites were occupied by their respective groups at the same time (Figure 3). Chronology B is a dynamic chronology, assuming movement of people over time based on the settlements' artifact assemblage and is divided into three: phases, B1, B2 and B3. Phase B1 is based on a chronological association based on the mixed ceramic assemblage at the sites M224A, M224B, M223B, M217 that placed each Chiribaya site closer to the Tumilaca period, with occupation closer to 1000 CE, well before Estuquiña settlements arrived in the valley (Figure 4). Following this period is Phase B2, where the northern Chiribaya settlements are abandoned either prior to or concurrent with the Estuquiña movement into the northern extent of the valley (Figure 5). Following this period is Phase B3, where the Chiribaya began abandoning the valley during the 13th century and the Estuquiña began migrating south and occupied sites like M21A closer to the end of the LIP and the beginning of the Late Horizon Period (Figure 6).

These chronologies changed how the settlements were grouped for the viewshed analysis. Chronology A included all settlements to simulate entirely contemporaneous groups. Under Chronology B, Phase B1 has all Chiribaya sites to simulate maximum Chiribaya influence. Phase B2 removes Chiribaya sites M224A, M224B, M223B, and M217 to simulate abandonment and includes all Estuquiña sites except M21A. Phase B3, adds settlement M21A, a site with some Inca ceramics, to the Phase B2 analysis. This thesis recognizes these chronologies are speculative pending date and artifact analysis. As the LIP chronology is better defined then these two proposed chronologies can be revisited with future testing.

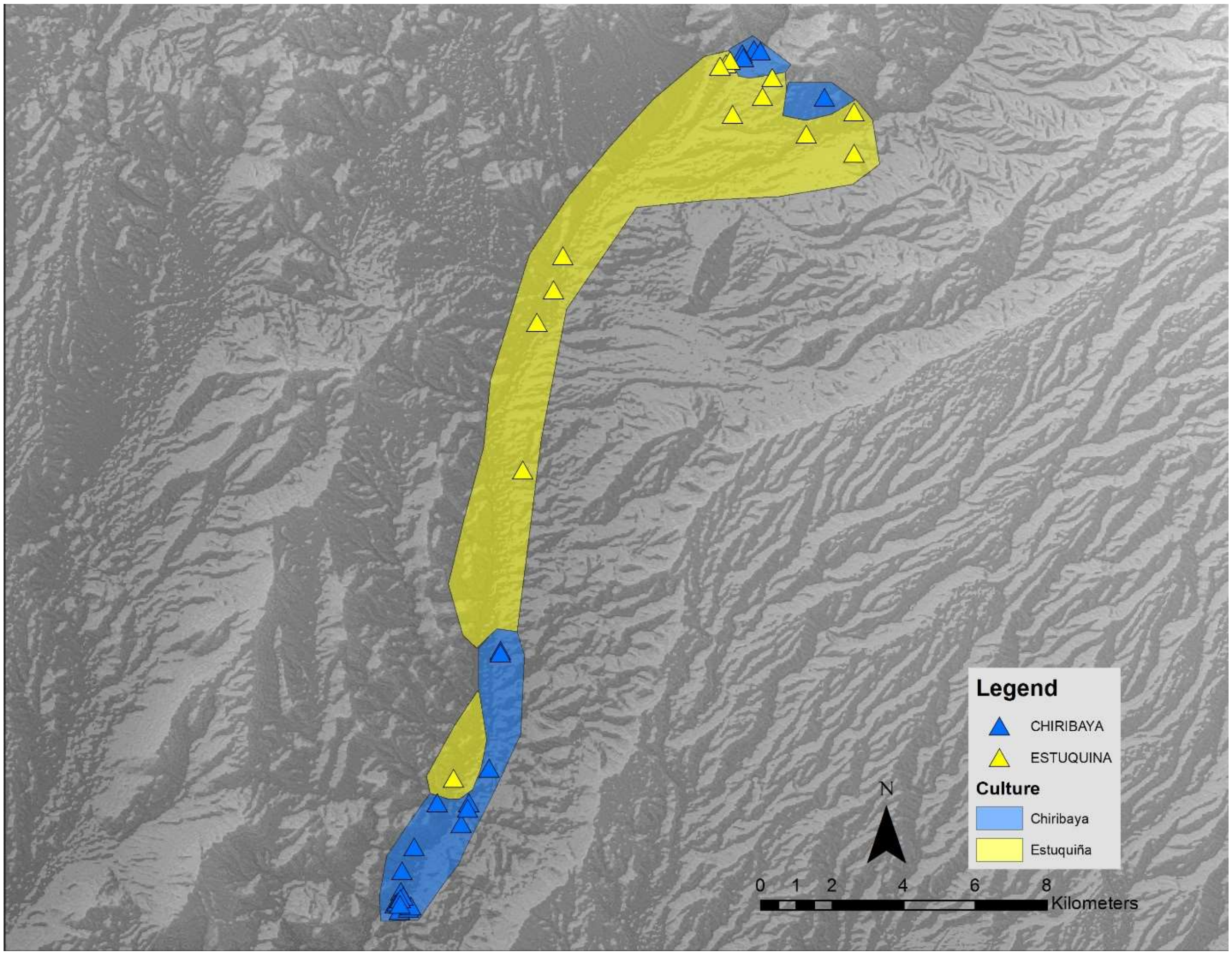

Figure 3: **Map showing Chiribaya and Estuquiña viewsheds under Chronology A** based on the assumption that all settlements were occupied contemporaneously. Blue depicts Chiribaya and yellow depicts Estuquiña areas of control. Triangles depict the settlement locations.

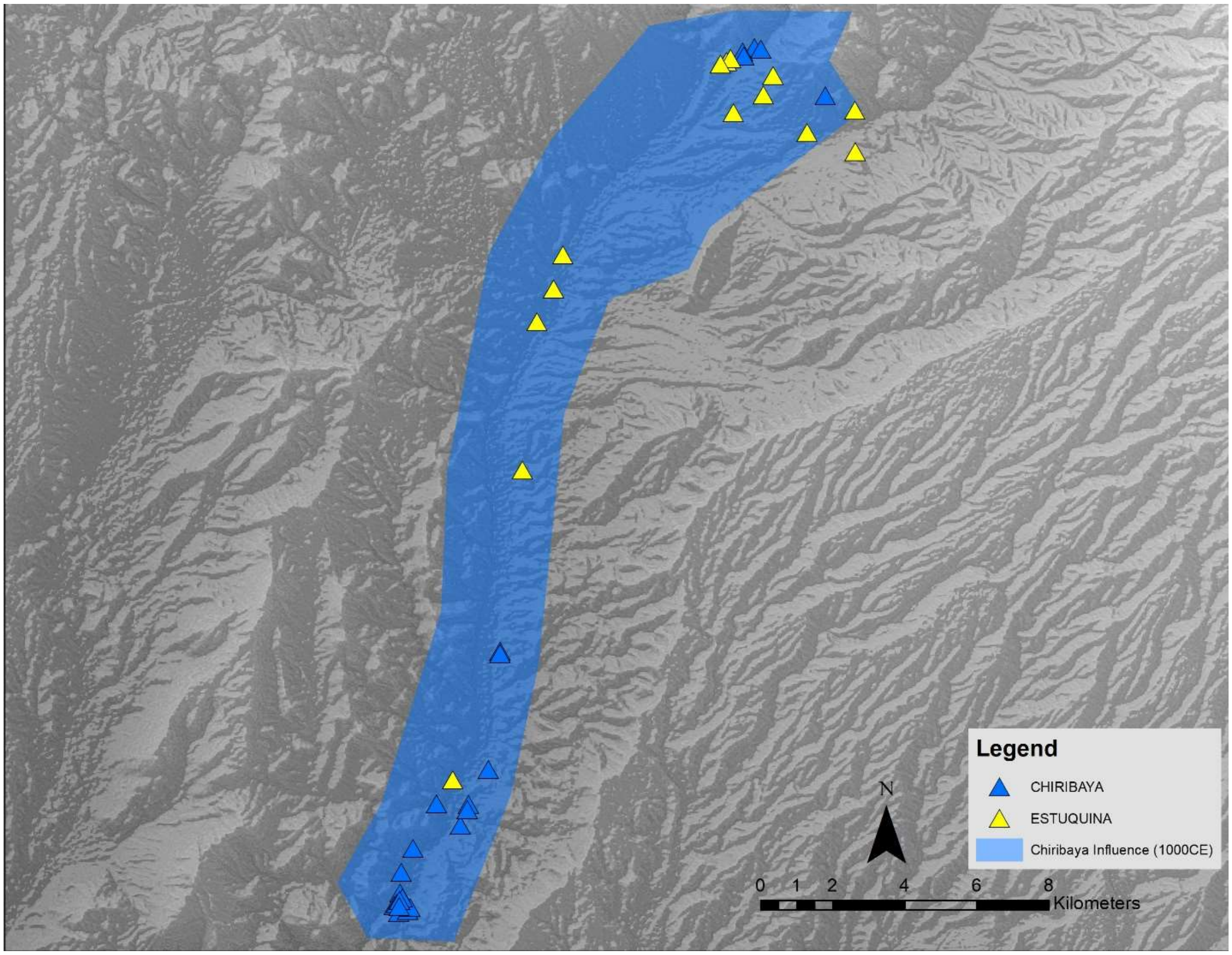

Figure 4: **Map showing Chiribaya viewshed under Chronology B, Phase B1** colored blue. This depiction assumes that all Chiribaya sites were occupied at the same time, prior to the Estuquiña occupation of the valley. Triangles represent the original settlement locations, yellow representing Estuquiña and blue Chiribaya.

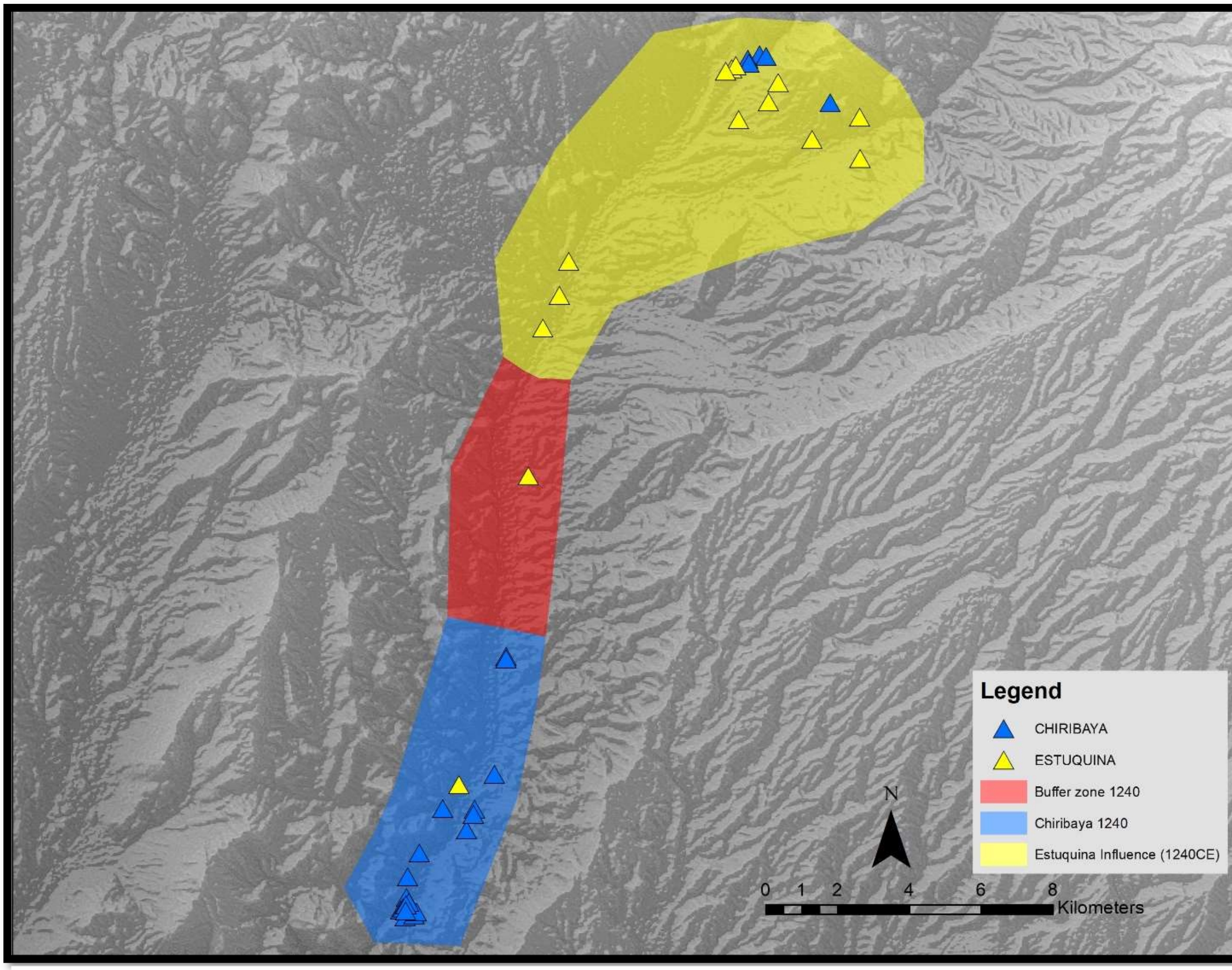

Figure 5**: Map showing Chiribaya and Estuquiña viewsheds under Chronology B, Phase B2** areas are based on viewshed analysis of LIP sites within the Moquegua valley. Blue depicts areas controlled by Chiribaya, Yellow areas depict areas controlled by Estuquiña, and red areas depict contested space/buffer zone. Triangles represent the original settlement locations.

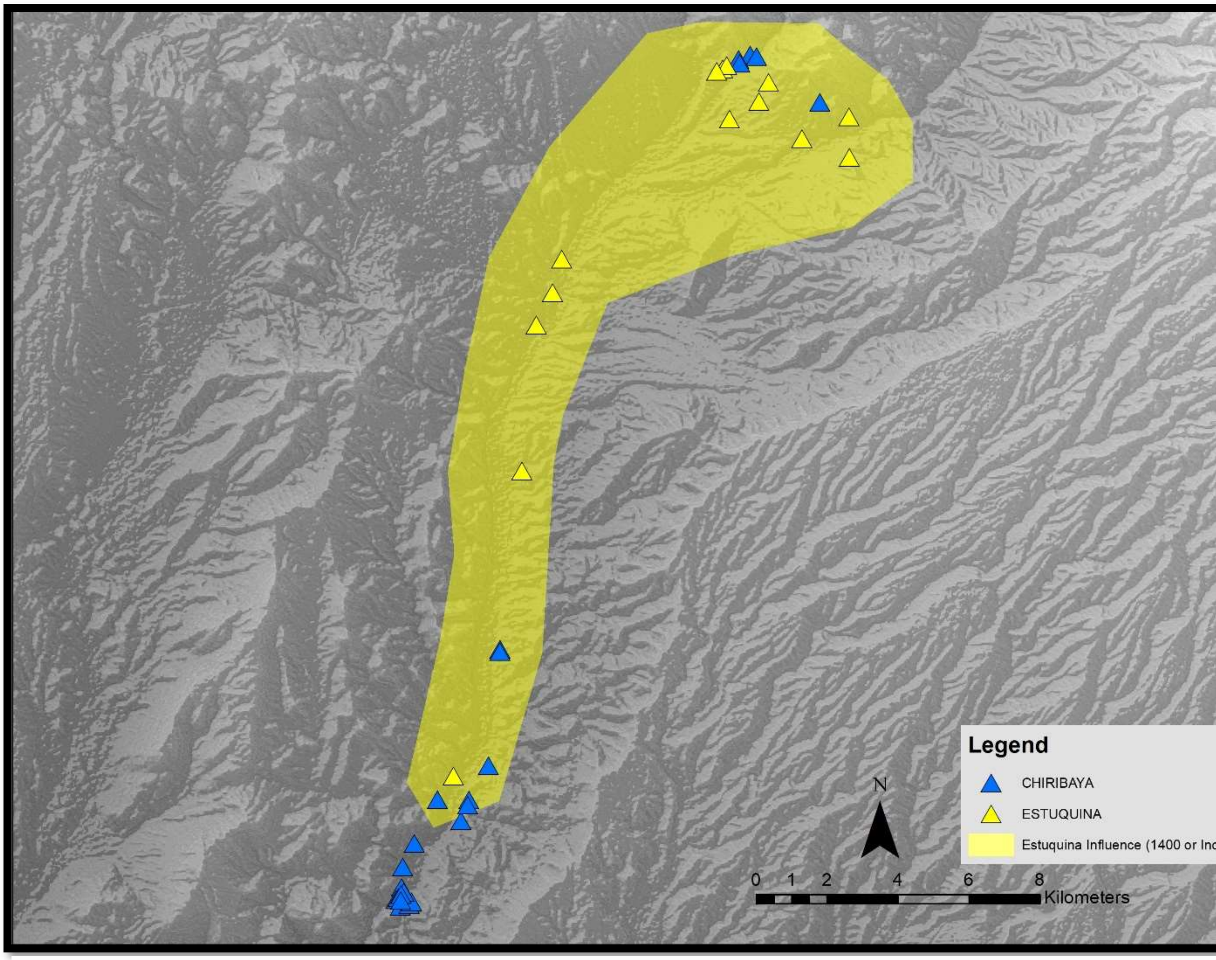

Figure 6: **Map showing Estuquiña viewshed under Chronology B, Phase B3** the areas of control based on visibility from all Estuquiña settlements, depicted in yellow. Based on the assumption that all Estuquiña sites were occupied after the Chiribaya left the valley. The triangles depict original settlements locations based on the MAS survey.

Results

This section discusses general results of the viewshed analysis, and how these viewsheds differed between chronologies. First, visibility of all sites during the LIP showed that besides a small area in the middle of the valley, most of the river valley was visible by at least one settlement either Chiribaya or Estuquiña. When looking at Chiribaya settlement viewsheds, it is apparent that vision is maintained throughout the southern valley, up until the valley bends eastward where the ability to see declines. Further north the Chiribaya regain a large area of visibility as Chiribaya view returns around sites M224A, M224B, M223B, and M217. When all Chiribaya settlement visibility is accounted for, a total area of 1632 ha of agricultural land is visible, but if M224A, M224B, M223B and M217 are removed from the analysis then it is reduced to 453 ha. This is caused by the wide agricultural area at the upper end of the valley, and could be indicative of a continual colonization effort to control the Moquegua valley by the Chiribaya prior to Estuquiña arrival.

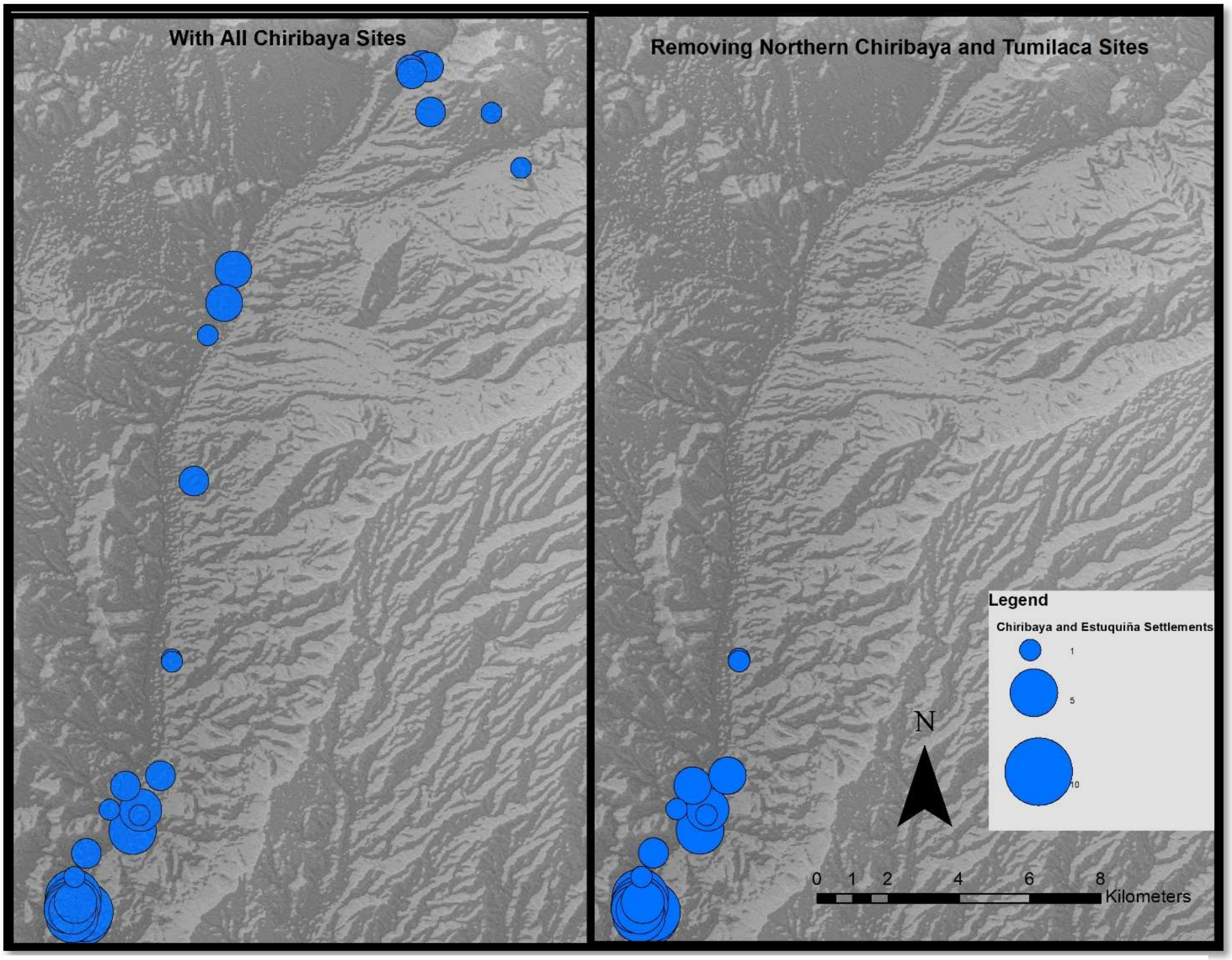

Figure 7**: Number of Settlements Visible from Chiribaya Settlements** a map of the Moquegua valley showing settlements with size indicative of the quantity of Chiribaya settlements that had visibility of it, any settlements with a visibility value of zero were not depicted in this map. Both Chiribaya and Estuquiña settlements are represented. The map is divided by the inclusion (left) and exclusion (right) of sites M224A, M224B, M223B, and M217 from the analysis.

Further, the Estuquiña maintain visibility of agricultural fields along the northern half of the valley with the view becoming sparse near the bend of the valley. With site M21A, vision is re-established and this possibly Estuquiña-Inca site can view a considerable extent of the southern valley, but does not ‘see’ into the Chiribaya area. This results in Estuquiña settlements, including M21A, maintained visibility of a total of 1507 ha agricultural land, which is reduced to 1256 ha of agricultural land if M21A is removed from the analysis.

Inter-settlement visibility, otherwise referred to as line of sight (LOS) between settlements, is quite high within the same broad cultural groups. Visibility between Chiribaya and Estuquiña settlements is a bit complex, with intercultural visibility is high in the north because of the Chiribaya settlements M224A, M224B, M223B, and M217 maintaining vision of 50% of Estuquiña sites. However, if these four settlements are removed from the analysis, in accordance with chronology B, Phase B2 (or if the sites represent Tumilaca, rather than Chiribaya occupations), the Chiribaya have very little LOS of Estuquiña sites, with the exceptions of M21A and M123, both of which are in the southern end of the Middle valley. Discounting the northern Chiribaya sites, the Estuquiña maintain LOS of only one Chiribaya site. This visibility is provided by the Estuquiña sites M21A and M123, sites which only have LOS of one Chiribaya settlement, M57B. In sum, for both groups, LOS of sites outside of their cultural group is relatively rare.

Within cultural groups, LOS to settlements appears quite high. The viewshed analysis of all Chiribaya sites show a common viewscape of the southern Moquegua Valley, with 88% of Chiribaya settlements having mutual visibility of one or more other settlement. However, three sites M71E, M71D, and M120, were not visible from other Chiribaya sites according to the viewshed analysis (Figure 3). Site M71E was a settlement just off the river valley and was one of the northernmost settlements (besides M224A, M224B, M223B, and M217), and was located below the hilltop site of M71D. M71E's location between two larger hills places in a hidden location, despite being close to other Chiribaya settlements[1]. It seems that M120 was not visible

[1] Site M71D, is on a large hill that could overlook the surrounding area, just south of M71E. However, the high vantage point made it higher than other locations and the analysis considered

from other Chiribaya sites. M120 is small site located in a remote area of the hillside, its placement between two hills prevents other sites in the southern area of Moquegua valley from having direct LOS of M120. Further, M120 is the only site in the study that did not maintain visibility of any agricultural land. When sites M224A, M224B, M223B, and M217 are included in the viewshed analysis one of these sites has visibility to site M120. The upper valley Chiribaya sites M224A, M224B, M223B and M217 maintain visibility of each other (Figure 7). Chiribaya visible agriculture is usually between 2-3 sites per cell of agriculture, including in the northern area of the valley, with the exceptions to the south where La Yaral (M8A-M8F) and some smaller sites provide higher numbers of visual overlap.

---

the center of the point as invisible to other Chiribaya sites. Still, the adjacent raster cells to M71D have values of 1-4 making it likely that the site was visible from other sites. However, to stay true to the project they are treated as hidden from other Chiribaya sites.

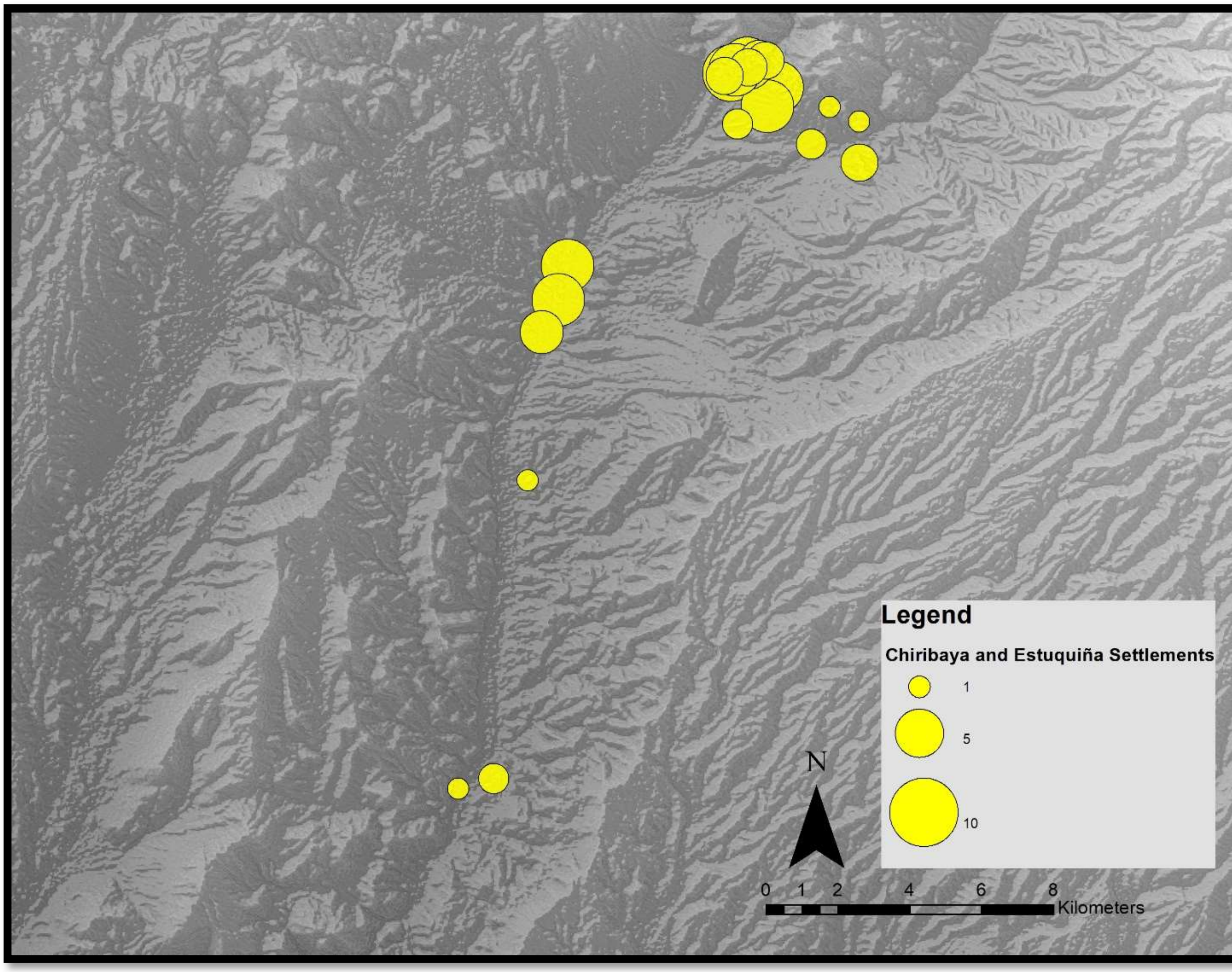

Figure 8: **Number of Settlements Visible from Estuquiña Settlements** a map of the Moquegua river valley showing settlements with size indicative of the quantity of Estuquiña settlements that had visibility of it, any settlements with a value of zero visibility were not depicted in this map. Both Chiribaya and Estuquiña settlements are represented.

Estuquiña settlements maintain LOS with other Estuquiña settlements. However, higher levels of visibility are maintained by sites in the upper valley. This phenomenon is caused by the closer congregation of settlements to the northern extent of the valley, and the wider regions of visibility caused by the relatively flat and wide valley floor. Further south, the Estuquiña sites M21A and M123 only maintained mutual visibility with each other.

Agricultural visibility provided another unique aspect to the investigation. All Estuquiña settlements maintain line of site to agricultural land within the valley and maintain vision with other Estuquiña sites (Figure 8). Viewsheds of all Estuquiña sites show a focused viewshed along the wide valley area to the north. The viewshed does show minimal visibility of the curve of the river towards the middle, but visibility is gained further south by site M21A. Estuquiña sites maintain views of agricultural land with larger instances of visual overlap within the northern area of the valley, but further south visible agriculture becomes isolated as visual overlap is minimized (Figure 9).

When visible agricultural land was compared to the area of the baseline agricultural land, visible agricultural land for both Estuquiña and Chiribaya accounted for 66% of the total agricultural area. However, this number does fluctuate depending on the chronology used, and this fluctuation is discussed in greater detail below. Some of the 'missing' land is caused by micro-gaps within visible agriculture, where local topography like a small hill would create a tiny shadow effect of missing or invisible agricultural land on its opposite side.

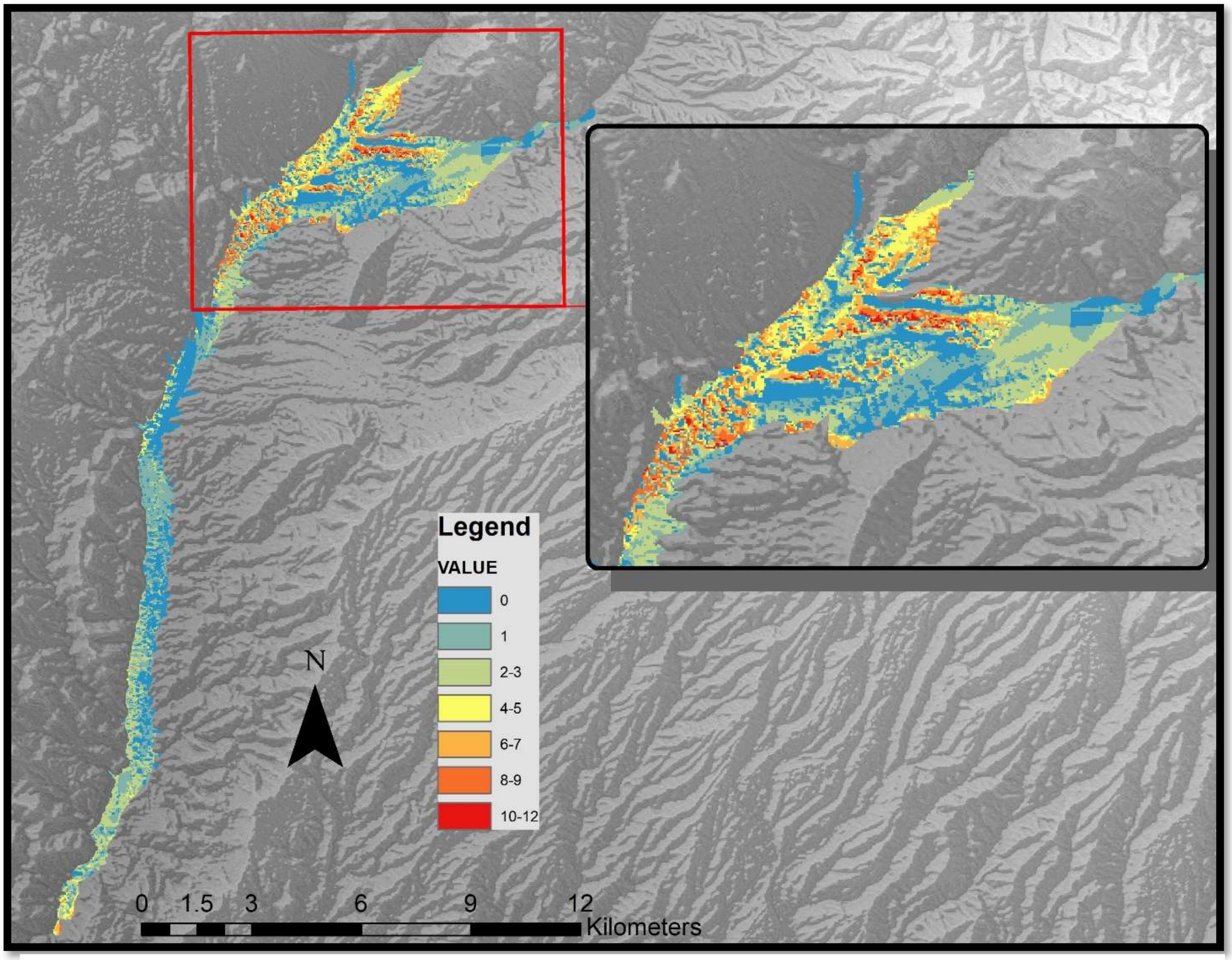

Figure 9: **Visible Agricultural Land Heat Map** of the Moquegua agricultural land where warmer colors depict areas that are visible by many settlements. Inlet map is zoomed to northern area of Moquegua Valley occupied by the Estuquiña.

Discussion

As previously stated the Late Intermediate Period (LIP) is considered a period of social turmoil and inter community conflict (Arkush 2008; Arkush and Stanish 2005; Sims 2006). If settlements are placed into hilltops for defensible positions in the landscape these higher vantage points would also provide wider visibility of the surrounding landscape that would be useful in times of conflict. This thesis uses visibility to look at aspects of defensibility, and control over a regional space. Within the discussion we assess the hypothesis: warfare and threats of violence would force communities to seek defensible locations in higher elevations, at the expense of important resources (Arkush 2011). If this is true in Moquegua during the LIP, then two things would occur within the viewshed. First, as settlements prioritize defensibility they would maximize distances away from possible threats while congregating near allies, this would result in a viewshed that has little overlap between enemies compared to friendly groups. Second, as distance is increased between opposing groups areas of viable agricultural land would not be visible as a buffer zone is formed between opposing groups. Within this discussion section this thesis addresses this hypothesis through two possible chronologies. Chronology A all sites are contemporary, and Chronology B site occupation is dynamic and changes through time. (Table 2; Figure 3 and 4).

Chronology A

If Chronology A is the case and all sites were occupied simultaneously, then a clear majority of agricultural land in the upper valley is contested by both Chiribaya and Estuquiña groups. Since both cultural groups are situated near each other in the northern extent of the valley, the viewshed results in high concentrations of visibility over agricultural fields, and each other (Figure 9). From the four upper-valley Chiribaya sites, settlements M224A, M224B, M223B, M217 could see over 50% of northern Estuquiña sites and themselves highly visible from Estuquiña sites. Further LOS of the two southern Estuquiña sites (M21A and M123) are visible by two Chiribaya settlements, and one Chiribaya site (M57B) is visible by the Estuquiña.

Since, the northern valleys have high levels of visible agriculture near settlements then both Chiribaya and Estuquiña settlements are increased proximity to each other. Further, at the southern interface between Chiribaya settlements M71E and D are in close spatial proximity of settlement M21A. This limited space between Chiribaya and Estuquiña sites here and in the upper valley makes the buffer zones between Chiribaya too small to detect and probably nonexistent. If this is the case then chronology A for the Moquegua valley is accurate then we must rule out the original hypothesis that warfare influenced the development of the valley.

Chronology A does not entirely fit the current archaeological record. Though there are limited bio-archaeological cases of skeletal trauma in mortuary studies of Estuquiña and Chiribaya sites which may corroborate this chronology, the prevalence of fortified and/or defensible locations of settlements points towards a period of warfare (Arkush and Tung 2013, 342). Similar conflict heavy time periods use fortifications that the production of these defenses was for immediate protection, and long-term prevention of violent action. There are seven Estuquiña sites with walls throughout the valley, but the Chiribaya sites M224A, M224B, M223B and M217B, lack any detectable architecture and are only defensible as a hilltop settlement. If the original hypothesis was incorrect and warfare did not affect these communities, which is evidenced by their proximity and high rating of visible agriculture, and near nonexistent buffer zones, it is likely that there would be some semblance of Estuquiña ceramics in the assemblage and we currently do not see such association. There are sites further inland at the Torata valley where Estuquiña sites do have Chiribaya and Tumilaca ceramics present in the assemblage, however it was argued as a prior occupation that was obliterated by the subsequent Estuquiña occupation (Burgi 1993, 110–57). Within the Chiribaya sphere there is little to no evidence of Estuquiña ceramics along the coast. Due to these inconsistencies this thesis doubts the possibility of chronology A however till accurate carbon dates are acquired it must be included within the analysis.

Chronology B:

With chronology A proving unlikely, the alternate must further be investigated. Within chronology B1 maintains that the entire valley at one point was occupied by or influenced heavily by Chiribaya presence. Based on the viewshed analysis LOS was maintained by the Chiribaya to at least one other Chiribaya site. This pattern along with shared ceramic style leads to the interpretation of ingroup solidarity. The presence of concentrated LOS networks of communication and response that would be important to consider within future archaeological research. The defensive utility of maintaining vision between 'friendly' settlements within the Moquegua valley would allow for information to be quickly spread and muster a rapid response to incoming threats in the valley, as seen above (Rua, Gonçalves, and Figueiredo 2013; Arkush 2011).

The Southern Chiribaya is comprised of 18 sites along the southern extent of the valley. The LOS of these settlements were maintained except for M120, M71D and M71E. Beyond a network of LOS, settlements were position within the surrounding geography that much of the visible agriculture was visible by two to three Chiribaya sites. This high visibility and proximity to other settlements further reflects cooperation pattern as there are no clear demarcation of settlement control over any land form. The four-upper valley Chiribaya sites are made up of four settlements (M224A, M224B, M223B, M217B). Each settlement was visible by at least one other northern Chiribaya site. Further, these northern settlements also exhibited a high visible agriculture levels with large areas of agriculture were visible by 2-4 of these settlements at one time.

Between the northern and southern groups there is a large region where no vision is present. This region of arable land that was not utilized by either Chiribaya pocket does resemble a buffer zone and would indicate some level of conflict (LeBlanc 2006). This relationship indicates that the original hypothesis may apply to the regional spacing of Chiribaya groups. While these pockets have a buffer zone which may be indicative of regional warfare, within these pockets the pattern indicates a higher likelihood of internal cooperation then internal warfare.

As noted previously the Northern Chiribaya settlements have both Tumilaca and Chiribaya ceramics present and can be interpreted two ways. First, that the northern sites were Tumilaca and the buffer zone was a defensive mechanic that separated the two polities who participated in trade. Or that the northern and southern settlements were all part of the Chiribaya polity. If this later interpretation is true, then the large buffer zone may indicate a strategy of defense that indicates conflict between these two Chiribaya polities.

Though this buffer zone is possible, it goes against other archaeological work that has argued the Chiribaya as a complex hierarchical polity (Rice 1993). To be honest the similarity of ceramics and lack of long term architecture in upper valley contexts is likely that the spacing is a result of colonization attempt in the upper valley by the Chiribaya. For if the Chiribaya were a part of a complex hierarchical polity we would assume strategic expansion as seen in the southern settlements who maintain high levels of visual agriculture.

Chronology B2

Since B1 and B2 differ by the addition of Estuquiña sites much of discussion will focus on the Estuquiña. With the arrival of the Estuquiña to the valley early occupation is limited to the northern extent of the upper valley. Towards the middle of the valley the Estuquiña do have three sites that are encroaching on the Chiribaya settlement. As expected with other frontier settlements between a cultural interface these three southern settlements are heavily defensible with a hilltop position and a large perimeter wall. Still, there are fortified settlements in the upper valley where there are Estuquiña settlements in the north that also maintain a fortified wall, like the site of Estuquiña (M8).

Within the north the Estuquiña maintain elevated levels of visibility among their settlements with a proclivity towards maintaining higher vision of fortified positions. In addition to inter-site visibility, settlements were situated near within the northern extent of the upper valley that had many sites maintain vision over the same agricultural areas. Within this timeline the Estuquiña and the Chiribaya do not maintain LOS of each other. Instead, there is a large region of unclaimed agricultural land between them that resembles the buffer zone.

Visual agricultural land control is completely distinct between Estuquiña and Chiribaya settlements. When comparing total visible agriculture Chiribaya settlements maintained a viewshed of only 24% of the visible agricultural land in the valley, while Estuquiña sites- maintained vision on more than 66% of the total visible agriculture. This discrepancy in visual area is due primarily to the geography of the terrain, with the northern extent of the valley is wider than the southern extent. Still, this agricultural disparity between communities does show that, Estuquiña settlements present a wider control of agricultural land within the Moquegua valley.

The patterns exhibited by the Chiribaya and Estuquiña within chronology B2 fits within what was expected if warfare was carried out between the two polities. The large buffer zone separates the two communities and when sites got closer to the 'border' the Estuquiña used external walls for defense as they were closer to Chiribaya. Within the Estuquiña sphere the proximity of Estuquiña settlements to each-other producing the elevated levels of visual overlap shows signs of cooperation rather than competition in that region. If this is true then it seems that the Estuquiña exhibited more interconnectivity with other Estuquiña sites than previously determined by Burgi (1993), and Stanish (1989). The Estuquiña sites to the south are more isolated and have less visual overlap then the northern sites, which does resemble the interpretation of the Estuquiña as isolated self-sufficient polities (Burgi 1989). Though what accounts for this discrepancy of strategies is uncertain.

Chronology B Phase B3:

Chronology B Phase B3, presents an abandonment of Chiribaya from the valley and control of valley left to the Estuquiña or Estuquiña-Inca. With the addition of vision from Estuquiña site M21A, a majority of the buffer zone between Chiribaya and Estuquiña, evident within chronology B Phase B2, is removed. If Phase B2 is correct and Estuquiña were in active conflict with Chiribaya, the presence of M21A coincides with abandonment of the Chiribaya presence within the Moquegua valley. Further, M21A is not visible by any other Estuquiña sites beyond M123 further to the south. Though LOS is maintained between these two settlements, there is little overlap of visible agricultural area between these two sites. It is important that both were recorded to contain Estuquiña and later ceramic styles such as Inca, or Colonial wares (MAS Survey Data). The Inca did not arrive to this valley until the 15th century well after the decline of the Chiribaya from the valley in the 13th century. With sites of M21A and M123 are placed prominently in the southern half of the Moquegua valley and provides a clear viewshed of otherwise Chiribaya agricultural zones. This prominence and lack of overlap between visible agriculture may indicate that these sites were later construction and increase power of Estuquiña over the Moquegua River. Future research should investigate the chronology of M21A and M123 to understand these late sites relationship ‘to the analyzed viewscapes.

Conclusions

As the above discussion illuminates, the possible chronology of habitation seems to be most likely dynamic (chronology B) rather than static (chronology A). This has major implications for understanding the political economy for the communities within the Moquegua valley during the LIP, especially the Estuquiña. The Chiribaya pattern in the valley seems to be more spread out than the Estuquiña, however their placement of Chiribaya settlements along the valley maintains a moderate level of shared vision over agricultural areas (generally between 2-3 settlements per cell). This pattern depicts more cooperation, which fits the assertions made by Rice and others which held the Chiribaya as a possible hierarchical polity with Chiribaya Alto as its core (Rice 1993). Though arguably defensive in location, the lack of fortifications may lead to the consideration that warfare was not an original concern for the Chiribaya as they colonized the middle valley. Rather, the colonization of the valley was primarily in concern with gathering agricultural resources from the productive river valley.

While the Chiribaya were entering the space held by the Tumilaca, when Estuquiña initially occupied the river valley it was controlled by the Chiribaya. The presence of fortifications in the upper valley (Burgi 1993; Conrad 1993; Rice1993), makes it likely that warfare or at least defense was a primary concern of the Estuquiña. Though this need for defense is present in the construction of the Middle Valley sites, the placement of Estuquiña settlements suggests they were cooperative with each other by congregating close together within the northern extent of the valley. If this is the case, then the pattern of Estuquiña seems to show a more cooperative political economy during this time than previously asserted by Burgi (1993), and Stanish (1989) who consider the Estuquiña as independent polities who may participate in some aspects of trade, but not necessarily in large alliances. When the valley was abandoned by the Chiribaya sometime during the 13th century the Estuquiña expanded south following the settlement patterns of isolated settlements seen elsewhere. This pattern of cooperation does resemble the theory of circumscribed spaces proposed by Carneiro, that posited that state formation and cooperation was created in regions where resources and space were restricted (Carneiro 1970). When the valley was occupied by Chiribaya and Estuquiña, the Estuquiña settlements were entering a hostile space. As a defensive strategy the Estuquiña developed settlements near each other, and maintained vision over the nearby and highly valued agricultural area. Once occupation of the valley was secure and the Chiribaya left the valley, latter Estuquiña sites resumed a more isolated pattern maintaining space between other Estuquiña sites. Though these conclusions seem plausible they are still tentative until better chronological data for these sites are procured.

There were a few deviations from this pattern. Most notably is the Estuquiña-Inca site M21A that is in the southern half of the river valley and out of view of other Estuquiña sites. Field notes recorded this site as containing Estuquiña, Inca, and local Gentilar ceramics and may be indicative of the Late Horizon Period after the Chiribaya abandoned the valley, rather than the Late Intermediate Period. Future research should investigate the chronology of M21A in-order to discuss the change of control of the southern Middle valley during this time.

Warfare is notably difficult to detect within the archaeological record, and this study's implementation of a viewshed analysis has allowed for more attributes of defensibility to be explored. First, both communities maintained a clear line of sight with other sites within their cultural affiliation. Second, a diminished viewshed in the less-populated middle stretch of the middle valley clearly shows a buffer-zone of arable land that was not exploited nor visually controlled. Third, viewsheds show that several settlements-maintained vision over the same agricultural fields, and this might signify an area of agricultural land that could be easily protected. This analysis has laid the foundation of inquiry important to explore defensibility of settlements. With the development of software tools like geographic information systems available more questions of warfare and defensibility can be explored.

References

Arkush, Elizabeth. 2008. "War , Chronology , and Causality in the Titicaca." *Latin American Antiquity* 19 (4): 339–73.

———. 2011. *Hillforts of the Ancienct Andes: Colla Warfare, Society, and Landscape*. University Press of Florida.

Arkush, Elizabeth, and Charles Stanish. 2005. "Interpreting Conflict in the Ancient Andes: Implications for the Archaeology of Warfare." *Current Anthropology* 46 (1): 3–28. doi:10.1086/425660.

Arkush, Elizabeth, and Tiffiny A. Tung. 2013. "Patterns of War in the Andes from the Archaic to the Late Horizon : Insights from Settlement Patterns and Cranial Trauma." *Journal of Archaeological Research* 21 (4): 307–69.

Bamber, J L, S Ekholm, and W B Krabill. 2001. "A New, High-Resolution Digital Elevation Model of Greenland Fully Validated with Airborne Laser Altimeter Data." *Journal of Geophysical Research* 106 (B4): 6733–45.

Bawden, G. 1989. "Settlement Survey and Ecological Dynamics on the Peruvian South Coast." *Andean Past* 2: 39–67.

Bermann, Marc, Paul S. Goldstein, Charles Stanish, and Luis Watanabe M. 1989. "The Collapse of the Tiwanaku State: A View from the Osmore Drainage." In *Ecology, Settlement and History in the Osmore Drainage, Peru*, edited by Don S. Rice, Charles Stanish, and Phillip R. Scarr, 269–86. Great Britain: BAR International Series.

Bernardini, Wesley, Alicia Barnash, Mark Kumler, and Martin Wong. 2013. "Quantifying Visual Prominence in Social Landscapes." *Journal of Archaeological Science* 40 (11). Elsevier Ltd: 3946–54. doi:10.1016/j.jas.2013.05.019.

Blom, Deborah E., María C. Lozada, Benedikt HallgríMsson, Linda Keng, and Jane E. Buikstra. 1998. "Tiwanaku 'Colonization': Bioarchaeological Implications for Migration in the Moquegua Valley, Peru." *World Archaeology* 30 (2): 238–61. doi:10.1080/00438243.1998.9980409.

Bongers, Jacob, Elizabeth Arkush, and Michael Harrower. 2012. "Landscapes of Death: GIS-Based Analyses of Chullpas in the Western Lake Titicaca Basin." *Journal of Archaeological Science*. doi:10.1016/j.jas.2011.11.018.

Borstel, Christopher L., Geoffrey W Conrad, and Keith P. Jacobi. 1989. "Analysis of Exposed Architecture at San Antonio: Foundation for an Excavation Strategy." In *Ecology, Settlement and History in the Osmore Drainage, Peru*, edited by Don S. Rice, Charles Stanish, and Phillip R. Scarr, 371–94. BAR International Series.

Bridges, Patricia S. 1996. "Warfare and Mortality at Koger's Island, Alabama." *International Journal of Osteoarchaeology* 6 (1): 66–75. doi:10.1002/(SICI)1099-1212(199601)6:1<66::AID-OA243>3.0.CO;2-J.

Burgi, Peter. 1993. "The Inka Empire's Expansion into the Coastal Sierra Region West of Lake Titicaca." University of Chicago.

Burgi, Peter, Sloan Williams, Jane Buikstra, Niki Clark, Maria Cecilia Lozada Cerna, and Elva

Torres Pino. 1989. “Aspects of Mortuary Differentiation at Estuquiña.” In *Ecology, Settlement and History in the Osmore Drainage, Peru*, edited by Don S. Rice, Charles Stanish, and Phillip Scarr, 329–46. Oxford.

Carlson, Toby C, and D.a. Ripley. 1997. “On the Relationship between NDVI, Fractional Vegetation Cover, and Leaf Area Index.” *Remote Sensing of Environment* 62: 241–52. doi:10.1016/S0034-4257(97)00104-1.

Carneiro, Robert. 1970. “A Theory of the Origin of the State.” *Science, New Series* 169 (3947): 733–38.

Cohen, Ronald. 1984. “Warfare and State Formation: Wars Make States and States Make Wars.” In *Warfare Culture and Environment*, 329–58. Academic Press, Inc. http://www.columbia.edu/itc/anthropology/v3922/pdfs/cohen.pdf.

Conrad, Geoffrey W. 1993. “Domestic Architecture of the Estuquina and San Antonio.” In *Domestic Architecture Ethnicity and Complementarity in the South Central Andese*, edited by Mark S. Albenderfer, 55–65.

Conrad, Geoffrey W, and Ann D. Webster. 1989. “Household Unit Patterning at San Antonio.” In *Ecology, Settlement and History in the Osmore Drainage, Peru1*, edited by Don S. Rice, Charles Stanish, and Phillip R. Scarr, 395414. Oxford University Press.

Constantinidis, Dora. 2009. “GIS for Managing the Analysis and Protection of Archaeological Remains in the Willandra Lakes World Heritage Area.” *Archaeology in Oceania* 44 (2): 112–18. doi:10.1002/j.1834-4453.2009.tb00054.x.

Coppock, John, and David Rhind. 2017. “The History of GIS.” Accessed March 23. http://www.geos.ed.ac.uk/~gisteac/ilw/generic_resources/books_and_papers/Thx1ARTICLE.pdf.

Crutchley, Simon. 2006. “Light Detection and Ranging (Lidar) in the Witham Valley, Lincolnshire: An Assessment of New Remte Sensing Techniques.” *Archaeological Prospection* 13 (4): 251–57.

Ferguson, R. Brian. 1990. “Blood of the Leviathan: Western Contact and Warfare in Amazonia.” *American Ethnologist*, 137–257. http://doi.wiley.com/10.1002/(SICI)1099-1212(199601)6:1%3C66::AID-OA243%3E3.0.CO;2-J.

Fleming, Andrew. 2006. “Post-Processual Landscape Archaeology: A Critique.” *Cambridge Archaeological Journal* 16 (3): 267–80. doi:10.1017/S0959774306000163.

Foucault, Michel. 1995. *Discipline and Punish: The Birth of the Prison*. Edited by Alan Sheridan. New York: Vintage Books. doi:10.1017/CBO9781107415324.004.

Fowles, Severin. 2010. “The Southwest School of Landscape Archaeology.” *Annu. Rev. Anthropol* 39 (2010): 453–68. doi:10.1146/annurev.anthro.012809.105107.

Gamon, John A, Christopher B Field, Michael L Goulden, Kevin L Griffin, E Anne, Source Ecological Applications, No Feb, et al. 2016. “Relationships Between NDVI , Canopy Structure , and Photosynthesis in Three Californian Vegetation Types.” *Ecological Applications* 5 (1): 28–41. doi:10.2307/1942049.

Goldstein, Lynne. 1981. “One-Dimensional Archaeology and Multi-Dimensional People: Spatial

Organisation and Mortuary Analysis." In *The Archaeology of Death*, edited by Robert Chapman, Ian Kinnes, and Klavs Randsborg, 53–69. Cambridge, New York: Cambridge University Press.

Goldstein, Paul S. 1989. "The Tiwanakus Occupation of Moquegua." In *Ecology, Settlement and History in the Osmore Drainage, Peru*, edited by Don S. Rice, Charles Stanish, and Phillip r. Scarr, 219–55.

———. 1993. "Tiwanaku Temples and State Expansion : A Tiwanaku Sunken-Court Temple in Moquegua , Peru." *Latin American Antiquity* 4 (1): 22–47.

———. 2000a. "Exotic Goods and Everyday Chiefs: Long-Distance Exchange and Indigenous Sociopolitical Development in the South Central Andes." *Latin American Antiquity* 11 (4): 335–61. doi:10.2307/972001.

———. 2000b. "Exotic Goods and Everyday Chiefs: Long-Distance Exchange and Indigenous Sociopolitical Development in the South Central Andes." *Latin American Antiquity* 11 (4): 335–61. doi:10.2307/972001.

———. 2005. *Andean Diaspora*. Gainesville: University Press of Florida.

Gustas, Robert, and Kisha Supernant. 2017. "Least Cost Path Analysis of Early Maritime Movement on the Pacific Northwest Coast." *Journal of Archaeological Science* 78 (February): 40–56. doi:10.1016/j.jas.2016.11.006.

Hodder, Ian. 1972. "The Interpretation of Spatial Patterns in Archaeology: Two Examples." *Journal of Archaeological Method and Theory* 4 (4). The Royal Geographical Society (with the Institute of British Geographyers): 223–29. doi:10.1111/j.1467-8306.2007.00533.x.

Ingold, Tim. 1993. "The Temporality of the Landscape." *World Archaeology* 25 (2): 152–74. doi:10.1080/00438243.1993.9980235.

Keeley, Lawrence H. 1996. *War Vefore Civilization.* New York: Oxford University Press.

Kennett, Douglas J., and Norbert Marwan. 2015. "Climatic Volatility, Agricultural Uncertainty, and the Formation, Consolidation and Breakdown of Preindustrial Agrarian States." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 373 (2055): 20140458. doi:10.1098/rsta.2014.0458.

Kintigh, Keith W, and Albert J Ammerman. 2008. "Heuristic Approaches to Spatial Analysis in Archaeology Author (s): Keith W . Kintigh and Albert J . Ammerman Published by : Society for American Archaeology Stable URL : Http://Www.Jstor.Org/Stable/280052." *American Archaeology* 47 (1): 31–63.

Knoerl, John. 1991. "Mapping History Using Geographic Information Systems." *The Public Historian*, Preservation Technology, 13 (3): 97–198. http://www.jstor.org/stable/3378555.

Knudson, Kelly J., Arthur E. Aufderheide, and Jane E. Buikstra. 2007. "Seasonality and Paleodiet in the Chiribaya Polity of Southern Peru." *Journal of Archaeological Science* 34 (3): 451–62. doi:10.1016/j.jas.2006.07.003.

Kosiba, Steve, and Andrew M. Bauer. 2013. "Mapping the Political Landscape Toward a GIS Analysis of Environmental and Social Difference." *Journal of Archaeological Method and Theory* 20 (1): 61–101. doi:10.1007/s10816-011-9126-z.

Langsjoen, Odin M. 1996. “Dental Effects of Diet and Coca-Leaf Chewing on Two Prehistoric Cultures of Northern Chile.” *American Journal of Physical Anthropology* 101 (4): 475–89. doi:10.1002/(SICI)1096-8644(199612)101:4<475::AID-AJPA3>3.0.CO;2-V.

LeBlanc, Steven A. 1999. *Prehistoric Warfare in the American Southwest*. University of Utah Press.

———. 2006. “Warfare and the Development of Social Complexity: Some Demographic and Environmental Factors.” In *The Archaeology of Warfare: Prehistories of Raiding and Conquest*, edited by Elizabeth Arkush and Mark Allen, 437–68. Gainesville: University Press of Florida.

Llobera, Marcos. 1996. “Exploring the Topography of Mind: GIS, Social Space and Archaeology.” *Antiquity* 70 (January): 612–22. doi:10.1017/S0003598X00083745.

Low, Setha M. 1996. “Spatializing Culture: The Social Production and Social Construction of Public Space in Costa Rica.” *American Ethnologist* 23 (4): 861–79. doi:10.1525/ae.1996.23.4.02a00100.

———. 2003. “Embodied Space(s): Anthropological Theories of Body, Space, and Culture.” *Space and Culture* 6 (1): 9–18. doi:10.1177/1206331202238959.

Magilligan, F. J., P. S. Goldstein, G. B. Fisher, B. C. Bostick, and R. B. Manners. 2008. “Late Quaternary Hydroclimatology of a Hyper-Arid Andean Watershed: Climate Change, Floods, and Hydrologic Responses to the El Niño-Southern Oscillation in the Atacama Desert.” *Geomorphology* 101 (1–2): 14–32. doi:10.1016/j.geomorph.2008.05.025.

Manners, R. B., Francis J. Magilligan, and Paul S. Goldstein. 2007. “Floodplain Development, El Niño, and Cultural Consequences in a Hyperarid Andean Environment.” *Annals of the Association of American Geographers* 97 (2): 229–49. doi:10.1111/j.1467-8306.2007.00533.x.

McCool, Weston C. 2017. “Coping with Conflict: Defensive Strategies and Chronic Warfeare in the Prehispanic Nazca Region.” *Latin American Antiquity* 28 (3): 373–408.

McCoy, Mark D., and Thegn N. Ladefoged. 2009. “New Developments in the Use of Spatial Technology in Archaeology.” *Journal of Archaeological Research* 17 (3): 263–95. doi:10.1007/s10814-009-9030-1.

McEwan, Dorothy Graves, and Kirsty Millican. 2012. “In Search of the Middle Ground: Quantitative Spatial Techniques and Experiental Theory in Archaeology.” *Journal of Archaeological Method and Theory* 19 (4): 491–94. doi:10.1007/sl.

Moore, Jerry D. 2004. “The Social Basis of Sacred Spaces in the Prehispanic Andes: Ritual Landscapes of the Dead in Chimú and Inka Societies.” *Journal of Archaeological Method and Theory* 11 (1): 83–124. doi:10.1023/B:JARM.0000014348.86882.50.

Moore, Jerry D. 1992. “Pattern and Meaning in Prehistoric Peruvian Architecture: The Architecture of Social Control in the Chimu State.” *Latin American Antiquity* 3 (2): 95–113. doi:10.2307/971938.

Ortloff, Charles R., and Alan L Kolata. 1993. “Climate and Collapse: Agro-Ecological Perspectives on the Decline of the Tiwanaku State.” *Journal of Archaeological Science* 20: 195–221.

Ottensmann, John. 1997. “Using Geographic Information Systems to Analyze Library Utilization.” *The Library Quarterly: Information, Community, Policy* 67 (1): 24–49.

Otterbein, Keith F. 1999. “A History of Research on Warfare in Anthropology.” *American Anthropologist* 101 (4): 794–805. doi:10.1525/aa.1999.101.4.794.

Otterbein, Keith F. 1968. “Internal War: A Cross-Cultural Study.” *American Anthropologist* 70: 277–89.

Owen, Bruce. 1992. "Coastal Colonies and the Collapse of Tiwnaku: The Coastal Osmore Valley, Peru." *Society for American Archaeology 57th annual meeting, Pittsburg,* 1-10

———1994. “Were Wari and Tiwanaku in Conflict, Competition, or Complementary Coexistence? Survey Evidence from the Upper Osmore Drainage, Peru.” *Society for American Archaeology 59th Annual Meeting, Anaheim*, 1–9. papers2://publication/uuid/1EF025D0-F5FD-46C6-954F-8945620404D9.

———1995. “Warfare and Engineering , Ostentation and Social Status in the Late Intermediate Period Osmore Drainage.” *SAA Annual Meeting, Minneapolis*.

———2005. "Distant Colonies and Explosive Collapse: the Two Stages of the Tiwanaku Diaspora in the Osmore Drainage." *Latin American Antiquity,* 16(1):45-80

Pickles, John. 1997. “Tool or Science? GIS, Technoscience, and the Theoretical Turn.” *Anals of the Association of American Geographers* 87 (2): 363–72.

Rapoport, Amos. 1977. *Human Aspects of Urban Form*. Pergamon Press.

Reichel, Clemens. 2009. “Beyond the Garden of Eden -- Competition and Early Warfare in Northern Syria (4500-3000 B.C.).” *Tagungen Des Landesmuseums Fur Vorgeshichte Halle* 9 (11): 17–31.

Rice, Don S. 1989. “Osmore Drainage, Peru: The Ecological Setting.” In *Ecology, Settlement and History in the Osmore Drainage, Peru*, 17–34.

———. 1993. “Late Intermediate Period Domestic Architecture and Residential Organization at La Yaral.” In *Domestic Architecture Ethnicity and Complementarity in the South Central Andese*, edited by Mark S. Albenderfer, 66–82.

Richards-Rissetto, Heather, and Kristin Landau. 2014. “Movement as a Means of Social (Re)Production: Using GIS to Measure Social Integration across Urban Landscapes.” *Journal of Archaeological Science* 41 (January). Elsevier Ltd: 365–75. doi:10.1016/j.jas.2013.08.006.

Rivera, Mario A. 1991. “The Prehistory of Northern Chile: A Synthesis.” *Journal of World Prehistory* 5 (1): 1–47. doi:10.1007/BF00974731.

Rua, Helena, Alexandre B. Gonçalves, and Ricardo Figueiredo. 2013. “Assessment of the Lines of Torres Vedras Defensive System with Visibility Analysis.” *Journal of Archaeological Science* 40 (4). Elsevier Ltd: 2113–23. doi:10.1016/j.jas.2012.12.012.

Ryden, Kent C. 2006. “Why Your World Looks the Way It Does and Why It Matters : Cultural Landscape As Visual.” *Visual Arts Research* 32 (2): 73–75.

Sakaguchi, Takashi, Jesse Morin, and Ryan Dickie. 2010. “Defensibility of Large Prehistoric

Sites in the Mid-Fraser Region on the Canadian Plateau.” *Journal of Archaeological Science* 37 (6). Elsevier Ltd: 1171–85. doi:10.1016/j.jas.2009.12.015.

Schild, Alex. 2016. “Archaeological Least Cost Path Modeling: A Behavioral Study of Middle Bronze Age Merchant Travel Routes Across the Amanus Mountains, Turkey,” no. May. http://spatial.usc.edu/wp-content/uploads/2016/04/Schild-Alex.pdf.

Sharratt, Nicola. 2011. “Tiwanaku State Fragmentation and Domestic Practice: Collapse Phase Households in the Moquegua Valley, Peru Nicola Sharratt Paper Presented at the 76,” 1–14.

Sims, Kenny. 2006. “After State Collapse: How Tumilaca Communities Developed in the Uper Moquegua Valley, Peru.” In *After Collapse*, edited by Glenn M Schwartz and John J. Nichols, 114–36. Arizona: The University of Arizona Press.

Stanish, Charles. 1989. “Household Archeology: Testing Models of Zonal Complementarity in the South Central Andes.” *American Anthropologist* 91 (1): 7–24. doi:10.1525/aa.1989.91.1.02a00010.

———. 1991. “A Late Pre-Hispanic Ceramc Chronology for the Upper Moquegua Valley, Peru.” *Anthropology* 16: 1–68.

Stanish, Charles, and Abigail Levine. 2011. “War and Early State Formation in the Northern Titicaca,” no. 25. doi:10.1073/pnas.1110176108.

Sutter, Richard C., and Nicola Sharratt. 2010. “Continuity and Transformation During the Terminal Middle Horizon (A.D. 950-1150): A Bioarchaeological Assessment of Tumilaca Origins within the Middle Moquegua Valley, Peru.” *Latin American Antiquity* 21 (1): 67–86. doi:10.7183/1045-6635.21.1.67.

Sweeney, Michael. 1997. “Geographic Information Systems.” *Water Environment Federation* 69 (4): 419–22.

Tomczak, Paula D. 2003. “Prehistoric Diet and Socioeconomic Relationships within the Osmore Valley of Southern Peru.” *Journal of Anthropological Archaeology* 22 (3): 262–78. doi:10.1016/S0278-4165(03)00039-4.

Vranich, Alexei, and Charles Stanish, eds. 2013. *Visions of Tiwanaku*. *Visions of Tiwanaku*. Cotsen Institute of Archaeology Press.

Walker, John H. 2012. “Recent Landscape Archaeology in South America.” *Journal of Archaeological Research* 20 (4): 309–55. doi:10.1007/s10814-012-9057-6.

Webster, David. 1975. “Warfare and the Evolution of the State : A Reconsideration.” *American Antiquity* 40 (4): 464–70.

Wernke, Steven A. 2007. “Negotiating Community and Landscape in Peruvian Andes: A Transconquest View.” *American Anthropologist* 109 (1): 130–52. doi:10.1111/J.2008.1548-1425.00031.X.

Williams, Patrick Ryan. 2002. “Rethinking Disaster-Induced Collapse in the Demise of the Andean Highland States: Wari and Tiwanaku.” *World Archaeology* 33 (3): 361–74. doi:10.1080/00438240120107422.

Williams, Sloan A., Jane E. Buikstra, Niki R. Clark, Maria Cecilia Lozada Cerna, and Elva Torres Pino. 1989. "Mortuary Site Excavations and Skeletal Biology in the Osmore Project"

In *Ecology, Settlement and History in the Osmore Drainage, Peru*, 329-346

Williams, S.R. 1990. "The Skeletal Biology of Estuquiña: A Late Intermediate Period Site in Southern Peru." Ph.D. dissertation, Department of Anthropology, Northwestern University, Evanston IL.

Wolock, D M, and C V Price. 1994. "Effects of Digital Elevation Model Map Scale and Data Resolution on a Topographic Based Watershed." *Water Resources Research* 30 (11): 3041–52.

Wright, Dawn J, Michael F Goodchild, and James D Proctor. 1997. "GIS: Tool or Science?" *Main* 87 (2): 346–62. doi:10.1111/0004-5608.00058.

Yano, Keiji. 2000. "GIS and Quantitative Geography." *GeoJournal*, The Contribution of GIS to Geographical Research, 52 (3): 173–80. doi:10.1023/A:1014252827646.

Zaro, Gregory, Kenneth C. Nystrom, Alfredo Bar, Adán Umire Alvarez, and Ana Miranda. 2010. "'Tierras Olvidadas': Chiribaya Landscape Engineering and Marginality in Southern Peru." *Latin American Antiquity* 21 (4): 355–74. doi:10.7183/1045-6635.21.4.355.

Zhang, Weihua, and David R Montgomery. 1994. "Digital Elevation Model Grid Size, Landscape Representation, and Hydrologic Simulations." *Water Resource Research* 30 (4): 1019–28.